the x-axis). This factor can be called the 'axis of confidence in science'. The second factor (right side of the y-axis), instead, shows much more pragmatic and active attitudes (for instance being in favour of environment protection), which are opposed to more theoretic positions supporting democratic right and equilibrium between private and public. This axis can be named as 'axis of theory and practice in politics'.

Looking the image on right side we can consider some simple correspondence. For instance, on the left side we find positions strongly related to creationism, while on the upper side there is a correspondence between updating biological knowledge and activism in politics.

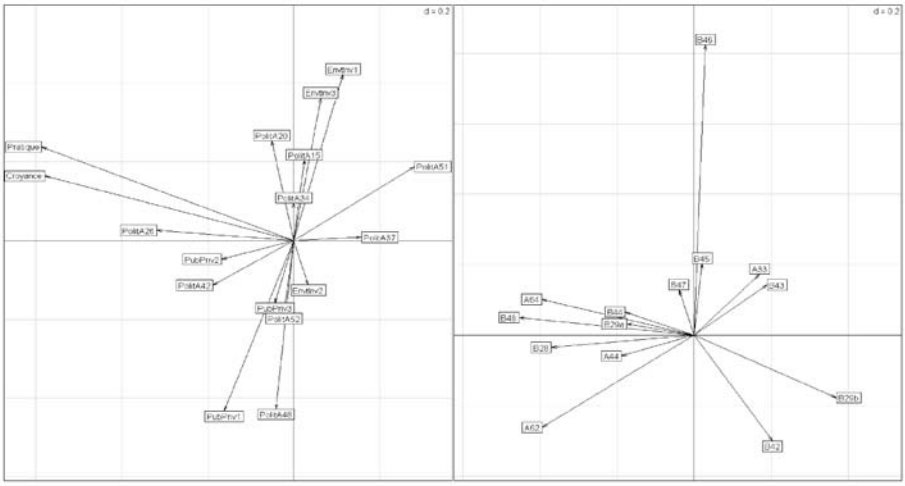


Figure 5 Factorial plan of the co-inertia analysis between the groups of variables on evolution and politics

4. CONCLUSION

The analysis of the Italian data confirms that conceptions supporting the theory of evolution or creationism are shaped along a wide range of positions in which religious beliefs represent only one of many interacting components. Italian pre-service and in-service teachers believing in God tend to have a creationist position, but there is no correlation between religious beliefs and a precise knowledge on evolutionary processes: they are independent components. Moreover, supporters of the theory of evolution are not completely identifiable with the conception that human species emerged by chance, and on the opposite side, creationists do not all believe that human species was the aim of evolution.

The system of values and beliefs represented in the Italian sample of in-service and pre-service teacher does not seem to be particularly influenced by specific knowledge on the evolution process and this represent a characteristics of the Italian results. This is shown in a first explorative analysis carried out within the Biohead project, which compare 12 countries, among which Italy [Munoz, Quessada, Clément]. In this analysis teachers who had a higher level of specific biological knowledge tend to be more

frequently supporters of the theory of evolution. The co-inertia analysis has shown that there is a relationship between involvement in politics and updated biological knowledge.

In the future a comparison of the questionnaire results with the analysis of textbooks carried out within the Biohead project can draw further insight in the complex process of shaping conceptions as well as on the interactions of different components influencing this process.

This complexity allows us to reflect on the importance of making teachers aware of these interacting components both at personal level and within the classroom.

BIBLIOGRAPHY

Clèment Pierre, Carvalho S. Graça, (2007). Biology, Health and Environmental Education for better Citizenship: teachers' conceptions and textbook analysis in 19 countries. In: XIII World Congress of Comparative Education Societies, & AFEC, Sarajevo, Sept. 2007.

Clemènt, P., Hovart, S. (2000). Environmental Education: analysis of the didactic transposition nd of the conceptions of teachers. In: H. Bayerhuber & J. Mayer. State of the art of empirical research on environmental education. Münster: Waxmann Verlag, p. 77-90.

Michael Greenacre (2007). *Correspondence Analysis in Practice, Second Edition*. Chapman & Hall/CRC, Boca Raton, FL.

Munoz François, Laurent Charline (2007). National analyses of the Biohead-Citizen questionnaire. Methodological leaflet, October Available at: http://projectos.iec.uminho.pt/projeuropa/

Munoz François, Quessada Marie-Pierre, Clèment Pierre (2007). Des analyses statistique multivariées pour traiter les donnèes issues de questionnaires: Conceptions d'enseignants et futurs ensegnants de douze pays sur l'Evolution. Available at: http://projectos.iec.uminho.pt/projeuropa/

PRE-SERVICE PHYSICAL SCIENCE STUDENTS' INFLUENCE OF SCIENCE, RELIGION AND INDIGENOUS KNOWLEDGE IN THE TEACHING OF COSMOLOGY AT THE FET LEVEL

Nadaraj Govender & Herby Govinden
University of KwaZulu-Natal, Edgewood Campus
Private Bag X03 Ashwood 3605
E-mail: govendern37@ukzn.ac.za

▼ Abstract

This paper examines pre-service students' conceptions of science, religion and culture with reference to the teaching of cosmology at the FET level in South Africa. The problems already encountered in the learning of new concepts introduced during the teaching of Astronomy are briefly referred to. Undoubtedly, the teaching and learning of Cosmology by both students and learners will experience similar difficulties and pose new challenges in the light of different cosmological worldviews of the communities in which they would serve. The transition from cultural, indigenous traditional viewpoints and religious beliefs to the world of science and cosmology poses particular challenges for final year teacher trainees entering classrooms with open-minded learners. An attempt is made to give a visual indication of how the three aspects of knowledge, namely science, religion and culture may be dealt with from both the teacher's and learner's viewpoint.

Key Words Cosmology, Science, Religion, Indigenous knowledge, Culture, pre-service, students' conceptions

1. INTRODUCTION

The new National Curriculum Statement for the Physical Sciences (Grades 10 - 12) in South Africa includes Cosmology and Astronomy as contexts relevant to the teaching of concepts in Physics (DOE, 2003). As the traditional teaching of the Physical Sciences did not include these contexts, studies have shown that in-service Physical Science teachers are barely equipped to handle these contexts at the FET level (Govender, 2004). Final-year pre-service Physical Science teachers were interviewed as to their experiences of Cosmology and Astronomy with reference to the evolution of the universe, as well as to the handling of issues which could give rise to controversies and debates in the science classroom as learners come from different religious and cultural backgrounds.

2. BACKGROUND

The inclusion of the theory of evolution and the introduction of astronomy and cosmology into the school curriculum has been the subject of heated controversy mainly in some parts of the United States (AIP Bulletin of Science Policy, 2005). However, the National Curriculum Statement of SA makes no such exclusions. In fact, one of the principles underpinning the value of Indigenous Knowledge Systems makes far-reaching implications for the science curriculum in SA as indicated by the following statement, "The NCS is premised on the view that there are competing perspectives and worldviews from which to understand and make sense of phenomena. A curriculum based on this view requires that these different perspectives and worldviews be recognized in the curriculum… "(NCS, 2003). The teaching of Astronomy has already begun at the GET level (DOE, 2002; Govender, 2004) and also for university foundation students at the University of Witwatersrand who do a course in geographical astronomy (Cameron, et al, 2005). These papers emphasize the problems encountered in both teaching and learning the 'new' concepts. Undoubtedly, the teaching and learning of Cosmology will be fraught with similar problems (Townsend, 2002). Researchers in IKS and Science (Jegede, 1998; Ogunniyi, 2000) points out the difficulties faced especially by disadvantaged learners in coping with concepts introduced during the teaching of Western science. Jegede emphasizes that "the learner' s understanding of any new meaning is strongly influenced and determined by prior knowledge that is in turn determined by cultural beliefs, traditions and customs governed by a world view" (Jegede, 1998, 160). Also in referring to African children, he continues "African children learn about their environment using prior knowledge situated within their non-Western world-view … (but) …prior knowledge situated within the African world-view becomes a handicap when a Western world-view is used as a framework for learning science" (Jegede, 1998, 161).

This implies that cultural differences form the basis of some of the problems in understanding scientific concepts. Phelan, Davidson & Cao (1991, p.228) define culture as the, 'norms, values, beliefs, expectations and conventional actions of a group'. It can be assumed, therefore that religion and indigenous knowledge systems are cultural phenomena which may then be subsumed under 'beliefs'. Researchers (Bryan & Atwater, 2002, p.821; Tobin & LaMaster, 1995; Jegede & Okebukola, 1991) has shown that knowing teachers' beliefs and designing instruction and experiences to explicitly confront those beliefs facilitate "refinement of and/or transformation" of beliefs and practices. Recent inclusion of IKS (Manzini, 2000, p.31), showed that learners appreciate the teaching of IKS, there was improved participation and a lack of "symbolic violence" on the part of learners. The current development towards globilised science in all parts of the globe requires that consideration be given to how learners move between their everyday life-world and the world of science, how learners deal with cognitive conflicts between those two worlds, and what this means for effective teaching. In this regard, Jegede and Aikenhead (1999) reviews a cognitive explanation called "collateral learning theory"- how learners cope with incongruent worldviews mediated by "transcending cultural borders between their everyday culture and the culture of science". The support that learners acquire when

they attempt to negotiate these cultural borders will influence their success at science. They propose a pedagogy in which teachers assume a role of culture broker or mediator in the classroom to achieve culturally sensitive curriculum and assessment.

3. DESIGN AND METHODOLOGY

This paper is based on part of a PhD student research presently underway in the School of Science, Mathematics and Technology Education on the Edgewood Campus of UKZN. The study involved engaging four students for six months in a final method course in Physical Science in energetic debates and discussions around issues of nature of science, cosmology, culture, religion and indigenous practices. Students were exposed via internet to the history of astronomy and cosmology. Formal lectures on modern cosmology were presented with opportunities for questioning, modeling and discussion. Two professors (one in Physics and one in Chemistry) and one Doctor (in Physics Education) were present to engage fruitfully in classroom in-depth discussions.

4. DATA COLLECTION

Discussions and unstructured interviews with four pre-service Bachelor of Education (B.Ed) student teachers were tape-recorded during two-hour sessions during the period August to November 2005. For ethical reasons, the students in question will be referred to by their pseudonyms: William, (a Christian-German fundamentalist religious background); Sipho (a Christian-culture African background), Suresh (a Hindu but not practising), John (a Christian-modern religious background). The data was analyzed using discourse analysis methods and categorized initially for each student and then arranged thematically.

In summary, the data revealed the following:

- The religious and cultural background of the interviewees.
- How this shapes their personal world-views on Cosmology?
- Their epistemological and ontological goals.
- Their views on the nature of science and the aims of science education.
- How their views influence their teaching of Cosmology?
- What are the issues fore grounded when they addressed issues in designing a Learning Programme in Cosmology as a context in the Physical Science curriculum for the FET band?

Some extracts from the interviews about the evolution of the universe:

William: "I would say to start off with Cosmology as a child was fairly simple. You know the Sun, Moon, stars are out there and so on…I've always been taught from a young age that God created the universe…"

"I do not believe that there has been any evolution of the universe. I believe that the universe was created by God about 6 000 years ago. Many

people believe that this belief is unscientific but in actual fact there is much science behind this belief since after all God created the science we live by".

Suresh: "My beliefs and perspectives on the evolution of the universe have been largely affected by science. The idea that the universe began when there was a major explosion (the Big Bang) is plausible. However, I also realize that science cannot explain everything. Alongside science, I believe that there had to be a force/energy whether it is God or something else that had to initiate a reaction."

Sipho: My belief is that God created the universe and everything in it. Something or someone who does not obey the laws of the universe should have created the point where matter must come from. Initially my perception of the universe did not expand beyond the Solar System… I did not worry much about what is space and how the earth was related to it. … Actually I have learnt more about the universe in the last two months than I had all my life. My idea of the universe has changed and I would never be able to talk about it without mentioning other models like the Big Bang and the Inflation model.

John: I am a devout member of the Christian faith. I support the biblical notion on the "evolution" of the universe. The Bible speaks of the creation of universe as taking place over a period of six days at the beginning of time. When was this beginning, I do not know? …I believe that the universe was created the instant God gave the Word. This instantaneous eruption of light and energy… could have taken the form of a Big Bang… I cannot say for sure whether or not the universe is expanding… If the universe is expanding where the extra space has come from? If not, what lies outside the universe?

5. DISCUSSION AND FINDINGS

It emerged clearly that the four interviewees came from backgrounds different with respect to religion and other aspects of culture. While William and John are Christians, William declared that the clung tenaciously to his faith as revealed in the Bible - that the sun, moon, stars, humankind, animals and plants were all created in six days and that happened 6000 years B.C.E. He was prepared to teach Cosmology and would show that textbooks gave the scientific views of creation which they had to learn about, but their personal views were also important.

John, on the other hand, appeared to be more open in his views - that God did create the universe but humankind was given the ability to discover how this occurred. He would point out in the class that science is a powerful method of discovering the world and how it came to exist. Learners' own religious views should also be taken into account.

Sipho stated that he, too, is a Christian but that he came from a rural setting and absorbed the culture beliefs common to the Africans in the village where he grew up.

They were interested only in the Sun and the Moon and the influence these 'heavenly bodies' had over their day to day living. They simply recognized the stars but their presence was a mystery. The universe as a whole did not matter to them - it was not visible. He has learnt a lot about the scientific views of the evolution of the universe and would try his best to teach his learners that the universe is more than what they observe about the Solar System.

Suresh is a Hindu - influenced strongly by the way his family (particularly his father) practised their faith. His is liberal in outlook and believed that there is a Great Force, who is responsible for the whole of creation. But science has revealed much to him and he is doing his best to understand the nature of the whole universe - the stars, the galaxies and what he learns from reading about astronomy. He would regard that his role as a teacher would be a real challenge and that he would be tolerant about the views expressed by his learners.

The above discussion gives only the preliminary findings as the analysis of data from the interviews conducted is still under way. A model of how teachers could view their knowledge positions is proposed in the form of a cultural triangle implying a connection with the three components of science, religion and indigenous knowledge. The model was presented to 200 high school science teachers at a teachers conference, some expressed delight in mapping their positions of the cultural triangle. Others were baffled at introduction of religion in science classes and yet others viewed the cosmological view of the universe and Big Bang as contradictions to their view of religion and concept of God.

The model called - The "Cultural Triangle" (see Figure 1) - using science (**S**), indigenous knowledge (**I**) and religion (**R**) as three components of culture (**SIR**) pertinent to the teaching of cosmology - is presented as a possible visual indicator of how a teachers' personal views may be 'equilibrated' in dealing with cosmological issues in the classroom. Suresh is almost position in the middle and towards science suggesting that he his views are more scientific with knowledge of other aspects. Such an adjustment may be necessary as learners come from various cultural backgrounds. The implications are for teacher education and science teachers' understandings of the competing power relations of ideologies in science education. In areas in the top triangle, science dominates, left triangle- indigenous knowledge dominates and right of triangle- religion dominates. Areas of the middle of the inner triangle indicate that science, indigenous knowledge and religion equilibrate. From the cultural triangle (Figure 1), William is strongly religious and scientific, Sipho is more balanced with indigenous emphasis, Suresh is balanced with strong scientific emphasis and John is towards the scientific and religious end. The ideal would be Suresh who is most likely to engage learners in open debates without indoctrinating his personal views or manipulating their worldviews to match his. Teachers who lack a particular area of knowledge should realize this from plotting their cultural positions in Figure 1 and consider development modules or self-study in these areas of knowledge. The internet is such a vast source of such information.

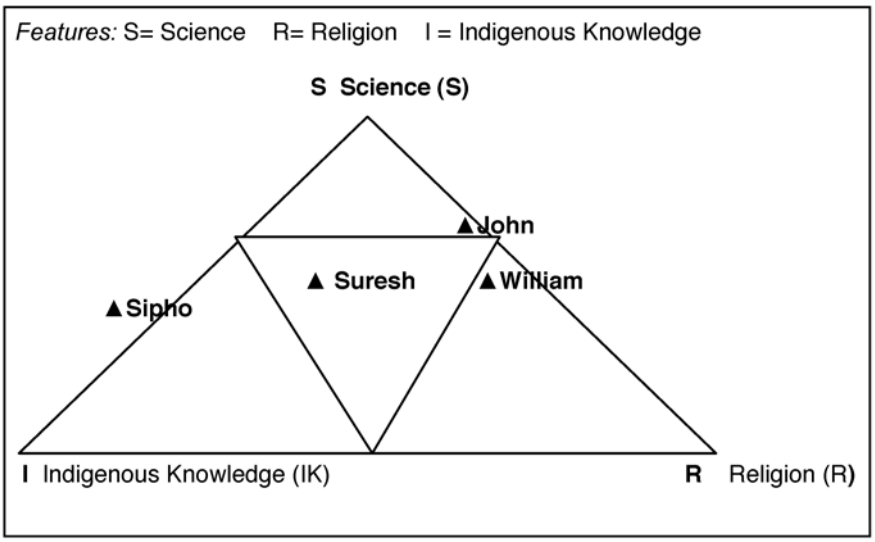


Figure 1 The Cultural Triangle

6. IMPLICATIONS

The above triangle can be used to plot teachers, students and learners cultural positions with regard to their cosmological views. As science teachers our goal is to get learners to or near the inner triangle and more towards science end where all three views reach equilibrium.

7. REFERENCES

Bryan, L.A. & Atwater, M.M. (2002) Teacher beliefs and cultural models: A challenge for science teacher preparation programs Science Teacher Education Volume 86 (6), 821 – 839.

Department of Education 2002. Revised National Curriculum Statement. Grades R-9 (Schools), Natural Sciences. Pretoria: Government Printer. Gazette No.; 23406. Vol 443, May 2002.

Department of Education 2003. National Curriculum Statement Grades 10-12 (Schools), Physical Sciences. Pretoria: Government Printer. Gazette: 2003

Govender, N. (2004). Physical Science educators' perceptions of the inclusion of astronomy and their conceptions in astronomy with regard to the new FET Physical Sciences curriculum in S.A. Poster presentation at ICPE/SAIP Internal Physics Education Conference held at University of KwaZulu-Natal, Durban, South Africa. On the 5-8 July. 2004.

Jegede, O.J and Okebukola, P.A.O. (1991). The effect of instruction on socio-cultural beliefs hindering the learning of science. Journal of Research in Science Teaching, Vol 28 (3), 275-285.

Jegede,O.J. & Aikenhead, G.S. (1999) - Transcending Cultural Borders: implications for science teaching. Research in Science & Technological Education, Vol. 17, No. 1, 1999, 45-66.

Manzini, S (2000). Learners' attitudes towards the teaching of indigenous African science as part of the school science curriculum. Journal of Southern African Association for Research in Mathematics, Technology and Science Education, Vol 4 (1), 19-32.

Ogunniyi, B.G. (2000). Teachers' and pupils' scientific and indigenous knowledge of natural phenomena. Journal of Southern African Association for Research in Mathematics, Technology and Science Education, Vol 4 (1), 70-77.

Phelan, P. Davidson, A.L. & Hanh Thanh Cao, T H. (1991). Students' Multiple Worlds: Negotiating the Boundaries of Family, Peer, and School Cultures. *Anthropology & Education Quarterly*, Vol. 22 (3), 224-250.

Tobin, K & LaMaster, SU. (1995). Relationships Between Metaphors, Beliefs, and Actions in a Context of Science Curriculum Change. Journal of Research in Science Teaching, 32 (3) 225-42.

Townsend, G. (2002). Culturally relevant college-level astronomy courses for non-science majors. Electronic Journal of Science, 6 (4), [Online]. Available: http://unr.edu/homepage/crowther/ejse (Accessed 20/11/2003).

8. ACKNOWLEDGEMENTS

The authors thank NRF-ThuThuka Grant-SA for funding this research.

USE ROOT CAUSE ANALYSIS TEACHING STRATEGY TO TRAIN PRIMARY PRE-SERVICE SCIENCE TEACHERS

Chow-Chin, Lu, Chun-Wei, Tsai, Jon-Chao Hong
National Taipei University of Education
134 He-Ping E. Rd., Sec. 2, Taipei, Taiwan, R. O. C.
E-mail: <luchowch@tea.ntue.edu.tw>

▼ Abstract

This study examined the Root Cause Analysis (RCA) Teaching Strategy on pre-service primary science teachers and instinct pre-service teachers to apply RCA Teaching Strategy to science curriculums. RCA Teaching Strategy is to coordinates 5Why Method and Fishbone Diagram. The participants included 18 pre-service primary science teachers and the training courses for 4 hours a week and lasted for 18 weeks. The result shows that pre-service primary science teachers are gradually familiar with RCA Teaching Strategy and can apply it to science curriculums from Microteaching Classroom Observation and Teaching-Portfolios. For example, in "The Influence of Heat on Materials" unit, fifth grade students observed the balloon on the PET bottle soaked in water swelled. Students would brainstorm all causes of balloon swelled with 5Why Method, and draw Fishbone Diagram together. Finally, they found the root cause with Root Cause Analysis.

Key Words Root Causes Analysis Teaching Strategy, Primary Pre-service Science Teachers, Microteaching.

1. INTRODUCTION

1.1 Rationale and Importance of this study

When United Nations Educational Scientific and Cultural Organization (1966) represented the "Recommendation Concerning the Status of Teachers", it mentioned, "Teaching should be seen as a professional career, a type of public service, and it also needed the professional knowledge and specific ability of teachers." Research about the teaching ability of professional teachers, Shulman (1986) stated the view of pedagogical content knowledge (PCK), including pedagogical content and teaching methods. He mentioned if a professional teacher owns the teaching ability, s/he would know how to transfer his or her understanding into the knowledge students realize. Allen and Ryan (1969) mentioned a training mode for improving teachers' teaching ability- Microteaching, which is applied to the professional development training of pre-service and in-service teachers. It provides them practice surroundings where reduce complicated factors in classrooms and increase a lot of feedback after teaching. Benton-Kupper (2001) stated pre-service teachers think that Microteaching was a perfect chance to attain pedagogical knowledge and skills, and there were more and

more evidences show that it was an effective method to promote teaching skills of pre-service teachers. Researchers further discovered that if we implement Microteaching in the science teaching of primary schools, accompanied the primary students' learning performances, teachers would solve tough problems of teaching through the reflection of using the teaching strategy.

1.2 Research Objectives

The study will educate pre-service teachers using "Root Cause Analysis (RCA) teaching strategy" in science curriculums. Through discussion of Microteaching with RCA teaching strategy and teaching in fifth grade of primary school, pre-service primary science teachers would promote their PCK ability. The research objectives are:

1. How is pre-service primary science teachers' application of RCA teaching strategy through Microteaching?
2. How is the relationship between primary students' learning effects in "The Influence of Heat on Materials" unit and pre-service primary science teachers' professional development?

2. LITERATURE OF REVIEW

2.1 Theory and Practice of Microteaching

Allen and Ryan (1969) proposed Microteaching was a specific mode of teacher training. The characteristic of Microteaching is to divide teaching techniques into small sections such as asking questions, reinforcement, and repeat, and it is a goal to only realize a small amount of sections when training. There are four steps of Microteaching: 1. Practicers are told certain techniques. 2. It is held the teaching of certain techniques in 5~20 minutes. 3. The instructor and practicers discuss the advantages and disadvantages when Microteaching. 4. Practicers teach again based on feedback of discussion (Allen,1967; Borg, Kelley, Langer, &Gall,1970).

To the view of Microteaching for pre-service teachers, Benton-Kupper (2001) summed up as follows: 1. It helps to confirm the advantages and disadvantages of teaching. 2. It provides chances to communicate with each other. 3. Watching recording would revise teaching techniques. 5. Practicers would produce intelligible thoughts when Microteaching. 6. Through kinds of Microteaching, practicers would learn many teaching strategies and thoughts.

2.2 The Ability of Pedagogical Content Knowledge (PCK) of Science Teachers

Shulman (1986) indicated PCK in accordance with the shortcomings that pedagogical knowledge and content knowledge were separated in America. Compared pedagogical knowledge of expert teachers with novice teachers, Shulman (1987) proposed seven categories of the teacher knowledge base: 1. Content knowledge. 2. General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter. 3. Curriculum knowledge, with particular grasp of the materials and programs that serve as "tools of the trade" for teachers. 4. Pedagogical content knowledge, that spe-

cial amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding. 5. Knowledge of learners and their characteristics. 6. Knowledge of educational contexts, ranging from the workings of the group or classroom, the governance and financing of school districts, to the character of communities and culture. 7. Knowledge of educational ends, purposes and values, and their philosophical and historical grounds.

Hong (2006) stated when we "confirm the reason" during problem solving process, we try to analyze by native, reliability, and consequence. In addition, the analysis method of consequence is 5Why Method. 5Why is proposed earliest by Taichi Ohno in Toyota Motor Company. In the company, they had used 5Why to deal with problems by asking "why" consistently (Yang, 2006). Lu, Hong and Tseng (2007) had designed inquiry-based learning curriculums through 5Why Scaffolding Guided Questioning. However, they found that students had difficulty to analyze the root causes of problems. It resulted from not finding a auxiliary means for students to display all possible causes.

2.3 Theory and Practice of Root Cause Analysis (RCA) Teaching Strategy

The objective of RCA is to identify "root cause(s)" so that these latent failures may eliminated or modified and future occurrences of similar problems or mishaps may be prevented (National Aeronautics and Space Administration [NASA], 2003). Some fire-fighting is carried out in order to handle and recover immediately. Since this expeditious approach deals with the patching up symptoms quickly, the problem seems temporarily solved. Over time, the problem is likely to recur, thereby eliminating or reducing the anomalous impact. The critical importance of is this prevention of recurring failures (Envision Software, 2003).

Hong (2006) stated when we "confirm the reason" during problem solving process, we try to analyze by native, reliability, and consequence. In addition, the analysis method of consequence is 5Why Method. 5Why is proposed earliest by Taichi Ohno in Toyota Motor Company. In the company, they had used 5Why to deal with problems by asking "why" consistently (Yang, 2006). Lu, Hong and Tseng (2007) had designed inquiry-based learning curriculums through 5Why Scaffolding Guided Questioning. However, they found that students had difficulty to analyze the root causes of problems. It resulted from not finding a auxiliary means for students to display all possible causes. To solve the problem like this, The Quality Assurance Project (2006) proposed that Cause-and-effect diagrams can reflect either causes that block the way to the desired state or helpful factors needed to reach the desired state, which named "Fishbone Diagram". The Fishbone Diagram helps teams to brainstorm about possible causes of a problem.

Above all, this study will develop pre-service teachers' application of RCA teaching strategy by Microteaching. And it emphasized that how re-service teachers attain PCK, curriculum knowledge, and knowledge of learner.

3. RESEARCH DESIGN

3.1 Research design and procedure

At first, we had pre-service teachers RCA teaching strategy training, including the theory and practice of RCA, 5Why teaching, Fishbone Diagram using, lesson plans

and learning sheets editing, and Microteaching. After that, we actualized Microteaching of "The Influence of Heat on Materials" unit, and the courses were altogether for 9 weeks. Finally, pre-service teachers taught in practice at a primary school in Taipei County. We analyzed the relationship between primary students' learning effects in "The Influence of Heat on Materials" unit and RCA teaching strategy of pre-service teachers.

3.2 Research Tools

3.2.1 Fishbone Diagram

We used "Fishbone Diagram" to assist learners finding the root causes of problems. The steps are: 1. The team agree on the problem or the undesired state and write specifically on the right of the paper, and draw a backbone from left to right side. 2. The team can gather data and brainstorm first about likely causes and fill them on the correct branches or sub-branches. 3. Keep asking "Why?" and "Why else?" for each cause until a potential root cause has been identified, maybe 4M (men, mechanism, materials, and methods) included. 4. Check the logic of the chain of causes and ensure that the answers to the "Why" questions are plausible explanations. 5. Generate solving strategy, and write it on the right side under the problem (NASA, 2003; The Quality Assurance Project, 2006).

3.2.2 Observation Records of Microteaching

The Observation Records of Microteaching was edited by Hong and Lu (2007) and includes conceptual communication and supportive communication. Conceptual communication includes RCA application, experiments demonstration, and teaching contents; supportive communication includes language expression, teaching aids, and learning sheets. It summed to 18 items and was approved from 3 professors of National University majored in science education of in content validity.

3.3 Participants

In this study, there are 18 primary pre-service science teachers of third grade at Department of Natural Science Education in a university of education in Northern Taiwan. They divided into six groups by themselves, and each group has three persons. Primary pre-service science teachers had own the ability of critical thinking and the knowledge of General Biology, General Physics, and General Chemistry.

3.4 Data Collection

Table 1 shows that the purposes and training curriculum of collecting each qualitative item. We collected data from Fishbone Diagram, Observation Records of Microteaching, and learning portfolio, and feedback list of teaching in practice. Then we did interpretive analysis and triangulation to summarize the results.

Table 1 The Purposes and Occasions of Qualitative Data in Training Courses

Data Collections	Purposes	Occasions
Fishbone Diagrams	Help teams to brainstorm about possible causes of a problem, and could be an auxiliary means of RCA teaching strategy.	1. Theory and practice curriculums 2. Microteaching 3. Teaching in practice in a primary school
Observation Records of Microteaching	Observe per-service teachers' promotion of conceptual communication and supportive communication	Microteaching
learning portfolio	Observe the reflection, thinking, and critique after teaching training.	1. Theory and practice curriculums 2. Microteaching 3. Teaching in practice in a primary school
feedback list of teaching in practice	Pre-service teachers discuss the effectiveness with instructor and peers after teaching in practice.	Teaching in practice in a primary school

4. RESULTS AND DISCUSSION

4.1 The effectiveness of using RCA Teaching Strategy through Microteaching

4.1.1 The learning effects of theory curriculums

In RCA Teaching Strategy course training, three teaching sessions and improvement of pre-service teachers and learning-portfolios are shown in Table 2.

Table 2 RCA Teaching Strategy of Learning-Portfolios

	First Learning-Portfolios	Second Learning-Portfolios	Third Learning-Portfolios
Acquire RCA concept	7 persons (39%)	16 persons (89%)	14 persons (78%)
Partially acquire	4 persons (22%)	2 persons (11%)	4 persons (22%)
Not acquire RCA concept	7 persons (39%)	0 persons (0%)	0 persons (0%)
Total	18 persons (100%)	18 persons (100%)	18 persons (100%)

Table 2 shows that for pre-service teachers to flexibly apply the teaching method, three teaching sessions were conducted. After that, they understand to design RCA teaching strategy. Result shows that finally 78% of pre-service teachers understood the spirit of "RCA teaching strategy" and were able to apply it in their teaching.

4.1.2 Applying RCA Teaching Strategy to primary science curriculum

RCA Teaching Strategy and self-designed course plan learning are showed in Table 3.

Table 3 Evidence of student thinking and RCA ability

RCA Teaching Strategy Learning Portfolio	RCA Teaching Strategy Classroom Discussion
S (majority): It is applicable in science teaching because the question and answer method best arouses students' curiosity, and the motive to learn. Students will practice to think with structuralized logics and the thinking modes also help cultivate students' feasible thoughts.	**S13:** In RCA teaching, do we must represent the results that are also interesting to students? **T:** Yes, the widespread application of RCA is in medical area, and it is usually used in accidental results in hospitals. When transferring it to apply in the teaching, we can also show the result first to attract students' concern, and then do RCA.

4.2 The relationship analysis between primary students' learning and pre-service teachers' professional development of PCK

4.2.1 Primary students' learning effects in "The Influence of Heat on Materials" unit Through RCA

We viewed Primary students' learning effects in "The Influence of Heat on Materials" unit Through Fishbone Diagram. We took the problem "Why did the balloon not swell when putting PET bottle in water?" for an example.

1. When student groups discussed the reasons with Fishbone Diagram, we found that certain of groups focused on the causes from balloons, and others focused on the size of PET bottle, the content of the bottle, or being heated of the bottle. Students could not consider each kind of aspects with great detail.
2. Teachers pasted the Fishbone Diagrams of those six groups, and students discussed more after seeing others' representations. Each group paid attention to the detail they didn't come out before.
3. Next, the class drew a complete Fishbone Diagram together under teacher's guidance. It shows in Figure. 1.

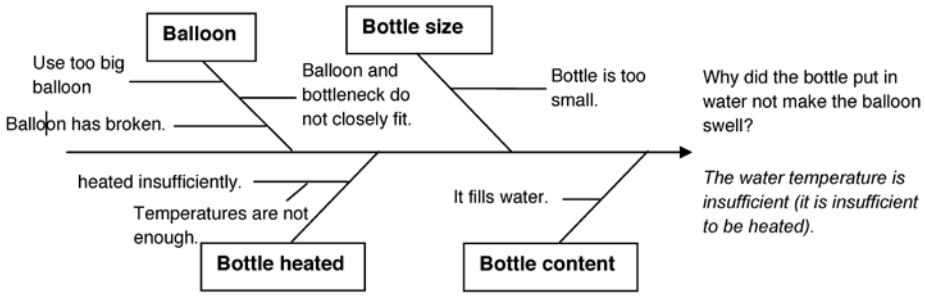


Figure 1 A Complete Fishbone Diagram under Teacher's Guidance

4. Finally, students use "Falisificationism" to determine the root cause. It is the water temperature that the bottle could not make the balloon swell.

4.2.2 Primary pre-service science teachers' professional development in PCK

4.2.2.1 Pedagogical content knowledge

When teaching in practice in a primary school, we found that teachers should guide students applying RCA to solve problems step by step although they were already fifth grade students. In 5Why asking, students would get used to teacher's questioning way. At first, students answered teacher's questions, and then students gradually asked questions and discussed each other. In instructing Fishbone Diagram, teacher gave group students a white paper so that they drew the Fishbone Diagram by themselves. However, students felt difficult and indecisive. In this situation, teacher tried to take problems of daily life for example. Teacher drew a backbone; guided students propose cause categories and filled them on the correct branches or sub-branches. After that, students considered every likely cause of each category. Finally, students could canvass and draw the Fishbone Diagram on their own, also find the root cause. So teachers' action research in Microteaching, we revised the steps as follows:

1. At first, teacher takes a problem of daily life for demonstration about how to apply Fishbone Diagram. Next, teacher draws the backbone and blanks which students should fill, and guide group students discuss step by step, filling the answers in those blanks.
2. After practicing several times, students will be familiar with Fishbone Diagrams.

4.2.2.2 Curriculum knowledge

From Observation Records of Microteaching, pre-science teachers ignored the using details of experimental materials and experimental skills. It resulted in failures or rough experiments, and teachers began to realize it through discussion in classroom and senior teachers' demonstration. Next, from learning portfolios, we found that pre-service teachers gradually chose the experimental materials suitable for students' levels and explained the details of using according to students' ability of experimental skills.

4.2.2.3 knowledge of learner

Through evaluating students' Fishbone Diagrams, pre-service teachers didn't notice the illogical parts in their Fishbone Diagrams. After group discussion, brainstorming, and other pre-service teachers' opinions, he/she had help students to focus on the reasonable and logical causes. The class listed all possible causes, and drew a complete Fishbone Diagram. Meanwhile, they thought about all likely causes by falsification so that students would develop their ability of causal thinking.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

After three teaching sessions of the theory curriculums were conducted, pre-service teachers could realize the characteristics of RCA teaching strategy and apply the teaching strategy to primary science curriculums. In students' learning effects

through RCA, we found that some groups couldn't think the whole causes thoroughly. Students finally complete the Fishbone Diagram under teacher's guidance. And in pre-service teacher's professional development after teaching in practice in a primary school, they have known that teachers should guide students applying RCA to solve problems step by step although they were already fifth grade students, and they learned to choose the experimental materials suitable for students' levels and explain the details of using according to students' ability of experimental skills.

In finding root cause process, students have learned to not believe those direct causes easily. This strategy can improve the shortcomings of only solving the single incident, tackling a problem on the surface but not at the root. It would train students to hold doubtful attitude of anything being seen at the moment, so it reduces the opportunity to judge the reasons by mistake. Also, students know that what data they missed before and what aspects they should reinforce in order that they can think completely. However, using RCA teaching strategy in class, teachers can only analyze and discuss to the single problem which should not be too complicated.

5.2 Implication

RCA teaching strategy is a method of finding out the root causes, and it develops students' habits of thinking all likely causes. On the one hand, teachers could apply the teaching strategy to other suitable units in science curriculums. In other hand, when selecting topics, teachers should consider that the cause kinds will not be too broad. Once the topics are too complicated, too many causes would let students out of focus. So, when teachers use RCA teaching strategy, they should think twice about choosing suitable problems for students.

6. REFERENCES

Allen, D., & Ryan, K. (1969). Microteaching. Readin, Massachusetts: Addison-Wesley.

Allen, D. (1967). Preface. In D. Allen (Ed.), Micro-teaching: A description. Palo Alto, CA: Standford University.

Benton-Kupper, J. (2001). The microteaching experience: Student perspectives. Education, 121(4), 830-835.

Borg, W. R., Kelly, M. L., Langer, P., & Gall, M. (1970). The Minicourse: A microteaching Approach to Teacher Training. Macmillan, London.

Envision Software, Inc. (2007). Root Cause Analysis. Retrieved September 27, 2007, from http://www.envisionsoftware.com/Management/Root_Cause_Analysis.htmlRoot Cause Analysis

Hong, J. C. (2006). A Study of Idea Searching as the Knowledge Creation Approaches on Chinese Eight Trigrams (Pa Gua). The 2006 ISPIM Conference in Athens, Greece on 11-14, June.

Lu, C. C., Hong, J. C., & Tseng, Y. C. (2007, May 28-30). The effectiveness of inquiry-based learning by scaffolding students to ask "5 Why" questions. Paper presented at Redesigning pedagogy 2007Conference, SCI 388, in National Institute of Education, Singapore.

National Aeronautics and Space Administration (NASA), Office of Safety & Mission Assurance. (2003, July).Root Cause Analysis Overview. Retrieved March 15, 2004, from http://www.hq.nasa.gov/office/codeq/rca/rootcauseppt.pdf

Shulman, L. S. (1986). Those who understand: Knowing growth in teaching. Educational Researcher, 15(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(l), 1-22.

The Quality Assurance Project (2006). Methods & tools, QA resources, cause-and-effect analysis. Retrieved August 8, 2007, from http://www.qaproject.org/methods/resc&e.html

UNESCO (1966). Recommendation Concerning the Status of Teachers. Record of the conference. UNESCO Statistic Report.

Yang, Y. F. (2006). Looks at the Domestic Enterprise From Toyota Motor Company.5Why. Retrieved August 29, 2006, from http://www.51made.com/zzxxh_show.asp?zid=638

7. ACKNOWLEDGEMENTS

We appreciated the funding supported from National Science Council, Taiwan, R.O.C. (NSC 95- 2511-S-152-003-MY3).

RELATIONSHIP BETWEEN TEST ANXIETY AND ACADAMIC ACHIEVEMENT: IMPACT ON HIGHER EDUCATION

Rizwan Akram Rana
Associate Professor
Institute of Education and Research,
University of the Punjab, Lahore, Pakistan
E-mail: drrarpu@gmail.com

▼ Abstract

The major purpose of the study was to explore the relationship between test anxiety and academic achievement of students at post graduate. A sample of 414 students was randomly selected from seven different science departments in a public sector university in Lahore, Pakistan. Pearson correlation and regression analysis were run for data analysis. It was found that there is a significant negative relationship exists between test anxiety scores and students' achievement scores. So is concluded that test anxiety is one the factor which is responsible for students' underachievement and low performance.

Key Words Test anxiety, Students' achievement, Higher education

1. INTRODUCTION

Higher education is viewed as a source of great potential for the socioeconomic and cultural development of the country. George (2006) discussed that "the last decade of the 20th century saw greater emphasis than ever before placed on higher education. In both developed and developing nations, higher education was believed to be the key to the continuing growth of national economies". Research literature indicates that colleges and universities can be extremely effective economic and social accelerators for both individuals and entire societies (Maoyuan, 2007; Zarycki, 2007; Leef, 2006;). Isani & Virk (2005) stated that through quality higher education, the nation can be transformed into a developed nation within the life of a single generation.

Tests and examinations at all stages of education and especially, at higher education level have been considered an important and powerful tool for decision making in our competitive society, with peoples of all ages being evaluated with respect to their achievement, skills and abilities. The era in which we live, is an era of test-conscious age in which the lives of many people are not only greatly influenced, but are also determined by their test performance. Test and examinations stress is thought to prevent some individuals from reaching their academic potential (Keogh, et al., 2004). In general, experts in this field are agreed that that most students in institutions of higher education conceive examination situations as threatening, and experiencing an increase in test anxiety (TA), which is, in fact, their transitory emotional state

(Spielberger, 1985) during (or just before the commencing of) tests, particularly in the natural science disciplines (Zoller & Ben-Chaim, 1989). As a result of this factor, test anxiety has become most upsetting and disorderly factor for students. It is one of the variables that most commonly accounted for students' underachievement and low performances at different levels of their educational life and has been shown to affect students' ability to profit from instruction. Several research studies indicated a significant but inverse relationship between test anxiety and students achievement (Putwain, 2007; Meijer, & Oostdam, 2007; Harrison, et al., 2006; Chapell et al., 2005; Cassady & Johnson, 2002; Diaz, 2001; Hanckock, 2001; Richards et al., 2000; Mclnerney & McInerney,& Marsh, 1997; Hagtvet & Benson, 1997; Goska & Ackerman, 1996; Mwamenda, 1994; Birenbaum & Nasser, 1994; Fincham, Hokoda, & Sandars, Jr., 1989; Humbree, 1988).

Berk & Nanda (2006), Chapell et al. (2005), Cassady & Johnson (2002), Diaz (2001), Hanckock (2001), Pintrich & Schunk (1996), Williams (1994) and several other researches (Humbree, 1988; Morris, Davis, & Hutchings, 1981; Depreeuw, 1984) have typically conceived of test anxiety as a bidimensional construct, with an affective and cognitive components. The affective dimension (emotionality) refers to behavioural or physical reactions to testing situations, such as fear, nervousness, and physical discomfort. These research studies indicated that high levels of emotionality dimensions of test anxiety are typical evident through physiological responses experienced during evaluative situations. The cognitive dimension (worry) refers to cognitive concerns about performance, such as worry about the testing situation or negative performance expectations. Bandlos, Yates, & Thorndike-Christ (1995), Keogh et al., (2004), Williams (1991), and Humbree (1981) discussed that cognitive aspect of test anxiety is the factor has been found to be significantly associated with declines in performance for adolescents and postsecondary students.

Several researchers explored the gender differences with respect to test anxiety and found that females have higher levels of overall test anxiety than males (Chapell et al., 2005; Cassady & Johnson, 2002; Bandalos et al., 1995; Mwamwenda, 1994). One explanation for the gender differences in test anxiety is that males and females experience similar levels of test worry, but females have higher levels of emotionality (Cassady & Johnson, 2002). Zeidner (1990) on the basis of his research concluded that difference in males and females levels of test anxiety is due to gender difference in scholastic ability. Keeping in view the above discussion, the present study was conducted to achieve the following objectives.

2. OBJECTIVE OF THE STUDY

The study was aimed to:

1. Determine the relationship between the Test Anxiety total scale scores and academic achievement scores of students in different science subjects.
2. Determine the relationship between the Test Anxiety Emotional scale scores and academic achievement scores of students in different science subjects.
3. Determine the relationship between the Test Anxiety Worry scale scores and academic achievement scores of students in different science subjects.

3. HYPOTHESES OF THE STUDY

Hypotheses of the study were:

H_{O1}: There is no significant relationship between students achievement score and test anxiety total scale scores.

H_{O2}: There is no significant relationship between students' achievement scores and test anxiety emotional scale scores.

H_{O3}: There is no significant relationship between students' achievement scores and test anxiety worry scale scores.

4. RESEARCH METHODOLOGY

A description of research methodology is described below.

4.1. Sample

The sample of the study was comprised of 414 randomly selected post graduate students (Male = 116, Female = 298) from seven different departments of a public sector university in Lahore, Pakistan. The detail is given below in table 1.

Table 1 Detail of sample of the study

S. No.	Department	Number of Students	
		Male	Female
1.	Mathematics	16	54
2.	Physics	36	26
3.	Statistics	22	80
4.	Geology	24	02
5.	Zoology	0	69
6.	Environmental Sciences	8	20
7.	Science Education	10	47
Total		116	298

4.2. Research Instrument

To measure the test anxiety of the students studying at post graduate level, Test Anxiety Inventory (TAI) developed by Spielberger (1980) was used. This scale comprised of 20 Likert Scale type items. The scale is further divided into two subscales: Worry Scale (8 items) and Emotional Scale (8 items). The Cronbach Alpha for total scale was 0.868 whereas, the reliability of emotional scale items was 0.767 and worry scale items was 0.720.

To collect information about demographic variables, Demographic Variables Information Proforma was developed by the researcher. It comprised of information regarding student's gender, department, semester and their achievement scores (Achiement scores were verified by the officials of concerned departments).

4.3. Analysis and Interpretation of Data

Data were collected personally from each student and analyzed by using SPSS-15 Software Package. The results of Pearson Correlation indicate that hypotheses of the study were rejected at $p \leq 0.05$ level of significance. Table 2 shows the results.

Table 2 Relationship between students' achievement scores and scores on test anxiety scale (Total scale, Worry Scale and Emotional scale)

Aspect	N	Pearson r	Significance
Total scale scores and achievement scores	414	- 0.653	.000
Worry scale scores and achievement scores	414	- 0.694	.000
Emotional scale scores and achievement scores	414	- 0.663	.000

It is evident from table 2 that there is strong negative and significant relationship exists between students' achievement scores and Total scale scores and also on subscales scores. The strong values of correlation coefficient lead to further analysis of data, so it was decided to run Regression analysis to explore cause effect relationship between achievement scores and test anxiety scale scores. The result is given in table 3.

Table 3 Regression analysis

Model	β	t-value	Significance	Model R square
Total anxiety scale scores	-.251	-. 6.700	.000	0.535
Worry scale scores	-.697	- 4.160	.000	
Emotional scale scores	-.140	-. 890	.374	

Table 3 shows that 53% variance was explained by the regression model which shows that test anxiety effects students achievement. It is further evident from table worry scales scores are the major contributor with respect to difference in students' achievement scores.

5. CONCLUSION AND DISCUSSION

On the basis of results of Pearson r and regression analysis, it is concluded that test anxiety is one of the cause for underachievement and low performances in different science subjects at post graduate level. These results are consistent with the findings of Chapell et al. (2005); Cassady & Johnson (2002) and Birenbaum & Nasser (1994) by indicating that cognitive dimension (worry) of test anxiety was far more influential on students' achievement than emotionality. The outcome of this study calls for some intervention strategies on the part of faculty members to overcome/reduces academic stress and test anxiety among students of higher educational institutions. Erbe (2007), Berk & Nanda (2006), Stober (2004), Haris & Coy (2003), Foster, Paulk, & Dastoor (1999), Kondo (1996), and Serok (1991) discussed various measures and strategies which can be applied by faculty members to reduce test anxiety among their students. These are described in the form of list: (i) Task orientation and preparation; (ii) Posi-

tive thinking; (iii) Seeking social support; (iv) Avoidance; (v) Relaxation training; (vi) Coaching/ Guided imagery; (vii) Self instructional training; (viii) Establishing purpose; (ix) Affirmation; (x) Modalities; (xi) Positive Anchors; (xii) Mental simulations; (xiii) Use of humor; (xiv) Preparation of cheat sheet; and (xv) Study skills training.

To summarize this discussion, it is concluded that we live in a test-taking society and when students are anxious pre and during tests, test anxiety has significant and effective impact on their performance. To effectively manage test anxiety, students can be helped by teachers, parents and educational administrators by use of cognitive, affective and behavioral strategies. It is further suggested that the students should be fully informed about the nature of courses, duration of semester, and level of commitment for successful completion of course by the faculty and administration of departments. The students with higher test anxiety must be identified and treated in order to increase their academic achievement.

6. REFERENCES

Bandalos, D.L., Yates, K., & Thorndike-Christ, T. (1995). Effect of math self-concept, perceived self-efficacy, and attribution for failure and success on test anxiety. *Journal of Educational Psychology, 11*, 351-360.

Berk, R.A. & Nanda, J. (2006). A randomized trial of humor effects on test anxiety and test performance. *Humor: International Journal of Human Research*, 19 (4), 425-454.

Berk, R.A. (2000). Does humor in course tests reduce anxiety and improve performance? *College Teaching, 48* (4), 151-58.

Birenbaum, M., & Nasser, F. (1994). On the relationship between test anxiety and test performance. *Measurement and Evaluation in Counselling and Development, 27*(1), 293-301.

Cassady, J.C., & Johnson, R.E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology, 27*, 270-295.

Chapell, M.S., Blanding, Z.B., Takahashi, M., Silverstein, M.E., Newman, B., Gubi, A., & mccann, N. (2005). Test anxiety and academic performance in undergraduate and graduate students. *Journal of Educational Psychology, 97* (2), 268-274.

Erbe, B. (2007). Reducing test anxiety while increasing learning. *College Teaching, 55* (3), 96-97.

Foster, S. K., Paulk, A., & Dastoor, B. R. (1999). Can we really teach test-taking skills? *New Horizons in Adult Education, 13* (1), 4-12.

George, E.S. (2006). Positioning higher education for the knowledge based economy. *Higher Education, 52* (4), 589-610.

Goska, R.E., & Ackerman, P.L. (1996). The aptitude-treatment interaction approach to transfer within training. Journal of Educational Psychology, 88 (2), 249-260.

Fincham, F.D., Hokoda, A., & Sanders, R. Jr. (1989). Learned helplessness, test anxiety, and academic achievement: A longitudinal analysis. *Child Development, 60*, 138-145.

Hagtvet, k.A., & Benson, J. (1997). The motives to avoid failure and test anxiety responses: Empirical support for integration of two research traditions. *Anxiety, Stress and Coping, 10*, 35-57.

Hancock, D.R. (2001). Effect of test anxiety and evaluative threats on students' achievement and motivation. *The Journal of Educational Research, 94* (5), 284-290.

Haris, H. L., & Coy, D. R. (2003). Helping students cope with test anxiety. *ERIC Digest.* (ERIC Document Reproduction Service No. ED 479355). Retrieved June 25, 20008 from a World Wide Web: http://www.ericdigest.org/2005-2/anxity.html

Harrison, L.A., Stevens, C.M., Monty, A.N., & Coakley, C.A. (2006). The consequences of stereotype threat on the academic performance of white and non-white lower income college students. *Social Psychology of Education, 9*, 341-357.

Hembree, R. (1988). Correlates, causes, effects, and treatment of test anxiety. *Review of Educational Research, 58* (1), 47-77.

Hopko, D.R., Crittendon, J.A., Grant, E., & Wilson, S.A. (2005). The impact of anxiety on performance IQ. *Anxiety, Stress and Coping, 18*(1), 17-35.

Isani, UAG., & Virk, M.L. (2005). *Higher education in Pakistan.* Islamabad: National Book Foundation.

Kondo, D. S. (1996). Strategies for coping with test anxiety. *Anxiety, Stress and Coping, 10*, 203-215.

Leef, G.C. (2006). The overselling of higher education. *Academic Questions, 19* (2), 17-34.

Maoyuan, P. (2007). We must start up scientific research in higher education: My humble opinion on the establishment of higher education as a discipline. *Chinese Education and Society, 40* (3), 27-44.

Meijer, J., & Oostdam, R. (2007). Test anxiety and intelligence testing: A closer examination of the stage-fright hypothesis and influence of stressful instruction. *Anxiety, Stress and Coping, 20* (1), 77-91.

Morris, L.W., Davis, M.A., & Hutchings, C.J. (1981). Cognitive and emotional components of anxiety: Literature review and a revised worry-emotionality scale. *Journal of Educational Psychology, 73*, 541-555.

Mwamwenda, T.S. (1994). Gender differences in scores on test anxiety and academic achievement among South African University graduate students. South African Journal of Psychology, 24 (4),

Orpen, C. (1996). The interactive effects of social support and test anxiety on students academic performance. *College Student Journal, 116*, (30), 464-465.

Pintrich, P.R., & Schunk, D. (1996). *Motivation in education: Theory, research, and applications*. Upper Saddle River, NJ: Erlbaum.

Putwain, D. (2007). Researching academic stress and anxiety in students: some methodological considerations. *British Educational Research Journal, 33*(2), 207-219.

Richards, A., French, C.C., Keogh, E., & Carter, C. (2000). Test anxiety, inferential reasoning and working memory load. *Anxiety, Stress and Coping, 3* (1), 87-109.

Serok, S. (1991). The application of Gestalt methods for the reduction of test anxiety in students. *Assessment and Evaluation in Higher Education, 16* (2), 157-64.

Spangler, G., Pekrun, R., Kramer, K., & Hofmann, H. (2002). Students' emotions, psychological reactions, and coping in academic examinations. *Anxiety, Stress and Coping, 15* (4), 413-432.

Spielberger, C. (1985). Assessment of state and trait anxiety: Conceptual and methodological issues. *The Southern Psychologist, 2,* 6-16.

Spielberger, C. (1980). *Test anxiety inventory: Preliminary professional manual*. Palo Alto, CA: Consulting Psychologist Press.

Stober, J. (2004). Dimensions of test anxiety: Relations to ways of coping with pre-exam anxiety and uncertainty. *Anxiety, Stress and Coping, 17* (3), 213-226.

Veenman, M.V.J., Kerseboom, L., Imthorn, C. (2000). Test anxiety and meta-cognitive skilfulness: Availability versus production deficiencies. *Anxiety, Stress and Coping, 13* (4), 391-412.

Williams, J.E. (1994). Anxiety measurement: Construct validity and test performance. *Measurement & Evaluation in Counseling & Development, 27* (1),

Zarycki, T. (2007). Cultural capital and the accessibility of higher education. *Russian Education and Society, 49* (7), 41-72.

Zeidner, M. (1990). Does test anxiety bias scholastic aptitude test performance by gender and sociocultural group? *Journal of Personality Assessment, 55*, 145-160.

Zoller, U., & Ben-Chaim, D. (1989). Interaction between examination type, anxiety state, and academic achievement in college science: an action-oriented research. *Journal of Research in Science Teaching,* 26(1), 65-77.

ACKNOWLEDGEMENT

I would like to thank Higher Education Commission (HEC), Government of Pakistan for providing full support and funding to conduct this research study.

QUALITATIVE TOOL FOR ASSESSING STUDENTS' ARGUMENTATION SKILLS IN NINTH-GRADE SCIENCE CLASSES

Anne Laius, Maili Petersen, Miia Rannikmäe
University of Tartu
anne.laius@ut.ee, maili.petersen@gmail.com, miia.rannikmae@ut.ee

▼ Abstract

The current research investigates the influence of social issue-based teaching in science classes on ninth-grade students' reasoning and argumentation skills. This paper reports on a methodological approach to the analysis of argumentation skills in Estonian primary school science classes developed as part of teachers' in-service courses. The sample was formed from 151 ninth-grade students from six schools. For analysing students' argumentation skills and reasoning patterns, a real-life situation was created with ties to scientific and social concepts. The results revealed that it is possible to define three different patterns of students' argumentation according to the way of beginning the argumentation. Also other characteristics have differential value: the number, quality and creative component of arguments. The research revealed that students have problems recognising the scientific nature when facing a socio-scientific problem and the students' use of scientific language is quite poor and the majority of students prefer to use everyday language.

Key Words argumentation, socio-scientific issues

1. INTRODUCTION

A primary objective for science education is to acquire knowledge that has applicability to socio-scientific problems. Sadler *et al.* (2006) have argued that if scientific literacy represents the ultimate aim of science education, then scientific literacy must entail the ability to thoughtfully negotiate socio-scientific issues (SSI). The term "socio-scientific issues" has come to represent controversial social issues with conceptual, procedural, or technological ties to science. SSI are typically contentious and ill-structured, which implies that they are open-ended problems subject to multiple perspectives and solutions. Socio-scientific issues have become important in science education because they occupy a central role in the promotion of scientific literacy (Sadler & Donnelly, 2006). The processes through which individuals access, negotiate and attempt to resolve SSI has been referred to as informal reasoning (Zohar & Nemet, 2002; Sadler, 2004).

In a broader context, informal reasoning describes how people think about open-ended, ill-structured problems, which are typically contentious and subject to multi-

ple perspectives and solutions (Means & Voss, 1996). SSI represents precisely the kind of ill-structured, complex and controversial issues to which informal reasoning can be applied. Argumentation, as a construct, has been characterized by a multiplicity of descriptions including oppositional interchanges, verbal expression of conflict resolution, consensus building, justification of controversial positions, social reasoning, and persuasion (Voss & Van Dyke, 2001). There is an obvious association between informal reasoning and argumentation. Informal reasoning represents the cognitive and affective processes undertaken by an individual as s/he considers ill-structured problems; whereas, argumentation represents the social negotiation of ill-structured problems. Argumentation is, at least in part, the expression of informal reasoning (Driver *et al*., 2000).

Over the past few decades numerous studies have focused on the analysis of argumentation discourse in educational contexts (Driver *et al*., 2000; Duschl & Osborne, 2002; Kelly & Takao, 2002; Schwarz *et al*., 2003; Katzav & Reed, 2004). Drawing on sociological and philosophical studies of science, science educators have begun to view argumentation as a central scientific practice, which students should learn (Sandoval & Millwood, 2005). Socio-scientific problems are common in everyday life and to solve them one needs to use scientific knowledge to reason.

There have been several studies within science education on characteristics of students "argumentation patterns of socio-scientific issues, most of them focusing on the role of scientific knowledge in the students" argumentation (Yang & Anderson, 2003; Sadler & Zeidler, 2004; 2005a,b; Kolstø, 2006).

The goal of this research was to develop a qualitative assessment tool for evaluation of students' reasoning and argumentation skills. Considering this goal, the following research questions have been put forward:

1. Does the manner, in which a student begins an argumentation, influence the quality of the argumentation?
2. What characteristics can be effectively used to describe the argumentation skills of students?
3. How does the use of language impact on the quality of argumentation?
4. Do the argumentation skills differ between boys and girls?

This paper reports a qualitative study on students' argumentation on a socio-scientific issue about the smell of smoke. The focus of the study is on the different characteristics of reasoning that could be used to describe qualitatively students' argumentation skills in the socio-scientific real-life situation.

2. METHODOLOGY

2.1. Sample

The sample for the current research was formed from 151 (73 boys and 78 girls) nine-grade students in 6 different Estonian primary and secondary schools. The schools were chosen based on science teachers (biology and/or chemistry) who participated in a schoolteachers' in-service course "The Development of Students' Critical and Creative Thinking Skills through Real-life Socio-scientific Situations" in the 2005/2006

school year. The instrument assessing the quality of argumentation skills was fulfilled during chemistry lessons. Schools did not assess responses.

2.2. Instrument

To analyse students' argumentation skills a real-life situation was created with ties to scientific (absorption, smell and olfactory organs, senses etc) and social (smoking as risk behaviour and ethics) concepts. The situation is given below:

Two boys were late for their class. They were chewing bubble gum. One of the boys smelt of smoke. The teacher suspected the boys had been smoking and wanted them to leave the class, as the smell of smoke is not healthful to the other students. The boys argued that they had been in a café eating French fries and that the smell of smoke comes from there. Their classmates tried to protect them and convinced teacher to allow them to join the lesson.

All students were given the task to write their reasons whether the boys were telling the truth if not, and what the boys might have been doing. The class asked to reason was why one of the boys smelt of smoke yet the other was not.

Science teachers validated this instrument during the in-service course. 34 nine-grade students' in one randomly chosen secondary school piloted the instrument.

3. RESULTS AND DISCUSSION

To analyse the students' argumentation skills, a series of characteristics were identified after reading students answers. Those characteristics were considered for finding the patterns of students' reasoning skills.

The following 5 characteristics were determined:

1.1. Total number of arguments given by students as quantitative measure

Table 1 indicates the number of arguments put forward by boys and girls, as well as overall. The number of arguments was taken as indicative of a level and this is also recorded in column 2 of table 1. As seen from Table 1, the majority of students (60%) are at the lowest quantitative level of reasoning. The quantitative level of boys' argumentation is lower than girls' as almost two thirds of boys (66%) belong to the lowest level (I) of argumentation whereas almost half of girls (46%) belong to the II and III level of argumentation.

Table 1 Number of arguments put forward by students

Number of arguments	Level	Total number (%) of students	Girls	Boys
0 – 2 arguments	I	90 (60%)	42 (54%)	48 (66%)
3 – 4 arguments	II	41 (27%)	25 (32%)	16 (22%)
5 or more arguments	III	20 (13%)	11 (14%)	9 (12%)

1.2. Points were awarded depending on the quality of the argument.

According to Table 2, only less than one third of students can reason well with sufficient argumentation and without mistakes of logic.

Table 2 Quality of arguments

Description	Level	Total number (%) of students	Girls	Boys
Presence of contradictions and/or mistakes in logic and/or very poor argumentation (for example 1 or 2 statements but nothing is reasoned)	I	26 (17%)	8 (10%)	18 (25%)
Presence of some contradictions in argumentation and/or some mistakes in logic	II	81 (54%)	46 (60%)	35 (48 %)
Adjoint and well reasoned text with sufficient argumentation	III	44 (29%)	24 (30%)	20 (27%)

1.3.Creative component – the level is depending on how many different versions students were able to come up with

As seen from Table 3, only less than a quarter of students are creative and the number of boys who are on the lowest level of creative component of argumentation is considerably bigger than the number of girls.

Table 3 Creative component of arguments

Description	Level	Total number (%) of students	Girls	Boys
One version (for example: Kalle was smoking but Rein was not)	I	74 (49%)	32 (41%)	42 (57%)
Two different versions (for example: Kalle was smoking but Rein was not, Rein and Kalle both were smoking)	II	42 (28%)	26 (33%)	16 (22%)
Three or more different versions (for example: Kalle was smoking but Rein was not, Rein and Kalle both were smoking, Kalle was smoking but Rein was not etc.)	III	35 (23%)	20 (26%)	15 (21 %)

1.4. The use of language

The use of language shows scientific component of students' argumentation. The Table 4 reveals that the majority of students (63%) use everyday language and only 5% of students use scientific language while arguing over a socio-scientific issue.

Table 4 The use of language

Language	Description	Total number of students (%)	Mean number of arguments
Meta-meta language	The most connected with science. It expects use of language that is connected with science (for example: scent molecules got into teacher's olfactory cells).	7 (5%)	2,0
Meta-object language	Presumes some kind of scientific thinking (for example: scent adheres to clothes).	47 (32%)	2,2
Object-object language	Use of everyday language and is not connected with science (for example: the boys were smoking and got caught while smoking and stink stacked).	95 (63%)	2,1

5.5. The beginning of argumentation.

In Table 5 there is given the number of boys and girls in three groups, categorised on the basis of how the students began their argumentation and descriptions of these groups. The greatest number of students (47%, from girls even 55%) were classified into the hypothetical group of argumentation, followed by the judgmental and procedural groups. Only very few girls (9%) began their argumentation from procedural point of view.

Table 5 The beginning of argumentation

		N=151		
Group	Description of the group	Total number (%) of students	Boys (N=73)	Girls (N=78)
Judgmental	Student begins one's response by giving personal evaluation to the situation. e.g. Kalle was just smoking and Rein was not and that is it / They lied to the teacher about going to the café.	50 (33%)	22 (30%)	28 (36%)
Hypothetical	Student begins one's response by assuming what might have happened. e.g. They maybe met in front of the school / Rein and Kalle maybe went to the café, but sat in different places.	71 (47%)	28 (38%)	43 (55%)
Procedural	Student's attention is focused on actions that caused the situation. e.g. Kalle went along with Rein to smoke /Rein went smoking and Kalle went with him.	30 (20%)	23 (32%)	7 (9%)

Dividing the students into the groups on the basis of how they began their argumentation, proved to be efficient because this method drew out the best patterns within the three groups (Figure 1). According to Chi-Square analysis the groups are statistically different on the basis of number of arguments ($\chi 2 = 27{,}99$; $df = 12$; $p < 0.006$), the quality of argumentation ($\chi 2 = 18{,}93$; $df = 4$; $p < 0.001$) and creative component ($\chi 2 = 10{,}95$; $df = 4$; $p < 0.027$).

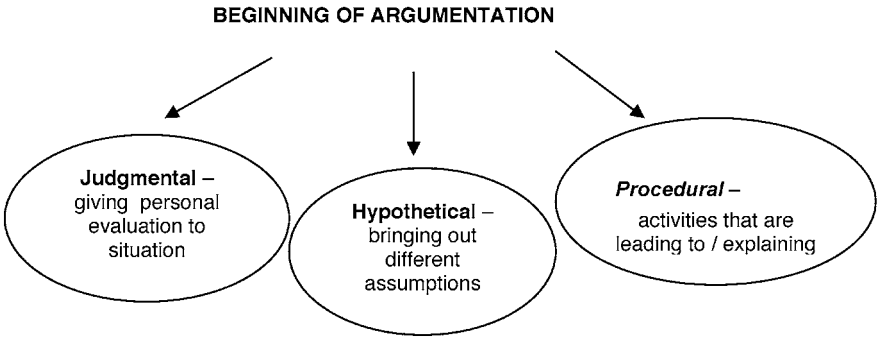


Figure 1 Three groups of students' argumentation

The students' argumentation groups differed within the estimated characteristics and if the beginning of argumentation is defined, it is possible to expect certain results of test (Table 6).

There were found correlations between the number and quality of arguments ($r = 0{,}290$, $p < 0{,}0001$); between the number of arguments and creative component of argumentation ($r = 0{,}252$, $p < 0{,}002$).

Table 6 Comparison of characteristics describing the three groups

Characteristics estimated	Judgmental group N=50	Hypothetical group N=71	Procedural group N=30
Number of arguments	1,4	1,7	1,2
Quality of arguments	2,2	2,1	2,2
Creative component	1,7	1,9	1,4
Use of language:			
meta-meta language	3%	5%	6%
meta-object language	30%	35%	25%
object-object language	67%	60%	69%

The description and proportion of the estimated groups is following:

Judgmental group. This is the second largest group. Number of boys and girls is rather equal in this group. For the judgmental group of students it was characteristic to use everyday language and in the focus there was purely a social problem. All characteristics of this group are mostly middle.

Hypothetical group. Most of the students belong to this group. Girls form a remarkable majority of this group. According to the number of arguments, creative component of argumentation and the least use of everyday language, it is the best group of students. The quality of argumentation and the use of scientific language were in the middle, compared to the other groups.

Procedural group. The least number of students gave responses belonging to this group, and then considerably more boys than girls. This group is described by the best comprehension of problems of a scientific nature. By number and creative component of arguments it appears to be the group with the weakest results. At the same time both *meta-meta* language (which indicates a scientific approach) and *object-object* language (which indicates the use of everyday language) are used more frequently compared to the other groups.

3.6. Scientific and social component of students' argumentation

When students are fronting a real-life situation with socio-scientific context, they often miss noticing the scientific background. In this study the use of scientific knowledge differed between the schools but in general was relatively low.

The most used arguments that were put forward, connected with the scientific explanation, were the following:

The wind blew scent molecules away/ to the other boy.

One of the boys was using a perfume.
Smell stays in different materials differently.

One of the boys was chewing gum

The rarest examples of statements brought by only one or 2 students:

Olfactory cells had gotten used to smell.

Cells of smell of smoke had dissolved in teacher's nose and stayed there of some time.

Particles of smell of smoke that entered teacher's nostrils got stuck to mucous membrane.

The judgmental approach to argumentation tends to be tightly connected with the use of everyday language and solving only the social aspects of the problem.

The number of arguments is connected to how the students begin their argumentation. When students begin the argumentation with a hypothetical argument, it promotes the bringing out several arguments to reason this concrete topic. It means that the more arguments were put forward by the students, the greater the number of different aspects was considered and the better and more creative results were obtained. The biggest variation appeared in the procedural group.

It became clear that the creative component (the number of versions) was not connected to how the argumentation was started. It appeared that in some schools, students tried to put forward as many different versions as possible. In another school they wrote only one statement and that was all. From that kind of information it is impossible to conclude that some students were more or less creative – this rather

indicates how the students have been taught to approach the given kind of problems. The number and quality of arguments was not often connected – several times it appeared that student started concentrating on quantity not quality. One wrote several statements what may have happened but did not reason why that kind of situation might have been the case.

From use of language it was obvious that all students preferred to use *object-object* language and use *meta-meta* language the least. *Meta-meta* language and terms connected to science (for example scent molecules, olfactory cell etc.) were used very seldom.

4. CONCLUSIONS

The results of current research revealed that it is possible to define three different patterns of students' reasoning (judgmental, hypothetical and procedural) and the important characteristic is the way of students' beginning of argumentation. The number and quality of arguments and the creative component of argumentation statistically differentiate these groups.

In the schools observed, students' argumentation skills were relatively low. It varied within different schools but all students had problems of recognising the scientific nature when facing a socio-scientific problem. Also the use of scientific language was very poor and the majority of students used only everyday language. With some exceptions, it is possible to predict how well a student continues reasoning by the beginning of argumentation. The effective characteristics (number, quality and creative component of arguments, use of language and the beginning of argumentation) were determined for describing qualitatively the student's argumentation skills.

It also occurred in this study that boys and girls use different argumentation patterns. Boys use more scientific language and recognize the scientific nature of socio-scientific problems better. Boys are also more action orientated than girls. Girls on the other hand, bring more arguments and the quality of their answers in general is higher.

According to the results of current research it seems that there is lack of integration between the different scientific subjects in Estonian school. Although the students made use of a range of both scientific and non-scientific knowledge, the students' seem to have difficulties associating science and real-life and therefore they use scientific explanations to solve socio-scientific problems seldom. Most of the participants of current research perceived the used real-life situation as a social problem.

Consequently, the developed qualitative assessment tool was effective for the evaluation of students' argumentation skills.

REFERENCES

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of argumentation in classrooms. *Science Education*, 84(3), 287–312.

Duschl, R., & Osborne, J. (2002). Supporting and promoting argumentation discourse. *Studies in Science Education*, 38, 39–72.

Kelly, G., & Takao, A. (2002). Epistemic levels in argument: An analysis of university oceanography students' use of evidence in writing. *Science Education*, 86(3), 314–342.

Katzav, J., & Reed, C.A. (2004). On Argumentation Schemes and the Natural Classification of Arguments. *Argumentation,* 18 (2), 239–259.

Kolstø, S.T. (2006). Patterns in Students' Argumentation Confronted with a Risk-focused Socio-scientific Issue. *International Journal of Science Education*, 28, (14), 1689–1716.

Means, M. L., & Voss, J. F. (1996). Who reasons well? Two studies of informal reasoning among children of different grade, ability, and knowledge levels. Cognition and Instruction, 14, 139–178.

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of the literature. *Journal of Research in Science Teaching,* 41, 513–536.

Sadler, T.D., Amirshokoohi, A., Kazempour, M., & Allspaw, K.M. (2006). Socioscience and Ethics in Science Classrooms: Teacher Perspectives and Strategies. *Journal of research in science teaching*, 43(4), 353–376.

Sadler, T.D., & Donnelly, L.A. (2006). Socioscientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education*, 28(12), 1463–1488.

Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, 88(1), 4–27.

Sadler, T. D., & Zeidler, D. L. (2005a). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching*, 42(1), 112–138.

Sadler, T. D., & Zeidler, D. L. (2005b). The significance of content knowledge for informal reasoning regarding socioscientific issues: Applying genetics knowledge to genetic engineering issues. *Science Education*, 85, 71–93.

Sandoval, W.A., & Millwood, K.A. (2005). The Quality of Students' Use of Evidence in Written Scientific Explanations. *Cognition and instruction*, 23(1), 23–55.

Schwarz, B. B., Neuman, Y., Gil, J., & Ilya, M. (2003). Construction of collective and individual knowledge in argumentation activity. *Journal of the Learning Sciences*, 12(2), 219–256.

Voss, J. F., & Van Dyke, J. A. (2001). Argumentation in psychology: Background comments. *Discourse Processes*, 32, 89–11.

Yang, F.-Y., & Anderson, O. R. (2003). Senior high school students' preference and reasoning modes about nuclear energy use. *International Journal of Science Education*, 25(2), 221–244.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching,* 39, 35–62.

ACKNOWLEDGEMENTS

This study was supported by the Estonian Ministry of Science and Education grant No. TBGBGB 2529.

PISA: POLITICS OR PEDAGOGY? A CRITIQUE OF THE OECD INTERNATIONAL TEST REGIME AND ITS IMPLICATIONS

Svein Sjøberg
Dept of Teacher Training and school development, Oslo University
PO Box 1099, Blindern, 0316 Oslo, Norway
E-mail: <svein.sjoberg@ils.uio.no>

Abstract

The PISA (Programme for International Student Assessment) project, run by the OECD (Organization for Economic Cooperation and Development), sets the educational agenda internationally as well as within the 60 participating countries. PISA results and advice are often considered by politicians, bureaucrats and the press as objective and value-free scientific truths, while they are, in fact, embedded in the overall political and economic aims and priorities of the OECD: economic growth and development in a global free market economy based on competition.

Through media coverage PISA results create the public perception of the quality of a country's overall school system, often to the neglect of national curricula and national aims, values and politically agreed purposes of the education system. In this sense, the "expert advice" from the PISA experts overrules democratically agreed national priorities about values, meanings and purposes of the school system.

After the publication of three rounds of PISA testing (2000, 2003 and 2006), one can see that PISA results are indeed used for policy purposes in most of the countries involved. I will provide examples to illustrate this claim.

In this paper, I will raise critical points about the PISA "test industry" from several perspectives; cultural, educational and political. The main point of view is that the PISA ambitions of testing "real-life skills and competencies in authentic contexts" are by definition impossible to achieve. By PISA testing, OECD also indirectly acts in a normative way; telling national education authorities what is important, and not important, in their national curricula. This constitutes a narrowing down of educational aims, and a neglect of the subjects as well as the value dimensions that are not part of the PISA testing regime.

Key Words Policy, comparative studies, assessment, PISA/OECD

1. INTRODUCTION

The international student testing programme PISA (Programme for International Students Assessment) is of the highest importance for educators all over the world. It

is financed by ministries and governments in the 60 participating countries, and it is organized and run by the OECD (Organization for Economic Cooperation and development). The project has as its main aim to provide information that may be used for policy purposes in the participating countries. PISA may be compared to "Big Science" of the natural sciences: PISA costs millions of dollars, involves hundreds of researchers, thousands of teachers and schools and half a million of students through the two hour testing.

After the publication of three rounds of PISA testing (2000, 2003 and 2006), one can see that PISA results are indeed used for policy purposes in most of the countries involved. I will provide examples to illustrate this claim.

The PISA project has positive as well as more problematic aspects, and it is important for educators and researchers to engage in critical public debates on this utterly important project, including its uses and misuses. Through media coverage PISA results create the public perception of the quality of a country's overall school system. The lack of critical voices from academics as well as from media gives authority to the images that are presented.

In this paper, based on a recent book chapter (Sjøberg, 2007) I will raise critical points from several perspectives. The main point of view is that the PISA ambitions of testing "real-life skills and competencies in authentic contexts" are by definition alone impossible to achieve. A test is never better than the items that constitute the test. Hence, a critique of PISA should not mainly address the official rationale, ambitions and definitions, but should scrutinize the test items and the realities around the data collection. The secrecy over PISA items makes detailed critique difficult, but I will illustrate the quality of the items with two examples from the released texts.

Finally, I will raise serious questions about the credibility of the results, in particular the ranking. Reliable results assume that the respondents in all countries do their best while they are sitting the test. I will assert that young learners in different countries and cultures may vary in the way they behave in the PISA test situation. I claim that in many modern societies, several students are unwilling to give their best performance if they find the PISA items long, unreadable, unrealistic and boring, in particular if bad test results have no negative consequence for them. I will use the concept of "perceived task value" to argue this important point.

2. THE POLITICAL IMPORTANCE OF PISA

Whether one likes the PISA study or not, one might easily agree about the importance of the project. When OECD has embarked on such a large project, it is certainly not meant as a purely academic research undertaking. PISA is meant to provide results to be used in the shaping of future policies. After 6-7 years of living with PISA, we see that the PISA concepts, ideology, values and not least the results and the rankings, shape international educational policies and also influence national policies in most of the participating countries. Moreover, the PISA results provide media and the public with convincing images and perceptions about the quality of the school system, the quality of their teachers' work and the characteristics of both the school population and future citizen.

Contemporary natural science is often labelled Big Science or Techno-science: The projects are multinational, they involve thousands of researchers, and they require heavy funding. Moreover, the traditional scientific values and ethos of science become different from the traditional ideals of academic science (Ziman, 2000). Prime examples are CERN, The Human Genome Project, European Space Agency etc. The PISA project has many similarities with such projects, although the scale and the costs are much lower. But the number of people who are involved is large, and the mere organization of the undertaking requires resources, planning and logistics unusual to the social sciences. According to Prais (2007), the total cost of the PISA and TIMSS testing in 2006 was "probably well over 100 million US dollars for all countries together, plus the time of pupils and teachers directly involved."

Why is an organization like the OECD embarking on an ambitious task like this? The OECD is an organization for the promotion of economic growth, cooperation and development in countries that are committed to market economies. Their slogan appears on their website: "For a better world economy."

The OECD and its member countries have not embarked on the PISA project because they have an interest in basic research in education or learning theory. They have decided to invest in PISA because education is crucial for the economy. Governments need information that is supposed to be relevant for their policies and priorities in this economic perspective. Since mass education is expensive, they also most certainly want "value for money" to ensure efficient running of the educational systems. Stating this is not meant as a critique of PISA. It is, however, meant to state the obvious, but still important fact: PISA should be judged in the context of the agenda of the OECD; economic development and competition in a global market economy.

The strong influence that PISA has on national educational policies should imply that all educators ought to be interested in PISA whether they endorse the aims of PISA or not. Educators should be able to discuss and use the results with some insight in the methods, underlying assumptions, strengths and weaknesses, possibilities and limitations of the project. We need to know what we might learn from the study, as well as what we cannot learn. Moreover, we need to raise a critical (not necessarily negative!) voice in the public as well as professional debates over uses and misuses of the results.

3. THE INFLUENCE OF PISA: NORWAY AS AN EXAMPLE

The attention given to PISA results in national media varies between countries, but in most countries it is formidable. In my country, Norway, the results from PISA2000 as well as from PISA2003 provided war-like headings in most national newspapers.

Our then Minister of Education (2001-2005), Kristin Clemet (representing Høyre, the Conservative party), commented on the PISA2000 results, released a few months after she had taken office, following a Labour government: "Norway is a school loser, now it is well documented. It is like coming home from the Winter Olympics without a gold medal" (which, of course, for Norway would have been a most unthinkable disaster!). She even added: "And this time we cannot even claim that the Finnish par-

ticipants have been doped!" (Aftenposten January 2001). An example of Press coverage is shown on Figure 1.

In fact, such headings were misleading. Norway has ended up close to the average among the OECD countries in all test domains in PISA2000 and PISA2003. But for some reason, Norwegians had expected that we should be on top – as we often are on other indicators and in winter sports. When we are not the winners, we regard ourselves as being losers.

The results from PISA (and TIMSS as well) have shaped the public image of the quality of our school system, not only for the aspects that have in fact been studied, but for more or less all other aspects of school. It has now become commonly 'accepted' that Norwegian schools in general have a very low level of quality, and that Norwegian classrooms are among the noisiest in the world. The media present tabloid-like and oversimplified rankings. It seems that the public as well as politicians have accepted these versions as objective scientific truths about our education system. There has been little public debate, and even the researchers behind the PISA study have little to modify and remind the public about the limitations of the study. In sum; PISA (as well as TIMSS) has created a public image of the quality of the Norwegian school that is not justified, and that may be seen to be detrimental. I assume that other counties may have similar experiences.

Figure 1 PISA results are presented in the media with war-like headings, shaping public perception about the national school system. Here are PISA results presented in the leading Norwegian newspaper Dagbladet with the heading "Norway is a school loser".

But PISA does not only shape the public image, it also provides a scientific legitimization of school reforms. Under Kristin Clemet as Minister of Education (2001-2005), a series of educational reforms were introduced in Norway. Most of these reforms were legitimized by reference to international testing, mainly to PISA. In 2005, we had a change in government, and Kristin Clemet's Secretary of State, Helge Ole Bergesen, published a book shortly afterwards in which he presented the "inside story" on the reforms made while they were in power. The main perspective of the book is the many references to large-scale achievement studies. He confirms that these studies provided the key arguments and rationale for curricular as well as other school reforms. Under the tabloid heading: **"The PISA Shock",** he confirms the key role of PISA:

With the [publication of the] PISA results, the scene was set for a national battle over knowledge in our schools.. […] For those of us who had just taken over the political power in the Ministry of Education and Research, the PISA results provided a "flying start" (Bergesen 2006: 41-42. Author's translation).

Other countries may have different stories to tell. Figures 2 and 3 provide examples from the public sphere in Germany. In sum: There is no doubt that PISA has provided - and will continue to provide - results, ideologies, concepts, analysis, advice and recommendations that will shape our future educational debates and reforms, nationally as well as internationally.

Figure 2 The political agenda and the public image of the quality of the entire school system is formed by the PISA results. This is an example from the German Newspaper Die Woche after the release of PISA 2000 results.

Figure 3 PISA has become a well-known concept in public debate: A bookshelf in a German airport offering bestselling books with PISA-like tests for self-assessment, very much like IQ-tests.

4. PISA: UNDERLYING VALUES AND ASSUMPTIONS

It is important to examine the ideas and values that underpin PISA, because, like most research studies, PISA is not impartial. It builds on several assumptions, and it carries with it several value judgements. Some of these values are explicit; others are implicit and 'hidden', but nevertheless of great importance. Some value commitments are not very controversial, others may be contested.

Peter Fensham, a key scholar in international science education thinking and research for many decades, has also been heavily involved in several committees in TIMSS and PISA. He has seen all aspects of the projects from the inside over decades. In a recent book chapter, he provides an insider's overview and critique of the values that underlie these projects. He draws attention to the underlying values and implications:

"The design and findings from large-scale international comparisons of science learning do impact on how science education is thought about, is taught and is assessed in the participating countries. The design and the development of the instruments used and the findings that they produce send implicit messages to the curriculum authorities and, through them, to science teachers. It is thus important that these values, at all levels of existence and operations of the projects, be discussed, lest these messages act counterproductively to other sets of values that individual countries try to achieve with their science curricula." (Fensham 2007: 215,216)

4.1. Aims and purpose of the OECD

In the public debate as well as among politicians, advice and reports from OECD experts are often considered to be impartial and objective. The OECD has become an important contributor to the political battle over social, political, economic and other ideas. To a large extent, these persons shape the political landscape, and their reports and advice set the political agenda in the national as well as international debates over priorities and concerns. But the OECD is certainly not a impartial group of independent educational researchers. The OECD is built on a neo-liberal political and economic ideology, and its advice should be seen in this perspective. The seemingly scientific and neutral language of expert advice conceals the fact that there are possibilities for other political choices based on different sets of social, cultural and educational values. Figure 4 shows how the OECD presents itself.

About the OECD

The OECD brings together the governments of countries committed to democracy and the market economy from around the world to:

- Support sustainable economic growth
- Boost employment
- Raise living standards
- Maintain financial stability
- Assist other countries' economic development
- Contribute to growth in world trade

Figure 4 The basis for and commitments of the OECD as they appear on http://www.oecd.org/ Retrieved Sept 7 2007

The overall perspective of the OECD is concerned with market economy and growth in free world trade. All policy advice they provide is certainly coloured by such underlying value commitments. Hence, the agenda of the OECD (and PISA) does not necessarily coincide with the concerns of many educators (or other citizens, for that matter). The concerns of PISA are not about 'Bildung' or liberal education, not about solidarity with the poor, not about sustainable development etc. - but about skills and competencies that can promote the economic goals of the OECD. Saying this is, of course, stating the obvious, but such basic facts are often forgotten in the public and political debates over PISA results.

4.2. Educational and curricular values in PISA

Quite naturally, values creep into PISA testing in several ways. PISA sets out to shed light on important (and not very controversial) questions like these:

Are students well prepared for future challenges? Can they analyse, reason and communicate effectively? Do they have the capacity to continue learning throughout life? (First words on the PISA home page at http://www.pisa.oecd.org/)

These are important concerns for most people, and it is hard to disagree with such aims. However, as is well known, PISA tests just a few areas of the school curriculum: Reading, mathematics and science. These subjects are, consequently, considered more

important than other areas of the school curriculum in order to reach the brave goals quoted above. Hence, the OECD implicitly says that our future challenges are *not* highly dependent on subjects like history, geography, social science, ethics, foreign language, practical skills, arts and aesthetics, etc.

PISA provides test results that are closely connected to (certain aspects of) the three subjects that they test. But when test results are communicated to the public, one receives the impression that they have tested the quality of the entire school system and all the competencies that are of key importance for preparing to meet the challenges of the future.

There is one important feature of PISA that is often forgotten in the public debate: PISA (in contrast to TIMSS) does *not* test "school knowledge". Neither the PISA framework nor the test items claim having any connection to national school curricula. This fact is in many ways the strength of the PISA undertaking; they have set out to think independently from the constraints of all the different school curricula. There is a strong contrast with the TIMSS test, as its items are meant to test knowledge that is more or less common in all curricula in the numerous participating countries. This implies, of course, that the "TIMSS curriculum" (Mullis et al 2001) may be characterized as a fossilized and old-fashioned curriculum of a type that most science educators want to eradicate. In fact, nearly all TIMSS test items could have been used 60-70 years ago. The PISA thinking has been freed from the constraints of school curricula and could in principle be more radical and forward-looking in their thinking. (However, as asserted in other parts of this paper, PISA does not manage to live up to such high expectations.)

PISA stresses that the skills and competencies assessed may not only stem from activities at school but from experiences and influences from family life, contact with friends, etc. In spite of this, both good and bad results are most often considered by both the public and politicians to be attributed to the school only.

4.3 Values in the PISA-reporting

The PISA data collection also covers a great variety of dimensions regarding background variables. The intention is, of course, to use these to explain the variance in the test results ("explain" in a statistical sense, i.e. to establish correlations etc.). Many interesting studies have been published on such issues. But the main focus in the public reporting is in the form of simple ranking, often in the form of league tables for the participating countries. Here, the mean scores of the national samples in different countries are published. These league tables are nearly the only results that appear in the mass media. Although the PISA researchers take care to explain that many differences (say, between a mean national score of 567 and 572) are not statistically significant, the placement on the list gets most of the public attention. It is somewhat similar to sporting events: The winner takes it all. If you become no 8, no one asks how far you are from the winner, or how far you are from no 24 at any event. Moving up or down some places in this league table from PISA2000 to PISA2003 is awarded great importance in the public debate, although the differences may be non-significant statistically as well as educationally.

The winners also become models and ideals for other countries. Many want to copy aspects of the school system from the winners. This, among other things, assumes that PISA results can be explained mainly by school factors – and not by political, historical, economic or cultural factors or by youth culture and the values and concerns of the young learners. Peter Fensham claims:

"… the project managers choose to have quite separate expert groups to work on the science learning and the contextual factors—a decision that was later to lead to discrepancies. Both projects have taken a positivist stance to the relationship between contextual constructs and students' achievement scores, although after the first round of TIMSS other voices suggested a more holistic or cultural approach to be more appropriate for such multi-cultural comparisons." (Fensham 2007: 218)

PISA (and even more so TIMSS) is dominated and driven by psychometric concerns, and much less by educational. The data that emerge from these studies provides a fantastic pool of social and educational data, collected under strictly controlled conditions – a playground for psychometricians and their models. In fact, the rather complicated statistical design of the studies decreases the intelligibility of the studies. It is, even for experts, rather difficult to understand the statistical and sampling procedures, the rationale and the models that underlie the emergence of even test scores. In practice, one has to take the results at face value and on trust, given that some of our best statisticians are involved. But the advanced statistics certainly reduce the transparency of the study and hinder publicly informed debate.

5. PISA ITEMS – A CRITIQUE

5.1 The secrecy

An achievement test is never better than the quality of its items. If the items are miserable, even the best statisticians in the world cannot change this fact. Subject matter educators should have a particular interest, and even a duty, to go into detail on how their subject is treated and 'operationalized' through the PISA test items. One should not just discuss the given definitions of e.g. scientific literacy and the *intentions* of what PISA claims to test. In fact, the framework as well as the intentions and ideologies in the PISA testing may be considered acceptable and even progressive. The important question is: How are these brave intentions translated into actual items?

But it is not easy to address this important issue, as only a very few of the items have been made publicly available. Peter Fensham, himself a member of the PISA (as well as TIMSS) subject matter expert group, deplores the secrecy:

> "By their decision to maintain most items in a test secret [….] TIMSS and PISA deny to curriculum authorities and to teachers the most immediate feedback the project could make, namely the release in detail of the items, that would indicate better than framework statements, what is meant by 'science learning'. The released items are tantalizing few and can easily be misinterpreted" (Fensham 2007: 217)

The reason for this secrecy is, of course, that the items will be used in the next PISA testing round, and therefore they may not be made public. An informed public debate on this key issue is therefore difficult, to say the least. But we scrutinize the relatively few items that have been made public. (All the released items from previous PISA rounds can be retrieved from the PISA website)

5.2 Can "real-life challenges" assessed by wordy paper-and-pencil items?

The PISA testing takes place in about 60 countries, which together (according to the PISA homepage) account for 90% of the world economy. PISA has the intention of testing

> … knowledge and skills that are essential for full participation in society. […] not merely in terms of mastery of the school curriculum, but in terms of important knowledge and skills needed in adult life. […]
>
> The questions are reviewed by the international contractor and by participating countries and are carefully checked for cultural bias. Only those questions that are unanimously approved are used in PISA. (Quotes from Pisa.oecd.org, retrieved 5 sept 2007)

In each item unit, the questions are based on what is called an "authentic text". This, one may assume, means that the original text has appeared in print in one of the 60 participating countries, and that it has been translated from this original.

There are many critical comments that can be made to challenge the claim that PISA lives up to the high ambition of testing real-life skills. An obvious limitation is the test format itself: The test contains only paper-and-pencil items, and most items are based on the reading of rather lengthy pieces of text. This is, of course, only a subset of the types of "knowledge and skills that are essential for full participation in society". Coping with life in modern societies requires a range of competencies and skills that cannot possibly be measured by test items of the PISA units' format.

5.3 Identical "real-life challenges" in 60 countries?

But the abovementioned criticism has other and equally important dimensions: The PISA test items are by necessity exactly the same in each country. The quote above assures us that any "cultural bias" has been removed, and items have to be "unanimously approved".

At first glance, this sounds positive. But there are indeed difficulties with such requirements: Real life is different in different countries. Here are, in alphabetical order, the first countries on the list of participating countries: Argentina*, Australia, Austria, Azerbaijan*, Belgium, Brazil*, Bulgaria*, Canada, Chile*, Colombia*, Croatia*, the Czech Republic, Denmark (The list is from http://www.pisa.oecd.org/ Countries marked with a * are not members of OECD, but are also assumed to unanimously agree on the inclusion of all test units.)

We can only imagine the deliberation towards unanimous acceptance of all items among the 60 countries with the demands that there should be no cultural bias and that context of no country should be favoured.

The following consequences seem unavoidable: The items will become decontextualised, or with contrived 'contexts' far removed from the reality of most real life situations in any of the participating countries. While the schools in most countries have a mandate to prepare students to meet the challenges in that particular society (depending on level of development, climate, natural environment, culture, urgent local and national needs and challenges, etc.), the PISA tests only aspects that are shared with all other nations. This runs contrary to current curriculum trends in many countries, where the issue of providing local relevance and context have become urgent. In many countries, educators argue for a more contextualized (or 'localized') curriculum, at least in the obligatory basic education for all young learners.

The item construction process also rules out the inclusion of all sorts of controversial issues, be they scientific, cultural, economic or political. It is indeed enough that the authorities in one of the participating countries have objections.

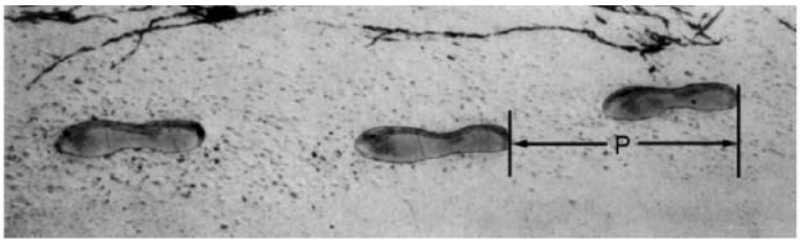
To repeat: Schools in many countries have the mandate of preparing their learners to take an active part in social and political life. While many countries encourage the schools to treat controversial socio-scientific issues, such issues are unthinkable in schools in other countries. Moreover, a controversial issue in one country may not be seen as controversial in another. In sum: The demands of the item construction process set serious limitations on the actual items that comprise the PISA test.

Now, all the above considerations are simply deductions from the demands of the processes behind the construction of the PISA instrument. It is, of course, of great importance to check out such conclusions against the test itself. But, as mentioned, this is not an easy task to complete, given the secrecy over the test items. Nonetheless, the items that have been released confirm the above analysis: The PISA items are basically decontextualised and non-controversial. The PISA items are - in spite of an admirable level of ambition - nearly the negation of the skills and competencies that many educators consider important for facing future challenges in modern, democratic societies.

PISA items have also been criticized on other aspects. Many claim that the scientific content is questionable or misleading and that the language is strange, often verbose. In the next paragraph, two examples of PISA units are discussed in some detail, one from Mathematics, the other from Science.

5.4 A PISA mathematics unit: Walking

In Figure 5 below the complete PISA test unit called Cloning is reproduced.



The picture shows the footprints of a man walking. The pacelength *P* is the distance between the rear of two consecutive footprints.

For men, the formula, $\frac{n}{P} = 140$, gives an approximate relationship between *n* and *P* where,

n = number of steps per minute, and

P = pacelength in metres.

Question 1: WALKING *M124Q01- 0 1 2 9*

If the formula applies to Heiko's walking and Heiko takes 70 steps per minute, what is Heiko's pacelength? Show your work.

Question 3: WALKING *M124Q03- 00 11 21 22 23 24 31 99*

Bernard knows his pacelength is 0.80 metres. The formula applies to Bernard's walking.

Calculate Bernard's walking speed in metres per minute and in kilometres per hour. Show your working out.

Figure 5 A complete PISA mathematics unit, "Walking", with the text presenting the situation and the questions relating to the situation.

COMMENTS TO WALKING

Some details first:
Note that Question 2 is missing! (This may be an omission in the published document.) Note also the end of Q1: "Show your work." And for Q2. "Show your working out." There also seems to be several commas too many. Consider the commas in this paragraph: "For men, the formula, n/P = 140, gives an approximate relationship between n and P where, etc…". In my view, all the 4 commas seem somewhat misplaced. Perhaps these are merely details, but they are not very convincing as the final outcome of serious negotiations between 60 countries!

The main comments to this unit are, however, more on the content of the item. First of all: Is this situation really a "real-life situation"? How real is the situation described above? Is this type of question a real challenge in the future life of young people – in any country?

But even if we accept the situation as a real problem, it seems hard to acknowledge that the given formula is a realistic mathematization of a genuine situation. The formula implies that when you increase the frequency in your walking, your paces simultaneously become longer.. To my knowledge, a person may walk with long paces and low frequency. Moreover, the same person may also walk using short steps at high frequency. In fact, at least from my point of view, the two factors should be inversely proportional rather than proportional, as suggested in the "Walking" item. In any case, a respondent who tries to think critically about the formula may get confused, but those who do not think may easily solve the question simply by inserting the formula.

But the problems do not stop here: Take a careful look at the dimensions given in the figure. If the marked footstep is 80 cm (as suggested in Q3 above), then the footprint is 55 cm long! A regular man's foot is actually only about 26 cm long, so the figure is extremely misleading! But even worse: From the figure, we can see (or measure) the next footstep to be 60% longer. Given the formula above, this also implies a more rapid pace, and the man's acceleration from the first to the second footstep has to be enormous!

In conclusion: The situation is unrealistic and flawed from several points of view. Students who simply insert numbers in the formula without thinking will get it right. More critical students who start thinking will, however, be confused and get in trouble!

5.5 A PISA science unit: Cloning

In Figure 6 below the complete PISA test unit called Cloning is reproduced.

S128: Cloning

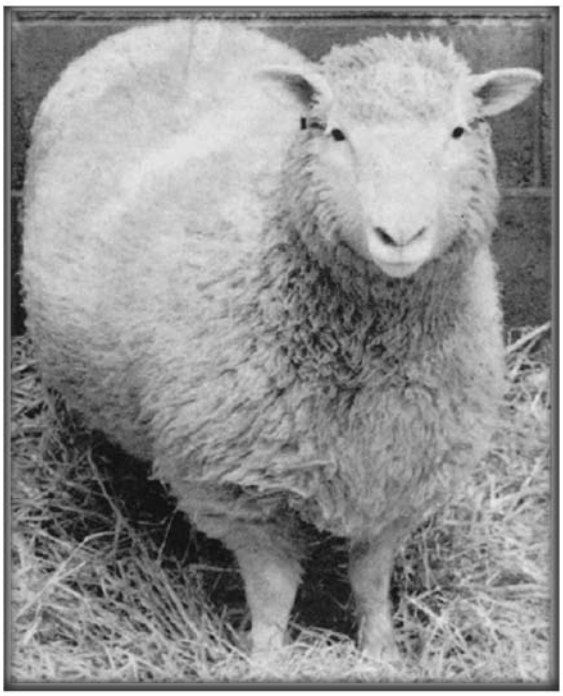
Read the newspaper article and answer the questions that follow.

A copying machine for living beings?

Without any doubt, if there had been elections for the animal of the year 1997, Dolly would have been the winner! Dolly is a Scottish sheep that you see in the photo. But Dolly is not just a simple sheep. She is a clone of another sheep. A clone means: a copy. Cloning means copying 'from a single master copy'. Scientists succeeded in creating a sheep (Dolly) that is identical to a sheep that functioned as a 'master copy'.

It was the Scottish scientist Ian Wilmut who designed the 'copying machine' for sheep. He took a very small piece from the udder of an adult sheep (sheep 1). From that small piece he removed the nucleus, then he transferred the nucleus into the egg-cell of another (female) sheep (sheep 2). But first he removed from that egg-cell all the material that would have determined sheep 2 characteristics in a lamb produced from that egg-cell. Ian Wilmut implanted the manipulated egg-cell of sheep 2 into yet another (female) sheep (sheep 3). Sheep 3 became pregnant and had a lamb: Dolly.

Some scientists think that within a few years it will be possible to clone people as well. But many governments have already decided to forbid cloning of people by law.



Question 1: CLONING

Which sheep is Dolly identical to?

A Sheep 1
B Sheep 2
C Sheep 3
D Dolly's father

Question 2: CLONING S128Q02

In line 14 the part of the udder that was used is described as "a very small piece". From the article text you can work out what is meant by "a very small piece".

That "very small piece" is

A a cell.
B a gene.
C a cell nucleus.
D a chromosome.

Question 3: CLONING S128Q03

In the last sentence of the article it is stated that many governments have already decided to forbid cloning of people by law.

Two possible reasons for this decision are mentioned below.

Are these reasons scientific reasons?

Circle either "Yes" or "No" for each.

Reason:	Scientific?
Cloned people could be more sensitive to certain diseases than normal people.	Yes / No
People should not take over the role of a Creator.	Yes / No

Figure 6 A complete PISA science unit, "Cloning", with the text presenting the situation and the three questions relating to the situation.

COMMENTS TO CLONING

This task requires the understanding of the rather lengthy 30 lines of text. In non-English-speaking countries, this text is translated into the language of instruction. The translation follows rather detailed procedures to ensure high quality. The requirement that the text should be more or less identical results in rather strange prose in many languages. The original has, we assume, been an "authentic text" in some language, but the resulting translations cannot be considered to be "authentic" in the sense that they could appear in any newspaper or journal in that particular country.

PISA adheres to strict rules for the translation process, but this is not the way prose should be translated to become good, natural and readable in other languages. In my own language, Norwegian, the heading "A copying machine for living being" is translated word by word. This does not make sense, and prose like this would never appear in real texts.

The scientific content of the item may also be challenged. The only accepted answer on Question 1 is that Dolly is identical to Sheep 1 (alternative A). It may seem strange to claim that two sheep of very different ages are "identical" – but this is the only acceptable answer. The other two questions are also open for criticism. Basically, they test language skills, reading as well as vocabulary. (The word 'udder' was unknown to me.)

In conclusion: Although the intentions behind the PISA test are positive, it becomes next to impossible to produce items that are 'authentic', close to real life challenges – and at the same without cultural bias and equally 'fair' in all countries. Items have to be constructed by international negotiations, and the result will therefore be that all contexts are wiped out – contrary to the ambitions of the PISA framework.

6. YOUTH CULTURE: WHO CARES TO CONCENTRATE ON PISA TESTS?

In the PISA testing, students at the age of 15 are supposed to sit for 2 hours and do their best to answer the items. The data gathered in this way forms the basis of all conclusions on achievement and all forms of factor analysis that explain (in a statistical sense) the variation in achievement. The quality of these achievement data determines the quality of the whole PISA exercise. Good data assumes, of course, that the respondents have done their best to answer the questions. For PISA results to be valid, one has to assume that students are motivated and cooperative, and that they are willing to concentrate on the items and give their best performance.

There are good reasons to question such assumptions. My assertion is that students in different countries react very differently to test situations like those of PISA (and TIMSS). This situation is closely linked to the overall cultural environment in the country, and in particular to students' attitudes to schools and education. Let me give an illustration of such cultures with examples from two countries scoring high on tests like PISA and TIMSS.

6.1 Testing in Taiwan and Singapore

An observer from Times Educational observed the TIMSS testing at a school in Taiwan, and he noticed that pupils and parents were gathered in the schoolyard before

the big event, the TIMSS testing. The director of the school gave an appeal in which he also urged the students to perform their utmost for themselves and their country. Then they marched in while the national hymn was played. Of course, they worked hard; they lived up to the expectations from their parents, school and society.

Similar observations can be made in Singapore, another high achiever on the international test. A professor in mathematics at the National University of Singapore (Helmer Aslaksen) makes the following comment: "In this country, only one thing matters: Be best – teach to the test!"

He has also taken the photograph from the check-out counter in a typical Singaporean shop, (see Figure 7). This is where the last-minute offers are displayed: On the lower shelf one finds pain-killers, while the upper shelf displays a collection of exam papers for the important public exams in mathematics, science and English (i.e. the three PISA subjects). This is what ambitious parents may bring home for their 13-year-old kids at home. Good results from such exams are determinants for the future of the student.

Figure 7 The context of exams and testing: This is the check-out counter in a shop in Singapore. Last-minute offers are displayed: On the lower shelf: Medicinal pain-killers. On the upper shelf: Exam papers for the important public exams in mathematics, science and English (i.e. the three PISA subjects).

This is definitely not the way such testing takes place in my part of the world (Norway) and the other Scandinavian countries. Here, students have a very different attitude to schooling, and even more so to exams and testing. The students know that the performance on the PISA testing has no significance for them: They are told that they will never get the results, the items will never be discussed at school, and they will not get any other form of feedback, let alone school marks for their efforts. Given the educational and cultural milieu in (e.g.) Scandinavia, it is hard to believe that all students will engage seriously in the PISA test.

6.3 Task value: "Why should I answer this question?"

Several theoretical concepts and perspectives are used to describe and explain performance on tests. The concept of self-efficacy beliefs has become central to this field. By self-efficacy belief, one understands it to be the belief and confidence that students have in their resources and competencies when facing the task (Bandura 1997). Self-efficacy is rather specific to the type of task in question, and should not be confused with more general psychological personality traits like self-confidence or self-esteem. PISA has several constructs that seek to address self-efficacy, and they have noted a rather strong positive relationship between e.g. mathematical self-efficacy beliefs and achievement on the PISA mathematics test on the individual level (Knain & Turmo 2003). (It is, however, interesting to note that such a positive correlation does not exist when countries are the unit of comparison.)

There is, however, a related concept that may be of greater importance when explaining test results and students' behaviour in test situations. This is the concept of task value beliefs (Eccles & Wigfield 1992, 1995). While self-efficacy beliefs ask the question, "Am I capable of completing this task?", the task value belief focuses on the question, "Why do I want to do this task?". The task value belief concerns beliefs about the importance of succeeding (or even trying to succeed) on a given task.

It has been proposed that the task value belief may be seen to have three different components or dimensions: These are the 1. attainment value, 2. intrinsic value or interest, and 3. utility value. Rhee et al (2007) explains in more detail:

"Attainment value refers to the importance or salience that students place on the task. Intrinsic value (i.e. personal interest) relates to general enjoyment of the task or subject matter, which remains more stable over time. Finally, utility value concerns students' perceptions of the usefulness of the task, in terms of their daily life or for future career-related or life goals."(Rhee et al 2007: 87)

I would argue that young learners in different countries perceive the task value of the PISA testing in very different ways, as indicated in previous sections of this paper.

Based on my knowledge about the school system and youth culture in my own part of the world, in particular Norway and Denmark, I would claim that many students in these countries assign very little value to all the above three dimensions of the task value of the PISA test and its items. Given the nature of the PISA tasks (long, clumsy prose and contrived situations removed from everyday life), many students can hardly find these items to have high "intrinsic value"; the items are simply not interesting and

do not provide joy or pleasure. Neither does the PISA test have any "utility value" for these Scandinavian students; the results have no consequence, the items will never be discussed, there is no feed-back, results are secret and do not count, neither for school marks nor in their daily lives. They do not count for students' future career-related or life goals. Given the cultural and school milieu and the values held by young learners in e.g. Scandinavia, it is hard to understand why they should choose to push themselves in a PISA test situation.

f so, we have an additional cause for serious uncertainty about the validity and the reliability of the PISA results.

REFERENCS

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Bergesen, O. H. (2006). *Kampen om kunnskapsskolen* (Eng: The fight for a knowledge-based school) Oslo: Universitetsforlaget.

Eccles, J. S., & Wigfield, A. (1992). The development of achievement-task values: A theoretical analysis. *Developmental Review*, ***12***, 256–273.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: the structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin*, ***21***, 215–225.

Fensham, Peter (2007). Values in the measurement of students' science achievement in TIMSS and PISA. In Corrigan et al (Eds) (2007). *The Re-Emergence of Values in Science Education,* (p 215-229) Rotterdam: Sense Publishers.

Knain, E. & A. Turmo (2003). Self-regulated learning Lie S et al (Eds) *Northern Lights on PISA*, University of Oslo, Norway (p 101-112).

Mullis, I. V. S., Martin, M. O., Smith, T. A., Garden, R. A., Gregory, K. D., Gonzales, E. J., et al. (2001). *TIMSS Assessment Frameworks and Specifications 2003.* Boston: International Study Center, Boston College.

Prais, S.J. (2007). England: Poor survey response and no sampling of teaching groups *Oxford Review of Education* vol. 33, no. 1.

Rhee, C. B., T. Kempler, A. Zusho, B. Coppola & P. Pintrich (2005). Student learning in science classrooms: what role does motivation play? In Alsop, S. (Ed). *Beyond Cartesian Dualism. Encountering Affect in the Teaching and Learning of Science* Dordrecht: Springer, Science and Technology Education Library.

Sjøberg, S. (2007). PISA and "Real Life Challenges": Mission Impossible? In Hopman S. (Ed): *PISA according to PISA. Does PISA Keep What It Promises?* Wien: LIT Verlag

Ziman, J.M. (2000). *Real Science: What it is and what it means.* Cambridge: Cambridge University Press.

CONSIDERATION SUPPLEMENTARY TO SCIENCE TEACHING IN WORLDVIEW-EDUCATION-ORIENTED SCIENCE EDUCATION

Ken KAWASAKI[1], Mitsuru NAKAJO[2]
[1]*Science Education Section, Faculty of Education, Kochi University*
[2]*Primary School Attached to Faculty of Education, Kochi University*
1-5-2 Akebono-cho, Kochi city, 780-5820 JAPAN
E-mail: kenknym@aqr.e-catv.ne.jp

▼ Abstract

This paper presents a supplementary consideration a science teacher gave in a primary school science in Japan. As a rule, science teachers should bring similar considerations into science lessons conducted in communities, where pupils' first language is incommensurate with some European languages. There, pupils are confronted with two worldviews different from each other in science lessons in the communities since a language entails a worldview inherent in the language. These two worldviews are the scientific worldview and the worldview pupils' first language entails traditionally. Because worldviews differently formulate sets of rules and beliefs respectively, pupils may follow the traditional worldview even in science lessons. This causes pupils' conceptual confusion about scientific concepts. In order to minimize pupils' confusion, science teachers have to realize pupils' language-culture milieu. Teachers should neither demonstrate just the superiority of the scientific worldview over pupils' traditional one nor encourage pupils to disregard it. A desirable outlook on these worldviews is to explain the differences in worldview occasionally. The explanations will be supplementary to teaching science. The present explanation is about distinguishing an individual name of a fish from its species name. Usually these two names are the same, but they are normally distinguishable according to the scientific worldview based on the dichotomy between the world of Idea and the phenomenal world, to use the Platonic terms. However, pupils do not distinguish between them in the Japanese worldview, because Japanese nouns do not change in their form whether singular or plural and because Japanese has never had an established method to form abstract nouns. From the viewpoint of the scientific worldview, the Japanese worldview appears to lack the world of Idea, which is essential for the scientific thought. The explanation is arranged in order to attract pupils' attention to the distinction between these two names.

Key Words Worldview education, non-Western World, Scientific Thought

1. ADDRESSING THE PROBLEM

It was the mid-nineteenth century when Japan opened to the world. Since then Japan has arranged a system of teaching school science and participated in developing Western Modern science and technology. However, it seems doubtful that Japanese people correctly understand scientific concepts following the scientific worldview, because Japanese people have cultivated their own worldview for more than fifteen centuries.

Accepting that a language entails a worldview inherent in the language, Kawasaki (1996; 2002) revealed differences between the scientific and the Japanese traditional worldviews. For instance, the Japanese term "shizen" that is the Japanese counterpart of "nature" normally calls for something supernatural in pupils' mind; consequently, they tend not to objectify their scientific objects but to have empathy with them even in science lessons. This throws pupils into confusion about scientific concepts.

2. JAPANESE WORLDVIEW ENTAILED IN JAPANESE

The most possible reason for pupils' confusion is that very few science teachers realize that the Japanese worldview differs entirely from the scientific worldview that is based on the dichotomy between the world of Idea and the phenomenal world, to use the Platonic terms. From the viewpoint of the scientific worldview, the Japanese worldview seems to lack the world of Idea. This reflects a difference between English and Japanese. Japanese nouns do not change in form whether singular or plural. Consequently, Japanese-speaking people do not make a deliberate distinction between a name of an individual thing and its species name.

This means that Japanese pupils are poor at abstracting scientific concepts from various observations. Those teachers who realize this will arrange for pupils to distinguish an individual name from its species name. This will be the first step to form the dichotomy essential to scientific thought in pupils' mind. Teachers' arrangement will be a result from a consideration supplementary to teaching science in communities without the dichotomy between these two worlds.

3. JAPANESE EXAMPLE OF SUPPLEMENTARY CONSIDERATION

One of the present authors, Nakajo, arranged a science lesson so that pupils could experience an abstracting process. The lesson was for the fifth grade pupils, who were expected to learn that "There are males and females among fishes" (Japanese Research Team 2004, 119). The class consisted of nine groups, each of which included four or five pupils. Each group had a Japanese killifish (*Oryzias latipes*) in a beaker, and then he directed to judge whether the killifish was male or female. In order to judge, pupils were allowed to compare theirs with others distributed to other groups.

In order to clarify his intention, it is effective to compare the present arrangement with another arrangement he had made previously. Before he realized the differences in worldview, he had delivered a pair of male and female killifish in a beaker to each group. Pupils had been expected to judge according to the photo and the illustration in their textbook. The photo and the illustration had shown features distinctive be-

tween male and female killifish. Pupils had understood the distinctive features in an abstract manner, and then had made their judgement about the killifish sexes in the beaker by their observing. Pupils had assigned male or female to their killifish according to the photo or the illustration and had not experienced any abstracting process. This reflects the Japanese traditional worldview.

In Nakajo's new arrangement pupils were faced with several killifish. They were actual individuals. In order to judge whether the killifish was male or female, pupils had to classify all killifish in the class into two groups. In this process pupils had to judge whether differences between two individuals were accidental or not; if accidental, pupils had to ignore the differences. Gradually pupils established viewpoints to classify. In this process, pupils were led to form abstract concepts of different two groups. Then, according to the illustration and the photo, pupils judged which group was male or female.

4. CONCLUDING REMARKS

Because teaching science presupposes pupils' ability to abstract, science teachers unwittingly make the presupposition. However, it is almost impossible for pupils to abstract in the Japanese language milieu, where the dichotomy has never been established. There, the supplementary consideration is essential. This is the first step to have pupils understand the differences in worldview. This understanding will lead pupils to another understanding that the scientific thought requires the dichotomy between the world of Idea and the phenomenal world. Then, pupils will liberate themselves from their conceptual confusion.

In the milieu of English, for example, Nakajo's previous arrangement will work well. By means of a combination of an article and a noun, pupils naturally judge whether the noun refers to the world of Idea or the phenomenal world. This is the reason why science teachers overlook the differences in worldview in Japan. The present discussion is an issue of the medium of instruction of school science, and then will be applicable to other communities, where pupils' first language does not entail the scientific worldview based on the dichotomy.

The present discussion is a direct consequence of worldview education (Kawasaki 2007) and the first step to accomplish it. Worldview education is a type of science education conducted by those science teachers who realize the differences between the scientific worldview and another worldview pupils' first language entails. In such communities, science teachers should take consideration of differences in worldview. In order to give the consideration, science teachers will have to accomplish another type of duty in addition to just teaching science: focusing explicitly on the traditional worldview shared in the community where pupils are growing.

REFERENCES

Tr. by Japanese Research Team (2004). The Course of Study in Japan (Provisional and unofficial translation).

Kawasaki, K. (1996). The Concepts of Science in Japanese and Western Education. *Science & Education, 5*(1), 1-20.

Kawasaki, K. (2002). A Cross-Cultural Comparison of English and Japanese Linguistic Assumptions Pupils' Learning of Science. *Canadian and International Education, 31*(1), 19-51.

Kawasaki, K. (2007). Towards Worldview Education beyond Language-Culture Incommensurability, *International Journal of Science and Mathematics Education, 5*(1), 29-48.

ACKNOWLEDGEMENTS

This investigation is partly supported by Grant-in-Aid for Scientific Research (B): "Comparative study on dependence of 'nature' on culture for improving science education" (No. 17300215, Principal Investigator: Kawasaki). I am grateful to Dr. Taylor for his comments on this issue.

AN IDENTIFICATION OF MULTIPLE INTELLIGENCE AREAS OF THE PRIMARY SCHOOL EDUCATION STUDENTS

Nilgün Yenice, Hilal Aktamış
Adnan Menderes University
Faculty of Education Science Education Department Kepez/AYDIN
E-mail: nyenice@gmail.com

▼ Abstract

According to Multiple Intelligence Theory, eight different types of intelligence can be used as eight different ways in such as for learning, problem solving, receiving, processing and using information. If daily plans and classroom activities are arranged by taking these eight types of intelligence into consideration, many problems about learning. For this reason, firstly teachers must determine which types of intelligences they developed and how they teach the lessons. In this view, educating the primary school teachers with high quality makes a current issue. This research, based on the necessities told above, investigated to identify the types of multiple intelligences of the students in Department of Primary School Education according to MI theory.

The research is a survey model, which has an approach aiming to describe the current status. The sample of the study consisted of the first, second, third and fourth grade students (n= 561) studying in formal and evening course programs of Adnan Menderes University Primary School Teacher Training Department. The sample of 67% (n=376) of the students were studying in formal education and 33% (n=185) of the students were from evening course programs. "Multiple Intelligence Inventory for Educators", developed by Saban (2001) and Personal Information Form, consisting of 7 questions were used in the study. Inventory was formed in Likert scale and it was consisted of 10 parts and 80 items.

When the students' intelligence range dispersion is examined, a 'moderately developed' homogeneous dispersion is seen in all intelligence range. Thus it is a good result for the profession of teaching that the teachers' intelligence range is dispersed in all areas homogenously in the study executed. It is important fot the teachers to be aware of their intelligence range for the role of the learning environment.

Key Words Multiple Intelligence, Primary School Education, Teacher Training,

1. INTRODUCTION

According to Piaget; the main purpose of education is not creating individuals who repeat the same things with their generation, but creating creative and innovation-

al individuals who are capable of doing something new. The second purpose of the education is raise creative brains who can make criticism, investigate the accuracy of findings and who does not accept everything they are taught. (Onur, 1993). For this reason, teacher-centered approach which has a negative effect on learning should be abandoned and teaching activities should be individualized as possible. Students come to classrooms with different individual learning abilities. Multiple Intelligence Theory is the one which gives importance to individual differences.

The theory of Multiple Intelligence has been attracted great attention with different kinds of intelligences since it was first suggested. According to MI theory, individuals have eight kinds of intelligence (Brualdi, 1994; Terry & Wayman, 1996; Checkly, 1997; Hoerr, 1998; Silver & et al., 2000).

According to Multiple Intelligence Theory, eight different types of intelligence can be used for eight different ways in such as for learning, problem solving, receiving, processing and using information (Yavuz, 2001). If daily plans and classroom activities are arranged by taking into consideration of (according to) eight types of intelligence, many problems about learning may disappear (Selçuk, Kayılı & Okut, 2002).

For this reason, firstly teachers must determine which types of intelligences they developed and how they teach (present) the lessons. In this view, it makes a current issue that primary school teachers' educate of high quality. This research, based on the necessities told above, investigated to determine the types of multiple intelligences of the students in Department of Primary School Education (Preservice teachers') according to MI theory. With the aim of this research, the questions were answered below:

1. How does the multiple intelligence theory based intelligence range of the preservice teachers disperse related with the level of education and class year?
2. Are there any significant differences between preservice teachers' education types (formal or evening course) and their types of intelligence based on MI theory?

2. METHOD

2.1. Research Model

The research is survey model, which has an approach aiming to describe the current status (Karasar, 1999). The base of the study is made up of (n=561) 1., 2., 3. and 4. year, formal and evening course students at Adnan Menderes University. In the students that participated in the study, 67% (n=376) were formal and %33 (n=185) were evening educated.

2.2. Tools for Gather Data

In order to gather data, a 'personal information form' which composed of 7 questions and is developed by Saban (2001) has been used. Inventory was formed in Likert scale and it was consisted of 10 parts and 80 items. The forms are used on 195 preservice teachers of the formal education class and cronbach alpha trust ratio is calculated as 88. Scales are developed by 5 degree likert type scaling system and 'I totally agree', 'I

agree', 'Undecisive', 'I disagree', and 'I totally disagree' options are used. Each intelligence range total points graded as '5= highly developed', '4=developed', '3=moderately developed', '2=slightly developed' and '1=undeveloped'.

2.3. Analysis of Data

During the analyses of the data, unrelated T-test and one way variance analyses are used in order to compare the students' educational type and class year (formal or evening), gender, type of the school from which they are graduted and high school majors. A Scheffe test is applied in order to determine between which groups were the differences realized by variance analyses. Analyses are made at SPSS 11.5 package program. 0.05 was the importance level.

3. FINDINGS

***Sub-problem of the 1. study*:** 'How does the multiple intelligence theory based intelligence range of preservice teachers' disperse related with the level of education and class year?' was asked.

Preservice teachers' arithmetic mean of dispersion of the multiple intelligence range is provided at Table 1 and 2 to search for an answer.

Table 1 Dispersion of the Multiple Intelligence Range (MIR) of the Formal Education Preservice Teachers According to the Class Year

	1. class		2. class		3. class		4. class		Total	
MIR	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Verbal- Linguistic	3.242	.729	3.252	.541	3.319	.659	3.237	.641	3.263	.645
Logical - Mathematical	4.000	.714	3.990	.692	4.096	.704	3.887	.675	3.997	.698
Visual - Spatial	3.859	.769	3.808	.680	3.819	.604	3.800	.682	3.823	.685
Musical - Ryhtmical	3.212	.940	3.323	.977	3.511	.969	3.275	1.055	3.331	.985
Bodily- Kinesthetic	3.626	.679	4.566	7.178	3.808	,692	3.925	.652	3.987	3,752
Social	3.758	.757	3.848	.733	3.808	.573	3.800	.770	3.804	.709
Instinctive	3.677	.697	3.737	.694	3.787	.654	3.625	.785	3.710	.705
Naturalist	3.444	.883	3.434	.916	3.287	.742	3.287	.957	3.368	.876

At Table 1, arithmetical mean of the dispersion of the MIR of the formal education students according to the class year is seen. When the results are examined, one can see that the freshmen logical-mathematical intelligence range is 'developed' and the rest of the intellingence range are 'moderately developed'. In sophomores it is seen that bodily-kinesthetic intelligence range is 'developed' and the rest is 'moderately developed'. In juniors logical-mathematical intelligence range is 'developed' and the rest of the intellin-

gence range is 'moderately developed'. In seniors it is seen that all the intelligence range are 'moderately developed'. In total, one can see that all the formal preservice teachers have dispersed as 'moderately developed' in average. Scheffe and Anova test are applied to see if there is a difference between classes and no reasonable result is found.

At Table 2, arithmetical mean of the dispersion of the MIR of the evening course students according to the class year is seen. In freshman class, verbal-linguistic intelligence range is 'slightly developed' and the rest are 'moderately developed'. In sophomores, all the intelligence range is 'moderately developed'. In junior class, logical-mathematical intelligence range is 'developed' and the rest are 'moderately developed'. In senior class, one can see that all the intelligence range is 'moderately developed'. In total, one can see that all the evening course students have dispersed as 'moderately developed' in average. Scheffe and Anova test are applied to see if there is a difference between classes.

Table 2 Dispersion of the MIR of the Evening Course Preservice Teacher According to the Class Year

	1. class		2. class		3. class		4. class		Total	
MIR	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Verbal- Linguistic	2.959	.576	3.306	.742	3.351	.612	3.176	.716	3.206	.672
Logical - Mathematical	3.592	.761	3.980	.661	4.017	.719	3.794	.729	3.857	,733
Visual - Spatial	3.653	.751	3.714	.764	3.789	.647	3.765	.741	3.730	.719
Musical - Ryhtmical	3.347	.903	3.306	.796	3.667	.988	3.088	.933	3.386	.925
Bodily- Kinesthetic	3.755	.596	3.898	,684	3.895	.588	3.823	.716	3.847	.638
Social	3.653	.597	3.816	.697	3.754	.714	3.588	.783	3.714	.694
Instinctive	3.531	.739	3.796	.612	3.702	.626	3.735	.618	3.688	.655
Naturalist	3.163	,850	3.326	,826	3.140	.875	3.471	.861	3.254	.856

An obvious difference is seen when the evening course preservice teachers' Verbal-Linguistic, Logical–Mathematical and Musical–Ryhtmical intelligence range is examined according to the class years ($p<.05$). When the Scheffe test is analysed, it is seen that the verbal-linguistic intelligence range difference is between freshman and juniors and when the means are examined, the juiors prevailed. Logical–Mathematical intelligence range difference is between freshman and juniors and when the means are examined, the juniors prevailed. Musical–Ryhtmical intelligence range difference is between seniors and juniors and when the means are examined, the juniors prevailed.

***Sub-problem of the 2. study*:** "Are there any significant differences between preservice teachers' education types and their types of intelligence based on MI theory?" was asked:

A T-test is used in order to comprehend the differences between intelligence range based on multiple intelligence theory according to the types of education preservice teachers are tought. Results are shown at Table 4.

When the table of MIR according to the types of education students are tought is examined, no main difference in intelligence range other than the one in logical–mathematical is found. A main difference in logical–mathematical intelligence range

is obvious between formal and evening course students. When one intends to see who prevails in the means of the student groups, it is seen that the formal education students advanced.

Table 4 MIR according to the types of education preservice teachers are tought

MIR	E.Type	N	Means	Standart Deviation	t	p
Verbal-Linguistic	Formal	372	3,2634	,64466	.977	.329
	Evening	189	3,2063	,67222		
Logical - Mathematical	Formal	372	3,9973	,69847	2.209	.028*
	Evening	189	3,8571	,73348		
Visual - Spatial	Formal	372	3,8226	,68541	1.485	.138
	Evening	189	3,7302	,71918		
Musical - Ryhtmical	Formal	372	3,3306	,98552	-.645	.519
	Evening	189	3,3862	,92485		
Bodily - Kinesthetic	Formal	372	3,9866	3,75206	.509	.611
	Evening	189	3,847	,638		
Social	Formal	372	3,8038	,70934	1.422	.155
	Evening	189	3,7143	,69409		
Instinctive	Formal	372	3,7097	,70548	.355	.723
	Evening	189	3,6878	,65470		
Naturalist	Formal	372	3,3683	,87577	1.472	.142
	Evening	189	3,2540	,85617		

4. RESULTS AND SUGGESTIONS

In this study, University of Adnan Menderes School of Formal preservice teachers' intelligence range based on multiple intelligence range and the difference in the intelligence range and the preservice teachers' type of education (formal or evening), gender, age, type of school graduated, high school majors are examined.

1. When the preservice teachers' intelligence range dispersion is examined, a 'moderately developed' homogeneous dispersion is seen in all intelligence range. Thus it is a good result for the profession of teaching that the teachers' intelligence range is dispersed in all areas homogenously in the study executed. (Durmaz & Ozyildirim 2005). The result of 'moderately improved' from the research executed on the high school sophomore students' intelligence range by Gurcay and Eryilmaz (2002) and the study based on the freshman students of Class and science preceptorship major at the school of Education and their multiple intelligence range supports our results.
2. There is no meaningful difference in intelligence range according to the type of education achieved by students. The only meaningful difference that is on formal preservice teachers' side is in logical–mathematical range. This may be

caused by the difference in higher points achieved in the acceptance by formal students than the evening students. The reason that there were no other main differences are found is because the acceptance is based on Turkish-Math amongst the students that chose elementary education major. There were no main differences found in the research done by Hamurcu and others (2002) based on the education types. This may be caused by the resaerches focus on an example group. These suggestions are developed according to the results of this research; It is important for the teachers to be aware of their own intelligence range in order to become a factor in the learning environment. For this, prospective teachers should identify their own MIR and provide appropriate environments for improvement. Expending study range, the prospective students can research on other subjects. The prospective teachers can learn how the students can improve their weak intellingence range and use the strong ones effectively while improving the prospective teachers' occupational formation.

5. REFERENCES

Brualdi, A. C. (1994). Multiple intelligences: Gardner's Theory. http://ericae2.educ.cua.edu/digests/tm 9601.htm.

Checkley, K. (1997). "The First Seven. .. The Eight: A Conversation with howard Gardner". Educational Leadership, vol: 55, issue:1.

Durmaz, H. and Özyıldırım, H. (2005). Fen bilgisi ve sınıf öğretmenliği öğrencilerinin kimya dersine karşı tutumları ve çoklu zeka alanları ile Kimya ve Türkçe derslerindeki başarıları arasındaki ilişkinin incelenmesi. Gazi Üniversitesi Kırşehir Eğitim Fakültesi, Cilt 6, Sayı 1, 67-76.

Gürçay, D. and Eryılmaz, A. (2002). Lise 1. Sınıf Öğrencilerinin Çoklu Zeka alanlarının Tespiti ve Fizik Eğitimi Üzerine Etkileri, Proceedings of V. National Science and Mathematics Symposium, I, 501-506.

Hamurcu, H., Günay, Y. and Özyılmaz, G., (2002). Buca Eğitim Fakültesi Fen Bilgisi ve Sınıf Öğretmenliği Bölümü Öğrencilerinin çoklu zeka Kuramına Dayalı Profilleri, Proceedings of V. National Science and Mathematics Symposium, I, *415-421*.

Hoerr, T. (1998). The Naturalist Intelligence. http://www.newhorizons. org/trm_hoerrmi.html.

Karasar, N. (1999). Bilimsel Araştırma Yöntemi-Kavramlar, İlkeler, Teknikler-. Ankara: Nobel yayın Dağıtım.

Onur, B. (1993). Çocuk ve Ergen Gelişimi. Ankara Üniversitesi, Eğitim Bilimleri Fakültesi, İmge Kitabevi, 1. baskı.

Saban, A. (2001). Çoklu zeka teorisi ve eğitim. Nobel Yayınevi.

Silver, H., Strong, R. & Perini, M. (2000). So Each May Learn "Integrating Learning Styles and Multiple Intelligences. USA: ASCD, 2nd, Alexandria.

Selçuk, Z., Kayılı, H. and Okut, L. (2002). Çoklu Zeka Uygulamaları, Ankara: Nobel Yayın Dağıtım.

Terry, K. and Wayman, M. (1996). Multiple Intelligences Key. http://www.athena.ivv.nasa.gov/curric/weather/adptety/multint.html.

Yavuz, K. E. (2001). Eğitim ve öğretimde çoklu zeka teorisi ve uygulamaları. Ankara: Özel Ceceli Okulları Yayınları.

HIGH SCHOOL STUDENTS' CONCEPTIONS OF NATURE OF SCIENCE

Sevgi Kıngır*, *Selcuk University, ksevgi@metu.edu.tr*
Nurdane Aydemir*, *Atatürk University*
Murat Aydemir*, *Akdeniz University*
Ömer Geban, *Middle East Technical University*
** PhD student at Middle East Technical University*
Middle East Technical University, Faculty of Education, Department of Secondary Science and Mathematics Education, 06531 Cankaya/Ankara, Turkey

▼ Abstract

This study investigated Turkish high school students' views about the nature of science. The participants included 181 high school students (53% female and 47% male) attending to a public high school. Of the participants 61% were at the 9th grade level and 39% were at the 10th grade level. Data were collected utilizing Turkish version of Views on Science-Technology-Society (VOSTS) questionnaire. The modified Turkish version of VOSTS included items regarding science and technology, influence of society on science/technology, influence of science/technology on society, influence of school science on society, characteristics of scientists, social construction of scientific knowledge, social construction of technology and nature of scientific knowledge. Data were analyzed by using frequency distribution of each item. Each statement in a VOSTS item was categorized into one of the three categories: realistic, has-merit and naive. Results of this study indicated that Turkish high school students' views of nature of science are neither clearly contemporary nor clearly traditional; they held mixed views of nature of science. They held contemporary views about the nature of observations, tentativeness of scientific knowledge, and precision and uncertainty in scientific knowledge. On the other hand, they held traditional views about the nature of scientific models and nature of classification scheme. Moreover, this study elicited high school students' misconceptions about the relationship between hypothesis, theory and law. Most of them believed that hypotheses become theories, and theories become laws.

Key Words nature of science, high school students, science education

1. INTRODUCTION

Development of scientific literacy has been the focus of many curricula all around the world in order to meet the goals of science teaching. One of the dimensions of scientific literacy is nature of science. There are various definitions of nature of science but it is commonly defined as the values and assumptions inherent to scientific

knowledge and development of scientific knowledge (Lederman & Zeidler, 1987). There are seven aspects of nature of science that are essential for all individuals to know: distinction between observation and inference; relationship between scientific laws and theories; scientific knowledge is partly based on observations of the natural world; scientific knowledge involves human imagination and creativity; scientific knowledge is partly subjective; scientific knowledge is tentative; and science is culturally and socially embedded (Lederman & Lederman, 2004).

Both students and teachers possess inadequate conceptions of nature of science (Lederman & O'Malley, 1990; Lederman, 1992; Abd-El-Khalick & BouJoude, 1997). The common incorrect ideas regarding nature of science are: theories become laws; hypotheses are educated guesses; there is a general scientific method; evidence leads to sure knowledge; science and its methods provide absolute proof; science is not a creative endeavor; scientists are objective; experiments are the principle route to scientific knowledge; and scientific conclusions are continually reviewed (McComas, 1996). Promoting accurate students' understandings of the nature of science is a primary objective of science education. To enhance students' understanding of nature of science, any science activity can be modified or some aspects of nature of science could be integrated into the lesson explicitly (Lederman & Lederman, 2004). Also, it is important to improve teachers' views on nature of science for effective nature of science instruction.

Identification of students' views on nature of science is the first step for the improvement of their understandings of nature of science. High school students' views about the nature of science were investigated by many researchers. Griffiths and Barry (1993) conducted an interview study to elicit high school students' views about nature of science and found that students held many misunderstandings, e.g., students believed that laws and facts represent certainty but theories are tentative. Kang, Scharmann and Noh (2005) investigated 1702 Korean 6th, 8th and 10th grade students views on the nature of science and concluded that majority of the students possessed an absolutist/empiricist perspective about the nature of science.

1.1. The Problem

The purpose of this study is to determine high school students' conceptions of nature of science and to make it clear whether these conceptions are realistic, has-merit or naive. The results of this study will provide insight about the improvement of high school students' understandings of nature of science.

2. METHOD

2.1. Design of the Study

Since this study aims to elicit high school students' views of nature of science, survey research design was used. Survey research involves researchers asking a large group of people questions about a particular topic or issue (Fraenkel & Wallen, 1996).

2.2. Sample

A total of 181 high school students (53% female and 47% male) attending to a typical public high school in Turkey participated in this study. Of the participants 61% were

at the 9th grade level and 39% were at the 10th grade level. The students' ages ranged from 15 to 17. Moreover, students' socio-economic statuses were examined through education level of their parents and family income. Most of the students' parents (85% mothers and 73% fathers) were not graduated from any university. In their family, generally fathers were working and family income was generally at about 1000 YTL. To sum up, most of the students' socio-economic statuses were low.

2.3. Instrument

In this study, the Views on Science-Technology-Society (VOSTS) questionnaire, developed by Aikenhead, Ryan and Fleming (1989) was used to elicit high school students' views of nature of science. VOSTS is a pool of 114 multiple-choice items that address a broad range of science-technology-society (STS) topics. VOSTS content includes science and technology, influence of society on science/technology, influence of science/technology on society, influence of school science on society, characteristics of scientists, social construction of scientific knowledge, social construction of technology and nature of scientific knowledge. For this study, a total of 25 items were selected from the VOSTS item pool and adapted into Turkish (Doğan Bora & Abd-El-Khalick, in press). The modified Turkish version of VOSTS includes items regarding science (1 item), influence of society on science/technology (2 items), influence of science/technology on society (3 items), characteristics of scientists (3 items), social construction of scientific knowledge (2 items), and nature of scientific knowledge (14 items). The split-half reliability of the modified version of VOSTS was found as 0.72.

Among the several standardized instruments assessing learners' nature of science views, VOSTS questionnaire was preferred because it includes empirically developed multiple choice items. In standardized instruments, researchers assume that there is no ambiguity, that is, students perceive and interpret the test items in the same way as researchers do (Aikenhead & Ryan, 1992). Aikenhead (cited in Aikenhead & Ryan, 1992) investigated likert-type items, written paragraphs, empirically developed multiple-choice items, and semi-structured interviews with respect to the problem of ambiguity. He concluded that likert-type items offered the most inaccurate data. Semi-structured interviews offered the most accurate data but it is very time consuming. Like semi-structured interviews, open-ended items are valid but a great deal of time is required for the collection and analysis of data. Paragraph responses were found ambiguous in about 50% of the cases while empirically developed multiple-choice items were ambiguous in only 20% of the cases. The problem of ambiguity can be diminished by using empirically developed multiple-choice items without time consuming.

2.4. Analysis of Data

In this study, data were analyzed by using frequency distribution of each item. The scoring procedure proposed by Rubba and Harkness (1996) was used to categorize high school students' views of nature of science. Each statement in a VOSTS item was categorized into one of the three categories: realistic, has-merit and naive. A statement is categorized as realistic if it expresses an appropriate view, has-merit if it expresses a number of legitimate points, and naive if it expresses an inappropriate view.

3. RESULTS

High school students' views of nature of science indicated a lack of coherence, that is, some views were consistent with contemporary (realistic) views of the nature of science, and some were consistent with traditional (naive) views of nature of science. Generally, the views of nature of science ranged from naive to realistic. The high school students held has-merit views regarding the definition of science. Most of the students (26%) defined science as 'finding and using knowledge to make this world a better place to live in'. A significant proportion of the students (17%) defined science as 'a body of knowledge, such as principles, laws and theories, which explain the world around us'. Only 14% of the students held contemporary definition of science. There were two items regarding the influence of society on science and technology. In the item concerning ethics, the percentages of high school students' naive views, has-merit views and realistic views were closer to each other. In the item addressing public influence on science and technology, they had realistic views (40.3%) and has-merit views (38.7%). 23% of the students viewed family, schools and community as giving children encouragement and opportunity to become scientists. There were three items about the influence of science and technology on society in which high school students held mixed views. 42% of the students viewed scientists as dealing with all the effects of their experiments which indicates a has-merit view. 28% of the students stated that the decision regarding the future biotechnology in Turkey should be made equally with respect to the viewpoints of scientists, engineers, specialists and informed public, which indicates a contemporary view. Students held realistic views regarding the resolution of social and practical problems. There were three items addressing the characteristics of scientists to which high school students responded differently. It can be said that they had mixed views about the characteristics of scientists. Most of the students thought that personal traits such as imagination, intelligence and honesty were required as well as being open-minded, logical, unbiased and objective in order to become the best scientist. Many students held contemporary views regarding the family and social lives of the scientists but they held traditional views by making distinction between the discoveries of female and male scientists. Moreover, high school students held has-merit views about the social construction of scientific knowledge. Finally, the high school students held mixed views about the nature of scientific knowledge. They held traditional views about the nature of scientific models and nature of classification scheme. 75% of the students viewed scientific models as copies of reality. They held contemporary views about the nature of observations, tentativeness of scientific knowledge, and 'precision and uncertainty in scientific knowledge'. There were three items about hypothesis, theories and laws, and three items about epistemological status of scientific knowledge. High school students generally showed naive views regarding hypotheses, theories and laws; and epistemological status of scientific knowledge. Most of the students believed that scientists discover laws and hypotheses. In the item addressing the relationship among hypotheses, theories and laws, 78.4% of the students had the misconception of 'hypotheses become theories, and theories become laws'.

4. DISCUSSION

The overall results of this study indicated that Turkish high school students' views of nature of science are neither completely contemporary nor completely traditional, that is, they held mixed views of nature of science. They held contemporary views about the nature of observations, tentativeness of scientific knowledge, and 'precision and uncertainty in scientific knowledge'. On the other hand, they held traditional views about the nature of scientific models and nature of classification scheme. These results support earlier findings (Haidar, 1999; Abd-El-Khalick & Lederman, 2000). Haidar (1999) investigated Emirates pre-service and in-service teachers' views about the nature of science and concluded that they held both traditional and constructivist views of nature of science. Likewise, Abd-El-Khalick and Lederman (2000) investigated college students' conceptions of nature of science via open-ended questionnaire with follow-up interviews. At the beginning of the study, they found that most of the participants held inadequate views of nature of science.

Understanding of the nature of science is one of the most common objectives of science education (Kimball, 1967-1968). Students should understand the nature of science because it is crucial for personal decision-making, and effective local and global citizenship (Smith & Scharmann, 1999). This study showed that Turkish high school students did not possess the desired conceptions of nature of science; they had misconceptions and this finding is consistent with the previous findings of other Turkish studies on high school students (Dogan Bora, Arslan & Cakiroglu, 2006). One of the reasons of the inadequacy of students' views of nature of science might be related to the use of laboratory in science courses because students who participated in this research stated that "we do not use laboratory in our science courses". Students' conceptions of nature of science might be enhanced by means of effective laboratory instruction. In the light of the findings of the current research, it is suggested that the effect of laboratory instruction on students' understanding of nature of science might be investigated.

5. REFERENCES

Schunk, D. H. (2001). Social cognitive theory and self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), Second Edition. Self-regulated learning and academic achievement: theoretical perspectives. (pp. 125-151).Hillsdale, NJ: Lawrence Erlbaum Associates.

Abd-El-Khalick, F. & BouJoude, S. (1997). An exploratory study of the knowledge base for science teaching. Journal of Research in Science Teaching, 34(7), 673-699.

Abd-El-Khalick, F. & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: a critical review of the literature. International Journal of Science Education, 22(7), 665-701.

Abd-El-Khalick, F. & Lederman, N. G. (2000). The influence of history of science courses on students' views of nature of science. Journal of Research in Science Teaching, 37(10), 1057-1095.

Aikenhead, G. S. & Ryan, A. G. (1992). The development of a new instrument: "Views on science-technology-society" (VOSTS). Science Education, 76(5), 477-491.

Aikenhead, G. S., Ryan, A. G. & Fleming, R. W. (1989). Views on science-technology-society (form CDN.mc.5). Saskatoon, Canada: Department of Curriculum Studies, University of Saskatchewan.

Doğan Bora, N. & Abd-El-Khalick, F. (in press). Turkish grade 10 students' and science teachers' conceptions of nature of science: A national study. Journal of Research in Science Teaching.

Doğan Bora, N., Arslan, O. & Çakıroğlu, J. (2006). Lise öğrencilerinin bilim ve bilim insanı hakkındaki görüşleri. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 31, 32-44.

Fraenkel, J. R. & Wallen, N. E. (1996). How to design and evaluate research in education. 3rd ed., New York, USA, Mc Grawhill, Inc.

Griffiths, A. K. & Barry, M. (1993). High school students' views about the nature of science. School Science and Mathematics, 93(1), 35-37.

Haidar, A. (1999). Emirates pre-service and in-service teachers' views about the nature of science. International Journal of Science Education, 21(8), 807-822.

Kang, S., Scharmann, L. C. & Noh, T. (2005). Examining students' views on the nature of science: results from Korean 6th, 8th, and 10th graders. Science Education, 89, 314-334.

Kimball, M. E. (1967-1968). Understanding the nature of science: a comparison of scientists and science teachers. Journal of Research in Science Teaching, 5, 110-120.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: a review of the research. Journal of Research in Science Teaching, 29(4), 331-359.

Lederman, N. G. & O'Malley, M. (1990). Students perceptions of tentativeness in science: development, use and sources of change. Science Education, 74(2), 225-239.

Lederman, N. G. & Lederman, J. S. (2004). Revising instruction to teach nature of science. The Science Teacher, 71(9), 36-39.

Lederman, N. G. & Zeidler, D. L. (1987). Science teachers' conceptions of the nature of science: Do they really influence teaching behavior? Science Education, 71(5), 721-734.

McComas, W. F. (1996). Ten myths of science: reexamining what we think we know about the nature of science. School Science and Mathematics, 96(1), 10-16.

Rubba, P. A. & Harkness, W. J. (1996). A new scoring procedure for the Views on Science-Technology-Society instrument. International Journal of Science Education, 18(4), 387-400.

Smith, M. U. & Scharmann, L. C. (1999). Defining versus describing the nature of science: a pragmatic analysis for classroom teachers and science educators. Science Education, 83(4), 493-509.

RESEARCH STUDY OF PERSPECTIVES ON SCIENCE (POS)

Ralph Levinson, Michael Hand, Ruth Amos
Institute of Education, University of London, 20 Bedford Way, London WC1H 0AL
r.levinson@ioe.ac.uk

▼ Abstract

We report on a research study into a new course aimed at 16-19 year olds, Perspectives on Science, where students study the historical, ethical and philosophical aspects of science. The course is unique in that it requires students to write an essay of their choice and to give a spoken presentation. Questionnaires, interviews and observations were used to evaluate the quality of discussion in bringing science knowledge to bear on broader issues and the overall management of the course. The structure of the course generated much high quality discussion consisting of rational argument, commitment to a position and respect for all participants. Preparing a structure and narrative for discussion were essential pre-requisites. Most discussion, however, focused on ethical aspects of science and there was little indication of knowledge and understanding of historical and philosophical aspects. Students and teachers welcomed the open structure of the course and the deep focus on one topic. The main problems were choosing an appropriate topic and selecting sources of information. The course is a useful model for other courses choosing to address broader aspects of science.

Key Words discussion skills, aspects of science, research project

1. INTRODUCTION

Perspectives on Science (POS) is a unique post-16 course of the history, philosophy and ethics of science. It draws on skills and knowledge which will be unfamiliar to many prospective students; the course is assessed through a 6 000 word research-based essay chosen by the student with the advice of a tutor as well as a ten minute oral presentation of the research followed by questioning from tutors and peers. Addressing the history, philosophy and ethical aspects of science introduces many challenges of pedagogy and epistemology. Previous research has shown that science teachers, who are primarily responsible for teaching *POS*, feel tentative and lack confidence when dealing with controversial socio-scientific issues, the nature of science and group discussions (Bryce & Gray, 2004; Levinson, 2004; Levinson & Turner, 2001; Osborne, Duschl, & Fairbrother, 2002). Science has traditionally been perceived as authoritative and instrumental (Ravetz, 1997); knowledge of the underpinning concepts of science has been gained through arduous research which is specialized and expert, its concepts are often counter-intuitive and deal with models and abstract entities which do not reflect the more overt human dimensions of the humanities and the social sciences.

What is more, the higher education of science teachers tends to reflect this epistemic approach: few entrants to the profession have been inducted into those meta-questions which constitute the nature of science (Abd-El-Khalick & Lederman, 2000).

There have also been numerous debates as to how much scientific knowledge one needs to understand a particular historical, philosophical, ethical or socio-scientific question, and that the kind of knowledge needed to make decisions with a science base is very different from the scientific concepts and procedures that young people learn at school (Ryder, 2001). In trying to bring historical, ethical and philosophical questions to science we need to understand that the discourses of these subjects are different from those of science although there are some commonalities, for example, that evidence is crucial to the practice of history and of science but how that evidence is selected and used to answer questions is different in the two domains (Fehn, 1997). Moreover the structure of the curriculum and the specialization of subject areas mean that there are few opportunities for inter-disciplinary collaboration.

Examples of students' research-based essays are:

How would nanotechnology be applied and regulated in modern medicine?

Should we erase memory?

Is it ethically right to keep animals in captivity regardless of the suffering caused?

If we accept incommensurability as defined by Kuhn in 'The structure of scientific revolutions' must we accept scientific relativism?

What is novel about POS are the emphases in the course on discussion, assessment by means of a research paper and oral presentation, and the involvement of teachers with diverse subject specialisms.

2. RESEARCH QUESTIONS

In studying the effectiveness of POS we have focused on how the different disciplines interact in *POS* and identified the role of discussion, dialogue and debate as ***core*** contributing factors to the effectiveness of learning and development of understanding.

There are thus two main research questions

To what extent is *POS* successful in promoting high quality discussion in class and what factors influence this?

How is the research project managed by teachers, students and course personnel and what constitutes good practice in this area?

We see a high quality discussion in a POS class as possessing the following features:

Relevant knowledge and understanding including accurate and purposeful scientific knowledge and historical knowledge which help to answer the research question; an ability to draw on different ethical frameworks and philosophical questions to justify and refute positions; an understanding of the nature of evidence, its relationship to theory building, the tentativeness of evidence in contemporary socio-scientific issues, a grasp of how evidence is selected and interpreted and the social influences which can accompany the ways in which evidence is used (Driver, Leach, Millar, & Scott, 1996; Kuhn, 1991)

Procedural knowledge and skills for discussion such as consistency and rationality in argument including the ability to: draw on appropriate evidence to support a claim

and to identify provisos and counter-positions; expose hidden assumptions and fallacious chains of reasoning; identify the difference between descriptive and normative premises; identify and respond to persuasive language (Bridges, 1979).

Dispositions and virtues associated with the social aspects of discussion where participants are willing to learn as a discursive skill, work collaboratively, sustain an argument in which they are willing to defend a position rather than backing down in the face of disagreement, show respect for others, open-mindedness, commitment to truth and appropriate emotional engagement (Burbules, 1993).

The role of the teacher is crucial here. We see the teacher as having a number of different roles: authoritative as informant, willingness to explore grey areas with students, facilitator and supervisor. How the teacher moves between these roles will vary according to the relationship between the students, pedagogic style and institutional constraints.

3. METHODOLOGY

To illustrate the strengths and possible limitations of pedagogy within the classroom we observed classes discussing topics run by science teachers as well as those organised by the students. We opted for a mixed method research design combining interviews and observations for fine-grained data and questionnaires for a broader perspective. The research design constitutes six principle sources of data: student questionnaires, teacher questionnaires, observation of sessions, teacher interviews and student interviews.

To study what constitutes high quality discussion and those factors which promote it we adduced six criteria of high quality discussion from the literature: knowledge sought for and acquired; deployment of reason; participation; criticality; dialogic requirements and evidence of change in opinion. Evidence was sought for factors promoting these criteria and for blocks to discussion. The model can be represented as in Figure 1:

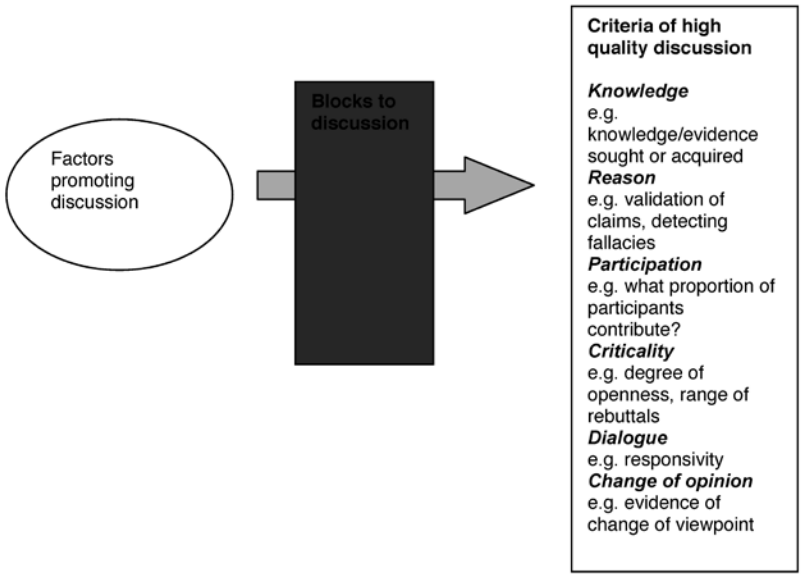


Figure 1 Model of study

3.1 Questionnaires

Student questionnaire covered three areas: the students' *background*.; their *research topics* including motivation, preparation, support, progress, organisation, resources and other learning opportunities; and *broader aspects of the course* including reasons for opting for POS, strengths and areas for improvement, structure and organisation of sessions and duration of the course.

Teacher questionnaires addressed: *personal experience* of teaching the course and support received, including opportunities for professional development; information about the structure and organisation of sessions, size and make-up of teaching groups; *nature of interactions* with students such as help in choosing the research question, use, accessibility and quality of resources, support and guidance given; *assessment* processes and arrangements.

3.2 Observation of sessions and interviews

Five teaching sessions were observed. During the visits teachers were interviewed in greater depth based on issues that emerged from the questionnaires which need further clarification, strategies and approaches towards discussion, 'significant' moments in the session, the pedagogic demands, and any other points that were deemed to be relevant. Focus groups of students were interviewed about approaches to learning, discussion, writing the assignment, preparation for the presentation and development of their communication skills. All discussions and interviews were fully transcribed and analysed. Transcripts were read by the three researchers, themes were inductively derived, tested and iterated.

4. FINDINGS

This research reports on the findings of the cohort of students studying *POS* in 2006-07 and in the first part of 2007-08. 115 student questionnaires were returned from the 2006-07 and 144 questionnaires from the 2007-08 cohort constituting 45% and 85% respectively of the student course population. 14 teachers completed the questionnaires which represents about 70% of those teaching the course. Five discussion sessions were observed.

4.1 Discussions

Observations of discussion sessions, interviews and questionnaires opened different windows onto the opportunities and challenges presented by discussion. The vast majority of students thought the course gave many opportunities for discussion and no students dissented from this. All the teachers felt that students were good listeners during discussions and supplied good reasons for their opinions. They felt students were often emotionally engaged in discussion but dispassionate enough to engage with other viewpoints. On the other hand they felt that discussions occasionally reached an early consensus and were dominated by the same few students. In all the discussions we observed most students who spoke gave reasons for their arguments and drew

on appropriate subject knowledge. Where the teachers tended to control, rather than facilitate discussions, they ensured that all voices were heard and that any misunderstood comments were clarified. They were also adept at drawing out consensus and then presenting opposing points of view. Those discussions which both sustained and developed knowledge had the following characteristics:

- a clear structure and narrative suggesting that they were well-prepared,
- the presence of a teacher or another authoritative figure who could act as facilitator, developer of discussion skills and critical enquirer;
- at least three students who presented different points of view,
- students who were prepared to take extreme points of view and defend them,
- at least one student who clarified any unclear statements,
- and the presence of conflict, i.e. a continuous thread of difference throughout the discussion.

Discussions which were staunched had none of these characteristics, particularly when religious views surfaced and students were content to let matters rest at 'different opinions'. All the discussions we observed were on ethical aspects of science such as abortion and xenotransplantation. Students were adept at using ethical frameworks and concepts but none drew on philosophical or historical concepts to illuminate scientific disagreements. This focus on ethical aspects of science might have been helpful since many students had opinions on these matters as opposed to higher requirements of knowledge of historical and philosophical aspects of science, and it was therefore a good vehicle to develop discussion skills particularly on reasoning, e.g. detecting fallacious arguments.

4.2 Management of the research project

Students begin their research project about one-third of the way through the course. Project titles are negotiated with the tutor and generally they are supervised on an individual basis. Over 70% of the students choose a topic that they find interesting or is of close personal relevance. The large majority of projects are on issues concerned with human reproduction and human health although there is a scattering of projects on investigating paranormal activity, evolution, artificial intelligence, space-universe-time, quantum mechanics and focused philosophical investigations. Tutors report that the two biggest challenges are helping students to focus their research questions on something that is manageable to investigate and to select appropriate resources. Difficulties in focusing on an appropriate research question are exemplified by the following problem a student faced:

'I changed my title about five times. Two weeks before the deadline I had mine changed. . . you don't get bored of it but because you're researching one thing for a whole year you have your original question and then you don't really like that so you do really change it quite a lot.'

In interviews, however, students gave clear and cogent reasons for assessing the validity of sources of information. Half the students found it difficult to locate appropriate sources of information.

Both teachers and students liked the assessment arrangements. Students particularly liked the fact that they could do a course which was not assessed by an examination. The vast majority of students welcomed the opportunity to study a topic in depth and to write an extended essay. Many reported that they found the thinking they had done for the project helped them in university interviews and there is some initial evidence to suggest that students have found the course has helped them in their studies at university. Teachers found the assessment criteria easy and accessible to use and few discrepancies have been reported in marking 6 000 word essays.

The other unique aspect of the course is the presentation which students have to give to their peers on the project. About two-thirds of the students felt confident about giving the presentation and had plenty of opportunities to practice in front of their peers. The criteria for good presentations had been made clear to most students.

5. IMPLICATIONS

The findings suggest that *POS* as a research-based course provides many opportunities for independent and critical thought and that this is welcomed by students and teachers. There therefore might be fertile soil to expand such research-based non-examined courses particularly on meta-scientific and socio-scientific issues and on the relations between science and technology. It was indicative that two teachers mentioned voluntarily that teaching on this course had helped to open up discussion on the nature of science in more traditional science subjects. However, such a course is distinct from the specialisms practitioners normally teach and teachers might not have enough confidence to address all matters competently outside their areas of expertise. There needs to be continuous professional development to support teachers and the infra-structure that goes with this. With a small population course like *POS*, where teachers have a number of opportunities for professional development, this works well but these problems might increase if numbers are expanded. Nearly all teachers and students gained benefit from the course because of its unique structure, the supporting materials and the freedom to think and discuss wider issues about science. With this freedom came rigour which students see lacking in other more general courses. Attempts to standardise the course more closely with other examined science courses might destroy a unique opportunity for open and critical thinking about science.

6. REFERENCES

Abd-El-Khalick, F., & Lederman, N. (2000). Improving science teachers' conceptions of the nature of science: A critical review of the literature. *International Journal of Science Education, 22*(7), 665-701.

Bridges, D. (1979). *Education, democracy and discussion*. Slough: NFER Publishing Company.

Bryce, T., & Gray, D. (2004). Tough acts to follow: the challenges to science teachers presented by biotechnological progress. *International Journal of Science Education, 26*(6), 717 - 733.

Burbules, N. (1993). *Dialogue in teaching: theory and practice*. New York: Teachers College Press.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham: Open University Press.

Fehn, B. (1997). *Historical thinking ability among talented math and science students: an exploratory study.* Paper presented at the Annual meeting of the American Research Association, Chicago.

Kuhn, D. (1991). *The Skills of Argument*. Cambridge: Cambridge University Press.

Levinson, R. (2004). Teaching bioethics in science: crossing a bridge too far? *Canadian Journal of Science, Mathematics and Technology Education, 4*(3), 353-369.

Levinson, R., & Turner, S. (2001). *Valuable lessons*. London: The Wellcome Trust.

Osborne, J., Duschl, R., & Fairbrother, R. (2002). *Breaking the Mould? Teaching Science for Public Understanding*. London: The Nuffield Foundation.

Ravetz, J. (1997). Simple scientific truths and uncertain policy realities: implications for science education. *Studies in Science Education, 30*, 5-18.

Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education, 36*, 1-44.

ACKNOWLEDGEMENTS

We are very grateful to the Science Education Group at the University of York for funding and supporting this project. Many thanks also go to the students and teachers at the POS centres who answered the questionnaires and participated in interviews.

USE OF CONCEPT CARTOONS AS AN ASSESSMENT TOOL IN PHYSICS EDUCATION

Şebnem Kandil İngeç, Mümin Sever
Gazi University, Turkey
singec@gazi.edu.tr
mumin.severr@gmail.com

▼ Abstract

There are numerous studies in literature related to the use of cartoons in physics, chemistry and mathematics education. However the studies on the use of cartoons as an alternative assessment tool are highly limited. This study is concerned with the use of cartoons as an alternative assessment method. There were five cartoons prepared related to impulse, momentum, impulse-momentum equation, conservation of momentum and vector property of momentum. The study revealed that physics pre-service teachers failed to emphasize the fact that momentum is vector quantity. Also the fact that only 15% of the participants scored a full point for the caricature related to the conservation of momentum is an issue which should seriously be considered. This shows us that there are some problems in the application of the conservation of momentum to everyday examples.

Key Words Concept cartoonsimpulse, momentum, physics education

1. INTRODUCTION

There are numerous studies in literature related to the use of cartoons in physics, chemistry and mathematics education. However the studies on the use of cartoons as an alternative assessment tool are highly limited. This study is concerned with the use of cartoons as an alternative assessment method. The topic chosen for this purpose were momentum and impulse which are thought to be easy to conceive but involves some difficulties in explanation. This study which aims at introducing cartoons as an alternative assessment tool in physics education is expected to fill an important gap in literature

1.1. Concept cartoons

There are numerous methods being developed in order to promote the construction of knowledge. One of these methods is concept cartoons (Keogh and Naylor, 1999). Cartoons are visual tools which combines exaggeratedly drawn characters with dialogues related to everyday events in a humorous and satirical fashion (Keogh and Naylor, 2000; Naylor, Downing and Keogh, 2001; Stephenson and Warwick, 2002; Coll, 2005). Concept cartoons are related to a special topic in science. There are three,

four or five students stating different opinions about a specific topic. The opinions are mainly misconceptions however one of them is scientifically acceptable. The others are not illogical and based upon the experiences of the students (Stephenson, P; 2002). The fact that people realized the effectiveness of the use of characters in dialogue with each other in education purposes was an important mile-stone in the development of concept cartoons. Cartoons enable the presentation of an example of a misconception in class room atmosphere by illustrating the misconceptions of the students in their minds at a much wider perspective (İngeç et al., 2006). In concept cartoons the opinions taken from everyday life related to the topic are presented in an argumentative manner. The learners are then asked to argue with the characters (Kabapınar, 2005). According to Dabell (2004) concept cartoons help the students to question their thoughts, solve the problem they encounter in their everyday lives, broaden their horizons and provide different perspectives for the events. This technique which was developed in 1990s did not receive the interest it deserves in our country until recent times. The studies carried out in recent times revealed the fact that the use of concept caricature would have a very positive effect on science education. Concept caricature may conveniently be used in classroom in order to promote the participation of the students and create a motivating atmosphere (Keogh an Naylor, 1999; Chambers and Andre, 1997; Keogh et al., 2000).

2. METHOD

In this study concept cartoons and achievement test were used. There were five cartoons prepared related to impulse, momentum, impulse-momentum equation, conservation of momentum and vector property of momentum. There were three experts consulted in the preparation of the cartoons. The participants were also subjected to 21- true or false question test prepared by H.Ş. Kızılcık. The test was analyzed using a classical item analysis approach. The reliability of the test was estimated by the use of Kuder-Richardson Formula 20 and the reliability coefficient was found as 0.53. The validity of test was verified by at least four experts in the field of physics. A total of 52 teacher candidates participated in the study. The concept cartoons which contained five study sheets were distributed one by one and they were collected in the same order without allowing the participants to go back to their previous answers. The participants were then subjected to an achievement test.

2.1. Scoring concept cartoons

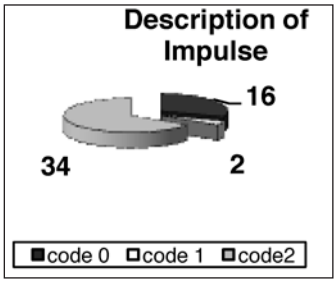
The participants were asked to write down the character that they agree together with the reasons. In two of the cartoons the answer was not given in the choices and it was left to the participants to write it down. The concept cartoons were scored on three categories as: [0]: Ones agree with the wrong character or left the box empty.

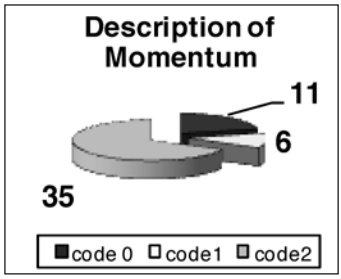
[1]: The ones agree with the right character but failed to state the exact reasons. [2]: The ones agree with the right character and provide the answers which match with the physical descriptions.

3. RESULTS

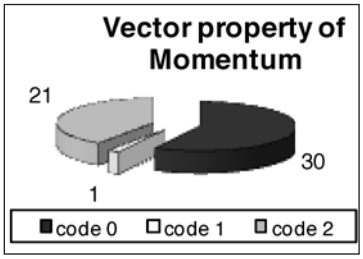
3.1. The data obtained as a result of the assessment of concept cartoons

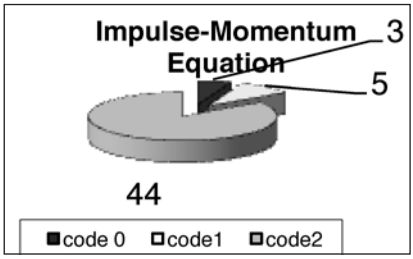
- 65% of the students gave the right and 30 % of the student gave the wrong answer to cartoons related to the description of impulse. The students have the opinion that the impulse is described by short term interactions.



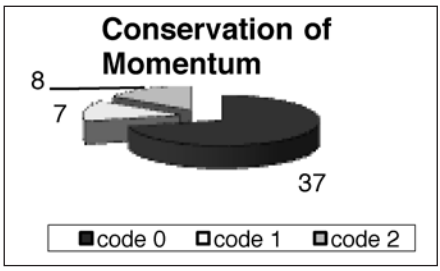


- 67.3 % of the participants scored two, 11.5 % scored one and 21.2 % of the participants scored zero points for the cartoons related to the description of momentum. The participants thought that the speed would be independent of the mass in projectile based on the conservation of energy and neglected the fact that the process was a problem of momentum.
- 57.7 % of the participants scored full two points for the cartoons related to the vector property of momentum. The ratios of the ones who scored one and zero points were 1.9% and 40.4%. The participants thought that momentum is preserved in non elastic collisions. It was also observed that the participants took momentum as a scalar quantity and failed to take the its vector property into account.





- 84.4 % of the participants scored full two points for the cartoons related to Impulse-Momentum Equation. 9.6 % of the participants scored one and 5.8 of them scored zero points. Most of the participants explained the phenomenon giving example from the everyday life.
- The ratios of the participants who scored full, one and zero points for the cartoons related to the conservation of momentum were 15.4%, 13.5% and 71.1% respectively. It was apparent that the participants had the misconception that the momentum is preserved in all types of collisions and neglected the internal and external forces.



3.1. The data obtained from the achievement test

The mean total test score of the participants related to impulse, momentum, impulse-momentum equation, vector property of momentum and conservation of momentum was 13.06. The corresponding value obtained from the cartoons was 5.87. The correlation coefficient between the cartoon and test scores was 0.14 indicating a positive and weak relation. The value of Cohen effect was calculated as 0.83. This shows that there is a highly significant difference between two scores showing that there is not a significant correlation between them.

Description of Impulse

The Pearson correlation coefficient between the achievement test scores and concept cartoon about description of impulse scores were found 0,58 indicating positive and moderate relations. Distribution of the normalization scores presented in Figure 1.

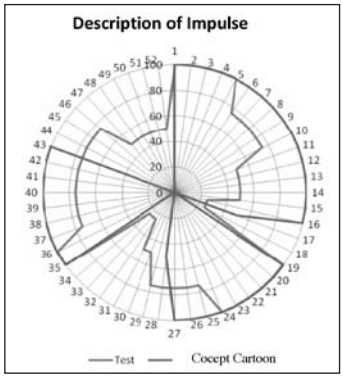


Figure 1 Distribution of the achievement test scores

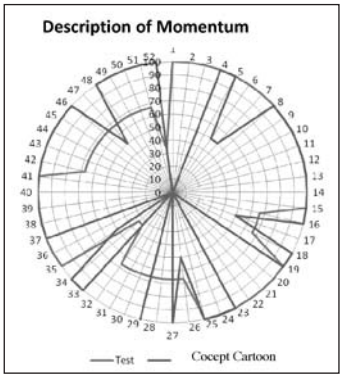


Figure 2 Distribution of the scores the achievement test scores and

and concept cartoon about description of impulse scores concept cartoon about description of momentum scores

Description of Momentum

The Pearson correlation coefficient between the achievement test scores and concept cartoon about description of momentum scores were found -0,12 indicating negative and weak relations. Distribution of the normalization scores presented in Figure 2.

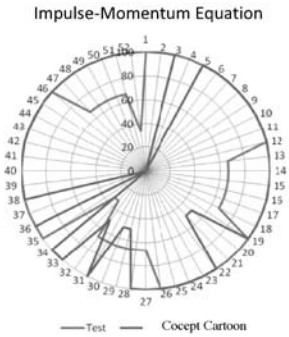


Figure 3

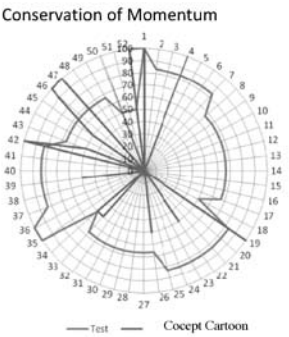


Figure 4

Impulse-Momentum Equation

The Pearson correlation coefficient between the achievement test scores and concept cartoon about impulse-momentum equation scores were found -0,11 indicating negative and weak relations. Distribution of the normalization scores presented in Figure 3.

Conservation of Momentum

The Pearson correlation coefficient between the achievement test scores and concept cartoon about conservation of momentum scores were found -0,06 indicating negative and weak relations between them. Distribution of the normalization scores presented in Figure 4.

Vector property of Momentum

The Pearson correlation coefficient between the achievement test scores and concept cartoon about vector property of momentum scores were found 0,20 indicating positive and weak relations. Distribution of the normalization scores presented in Figure 5.

Figure 5 Distribution of the scores the achievement test scores and concept cartoon about vector property of momentum scores

4. DISCUSSION

The study revealed that physics pre-service teachers failed to emphasize the fact that momentum is vector quantity. Also the fact that only 15% of the participants scored

a full point for the caricature related to the conservation of momentum is an issue which should seriously be considered. This shows us that there are some problems in the application of the conservation of momentum to everyday examples. As determined by Graham and Berry (1996) there are two possible reasons for this outcome. The first is that some textbooks and teachers do not emphasis on and provide into two dimensions sufficiently. So, some students do not recognize momentum as a vector quantity. They therefore are not able to explain the conservation of momentum. The second is that this is an area of considerable difficulty. Another reason for ignoring the vector aspects of momentum is that some textbooks and teachers do not give sufficient examples for the cases where momentum is conserved or not conserved. The students are unable to perceive the vector property of momentum since the text books in Turkey contain only examples where the momentum is conserved. It is necessary that the role and importance of internal/external forces in collisions should be underlined in teaching conservation of momentum and examples should be given for both cases where momentum is conserved or not conserved. The use of concept cartoons as an alternative assessment tool will help the measurement of the academic achievements of the students and help them to become questioning individuals since they can easily utilize the concept cartoons in their everyday lives. Concept maps may also constitute an important step in the determination and elimination of misconceptions since they provide the opportunity to discuss the reasons behind these misconceptions.

5. REFERENCES

Chambers, S. and Andre, T. (1997). Gender, prior knowledge, interest and experience in electricity and conceptual change text manipulations in learning about direct current. Journal of Research in Science Teaching, 34,107-123.

Coll, R. K. (2005). The Role of Models/and Analogies in Science Education: Implications from Research. International Journal of Science Education. 27(2). 183-198.

Dabell, J. (2004). The Maths Coordinator's File- Using Concept Cartoons. London: PFP Publishing.

İngeç, Ş.K., Yıldız, İ. and Ünlü, P., "Kavram Karikatürlerinin Kavram Yanılgısı Tespitinde Kullanılması: Düzgün Dairesel Hareket", VII. National Science and Mathematics Education Conference, 6-8 Eylül 2006, Ankara.

Kabapınar, F. (2005). Effectiveness of Teaching Via Concept Cartoons From the Point of View of Constructivist Approach. Kuram ve Uygulamada E_itim Bilimleri Dergisi. 5(1). 135- 146.

Keogh, B. ve Naylor, S. (1999). Concept Cartoons, Teaching and Learning in Science: an Evaluation. International Journal of Science Education. 21(4). 431- 446.

Keogh, B. ve Naylor, S. (2000). Teacher and Learning in Science Using Concept Cartoons: Why Dennis Wants to Stay in at Playtime. Australian Primary and Junior Science Journal. 16(3).

Keogh, B., Naylor, S., de Boo, M. ve Feasey, R. (2001). (Ed: B, Helgard) Research in Science Education- Past, Present and Future, Formative Assesment Using Concept Cartoons: Initial Teacher Training in the UK. Hingham, USA: Kluwer Academic Publishers.

Keogh, B., Naylor, S. ve Downing, B. (2003). Children's Interactions in the Classroom: Argumentation in Primary Science. Noordwijkerhout, Netherlands: 4th European Science Education Research Association Conference.

Naylor, S., Downing, B. ve Keogh, B. (2001). An Empirical Study of Argumentation in Primary Science, Using Concept Cartoons as The Stimulus. Greece, Thessaloniki: 3rd European Science Education Research Association Conference.

Stephenson, P. ve Warwick, P. (2002). Using Concept Cartoons to Support Progression in Students' Understanding of Light. Physics Education. 37(2). 135-141.

LEARNING OBJECT IN THE CLASSROOM AS A TOOL IN SCIENCE TEACHING AT ELEMENTARY SCHOOL.

Dalva Mariana Affonso
Master Degree Student in Science Education, São Paulo State University – UNESP/Bauru.
Dr. Paulo Valle street, nº 2-37
dalva.mariana@gmail.com

Wilson Massashiro Yonezawa
Assistant Professor, Department of Computer Science, São Paulo State University – UNESP/Bauru

▼ Abstract

A contemporary challenge is in front of science education: is it educated students able to realize the relationship between science and technology? This paper will show how computer technology can be used as a tool for science teaching. The technology discussed here is a Digital Learning Object about the human digestive system. The students have your own ideas about the digestive system and these ideas are often discussed between teacher and the students. Our findings has suggested that computer technology can create new teaching possibilities. In addition the Learning Object has a significant effect on development scientific concepts.

Key Words science education, Digital Learning Object, Zone of Proximal Development.

1. INTRODUCTION

Studies has suggested that technology can create new teaching possibilities (KOZULIN, 2003; BANNAN-RITLAND, 2000; WILEY, 2001). In addition the Learning Object has a significant effect on the of development scientific concepts.

First of all, we need to understand the role of technology interactions in the development of scientific concepts. The discussions about the students' concepts showed in classroom enables investigate and perceive the cognitive components of science.

The research question was involved with the use of a Learning Object (LO) as tool in the of development scientific concepts by students, i. e. to understand the assimilation of nutrients by the human body through the digestive system.

LO can be used to increase students skills in many subjects and the science is one of them. We can found several ideas about what is a LO. In this work we used Wiley´s definition for LO. Wiley (2001) states "Learning objects are defined here as any entity, digital or non-digital, which can be used re-used or referenced during technology supported learning."

In order to achieve the influence of LO in the classroom, we must look at authentic processes and environments, not artificial ones in which the student is isolated, un-

able to obtain feedback, encouragement, questionament or guidance through technology. Perhaps the best and most compatible, theoretical perspective from which to address these issues is from the Social Learning Theory. This theory raises culturally media-oriented questions and contents that "children solve practical tasks with the help of their speech, as well as their eyes and hands" (Vygotsky, 1978, p. 26).

Lev Vygotsky (1978), who developed the Social Learning Theory, explained the role of the biological and social psychological development by a principle referred to as the general law of genetic development. This law states that cultural development occurs first at the social level and then on the internal level. Due the fact that "the two processes that make up development are mutually dependent and interactive" there is a need for the development of methodology to study these processes (Vygotsky, 1978, p. 81).

We are interessed at which social theorist could examine the developmental processes at the individuals Zone of Proximal Development (ZPD). The ZPD are levels of development that with the aid of adults or more "competent peers" (i.e. social interactions) students can solve problems that are beyond their capabilities (Vygotsky, 1978). These interactions and activities that occur around (or slightly beyond) the ZPD are what, Vygotsky (1978) claims, fosters development.

The use of LO as a tool in science class intend to know how students from Elementary school could be help with tool in their class daily. Looking at some technology interactions obtained as students perform an activity, beyond their ZPD, or what they could accomplish on their own, should show us how students talk to each other in ways that foster science development could emerge. This examination should also demonstrate which benefits students could obtain from all those technology interactions looking at shifts in the internalization of scientific concepts through their own work.

2. METHODOLOGY AND PROCEDURE

The methodology used in this research was qualitative type, which contain detail data and they are related to people, places and talk, and it demand complex statistic treatment (Bogdan & Biklen, 1994).

The meaning human digestive system was investigated using the Vygotsky' socioconstrutivism theory through for educational intervention with and without the LO. Besides Vygotsky's theory was used the evaluation as regulation process referred by Pujol (200-?), that methodology defends evaluation should happen in all teaching process. Second her, one evaluation do not represent spontaneous concept for the student.

The subjects were 5 seventh-grade students (all female). The classes had a 50 minutes weekly class period attneded by the same teacher. The public elementary school is in outskirts of Bauru city, located at São Paulo state, Brazil. The majority of children from this neighborhood have are poor income and according to coordinator school they presented many difficulties at learning,

So, the research was divided in three phases (Figure 1). The first phase of the project was realized without use the LO. So that, to the students were given pre-test measuring scientific concepts about digestive system by asking them to draw or to write a little text from the question: "What is your think understanding about what is happened with food when you put it in your mouth?". Students were given a 35

minute time limit to develop the activity. Students were not allowed to talk between with otehr while taking the test. On the next class, the same question was repeated but in this activity the students need to discuss between them and they should give one answer that pleased them. A week later the phase two was put in practice, students were asked to use the LO in the computer lab. Finally, the third phase occur after some class using the LO at the students were given the question from beggining, however the students could look the LO to respond. Each class session was transcripted and all physical and verbal interactions between students were recorded.

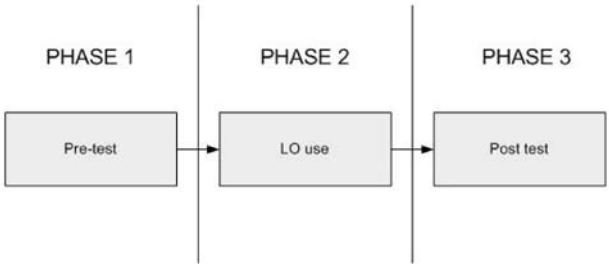


Figure 1 Research phases.

CONSTRUCTION OF LO

The LO called "Route food: from farm to digestive system" constitutes a proposal of educational resource for science class. This proposal is compatible with educational construtivists parctices. LO was prepared having human digestive system as a goal. Further, the digestion context emphasized solid food particles are absorbed into the circulatory system (liquid), which delivers the particles to all cells of the body (Figure 2). Furthermore, environmental and social themes were deal.

This LO presents simulations about some process that occur in the human digestive system and it is divided in three parts: chew, it where presented the use of a teeth to bite a food in the mouth into small pieces so that it can be swallowed; digestion, the stomach then digests the food, changing the food into the substances that your body needs; in the absorption process where the nutrients takes in a substance, form of energy or liquid. Besides, the LO shows how the food leave the farm and it how arrive at town (Figure 3).

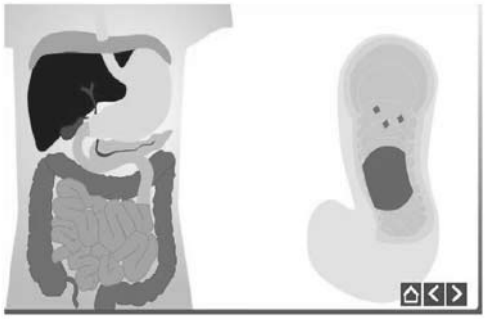


Figure 2 LO screen about absorption process.

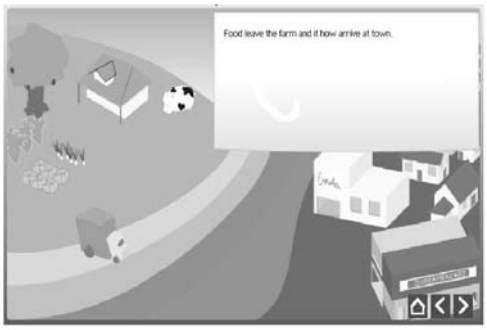


Figure 3 LO screen showing the food leave the farm and it how arrive at town.

For the construction of LO' contents was used a conceptual map plus the instructional design by Reigeluth. Second this author, the instruction should be explained to student like something to make difference for a significative learning (Reigeluth, 1983).

3. RESULTS

The results of the pre-test showed that scientific concepts were not obtained in the tests. The interactions observe during the class provide some interesting results. Students with concepts developed did not initiate interactions with their peers, were questioned frequently and spent less time than any other engaged in the activity. During the activities in computer, each student was able to interact with your peer or with the teacher about the topic it was learning. Some interesting changes were evident in the development of scientific concepts from the post-test. The research question was not answered, but students developed the concepts about the name organs from this system.

After using LO, we realized that students' answers attempted to link transportation nutrients to the circulatory system. As result they expressed that some kind of transformation had occurred, but the lack of concepts denied them to respond correctly.

Moreover, we realized that the activities gave them (the studends) opportunities to use scientific concepts daily life decision. Zabala (1998) call this as "worth and knowledge integrations".

The ZPD in our point of view is an incognito and it coul be seen as a 'bridge' between the real development and the potencial development (Figure 4). The real development is the student's knowledge and the potencial development is the knowledge which student can reach. Besides, we considered that to student reach the potencial development some kind of mediation should occur, for example a teacher helping the student in a resolution of a problem.

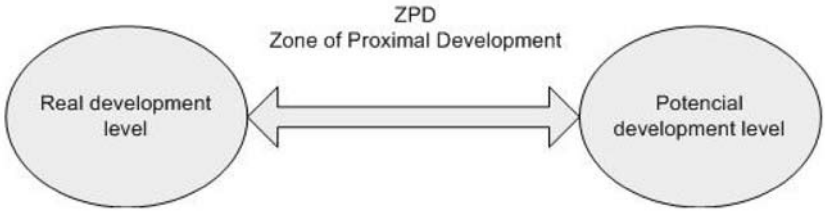


Figure 4 ZPD position accordin to Vygotskyan theory.

4. CONCLUSIONS

Are the interactions supporte by computer technology and the consequent development of scientific concepts interdependent and interactive? A comparative analysis of the data collected in these work suggest that there is a connection between peer-to-peer interactions and development of scientific concepts.

Students, according to pre-test scores, performed amaximum interactions with technology and to their peers and showed little increase in the development of concepts. Moreover, the transcripted sessions did show that students interacted frequently with their peers, by asking and answering some questions.

The curricular grade has to address the student engagement in "collaborative" processes where they can perform activities beyond their individual capabilities. Due to the possibility to foster scientific growth through peer-to-peer interactions, we can introduced some more challenging and advanced curricular grade guidelines that can promote peer-to-peer collaboration. Performing an activity in "collaboration" with their peers and beyond their ZPD the student can foster their scientific development and there are some needs to promove a re-examination of curriculum models which depend upon Piagetian theories of development.

Science teachers also need to be aware about the types of interactions students need in the classroom environment that can lead to encourage in the scientific development. The old days of the "silent" classroom are over and unfortunately, for those teachers who like silence, the activity that tends to encourage scientific development in the classroom enabling the discussion with their peers,. LO in classrooms could be an alternative choice to change the classroom environment because students can be interct with each other through this technology. Science teachers need to examine their activities in a Vygotskian prospective, which have been shown to be effective in the fostering scientific development, and how they can be applied the LO and others technologies in science education curriculum.

5. FUTURE WORKS

The focus on this work was out of tiny numbers of means but the several contents that LO propose, such as trophic networks, the agrochemicals used in farming could be explored in new projects from central idea the reusability of LO: the use of the technologies employed in the confection this tool plus the know-how got in this work.

In future investigations the students' understanding about human digestive system concepts could be more detailed through of evaluations more complete and deeper. For example, the confection of concepts maps for the students could be an useful strategy to discover more details about the organization these concepts in student's cognitive structure.

Our experience with the educational proposal become possible to recommend that it should invest on development and evaluation of materials in form of Learning Objects structured according to educational theories. It should include in these materials orientation for it educational use and it was deeper in topics about biological process. These educational products could be planned for use in presence class or to attend distance learning courses mediated by internet.

6. REFERENCES

BANNAN-RITLAND, Brenda; DABBAGH, Nada; MURPHY, Kate. 2000. **Learning object systems as constructivist learning environments:** Related assumptions, theories, and applications. In: Wiley, David A. (Ed.). **The Instructional Use of Learning Objects:** Online Version. Available on <http://reusability.org/read/chapters/bannan-ritland.doc>. Access: 23 jan. 2008.

BOGDAN, R. & BIKLEN, S. 1994. **Investigação Qualitativa em Educação:** Uma Introdução à Teoria e aos Métodos. Porto: Porto Editora.

KOZULIN, Alex. 2003. Psychological tools and mediated learning. In: _____. **Vygotsky's Educational Theory in Cultural Context.** p. 15-39. New York: Cambridge University Press.

PUJOL, R. M. 200-?. **Didáctica de las ciencias en la educación primaria.** Madrid: Síntesis Educación.

REIGELUTH, C.M. 1983. **Instructional Design Theories and Models.** New Jersey: Lawrence Erlbaum Associates.

VYGOTSKY, L. 1978. **Mind in Society**: The Development of Higher Psychological Processes. Cambridge: Harvard University Press.

WILEY, D. A. 2001. **Connecting learning objects to instructional design theory:** A definition a metaphor, and a taxonomy. Available on http://reusability.org/read/chapters/wiley.doc. Access in 21 apr 2006.

ZABALA, A. 1998.**A prática educativa:** como ensinar. Porto Alegre: Artmed.

7. ACKNOWLEDGEMENTS

Acknowledgements to: CAPES, Pós-Graduação em Educação para a Ciência from São Paulo State University – UNESP/Bauru, Francisco Alves Brizola Elementary School – Bauru/Brazil.

GENDER EFFECTS ON STRATEGY USE IN A PHYSICS COURSE

Gamze Sezgin Selçuk, Serap Çalışkan, Mehmet Şahin
Department of Secondary Science and Mathematics Education,
Dokuz Eylül University, Buca, 35160, Izmir, TURKEY

▼ Abstract

This study has examined gender effects on learning strategy use of student teachers in an introductory physics course. In this study, pretest-posttest quasi-experimental design with equivalent control group was used. Two groups of student teachers (n=75) who took Physics II course participated in the study. In the strategy group, questioning, summarizing plus graphic organizers were taught. No strategies were taught to the control group. Data of the study were collected by the Learning Strategies Scale Used in Physics. Findings of the study indicate that gender is effective on strategy use. The implications of these results for physics instruction are discussed.

Key Words gender, learning strategy instruction, physics

1. INTRODUCTION

Learning strategies can be defined as behaviors and thoughts that a learner engages in during learning and that are intended to influence the learner's encoding process (Weinstein & Mayer, 1986). These strategies range from simple study skills, such as underlining a main idea, to complex thought processes, such as using analogies to relate prior knowledge to new information (Weinstein, Ridley, Dahl, Weber, 1989). Learning strategies is one of topics that instructors from all around the world attribute utmost importance. When strategy literature is examined, it is seen that innumerous studies have been done and many articles and books have been published. The results of gender studies indicate various different effects on strategy use. Some reported no significant difference between males and females in strategy use, while others indicated positive effects in favor of females, still others reported positive effects in favor of males. The discrepancies among the results of many studies suggest that there is need for more research about the relationships of gender and strategy use on different subjects and grade levels. In addition, there are few studies about this topic in physics (e.g., Austin & Shore, 1995; Harper et al., 2003). Unfortunately, learning strategy usage is neglected in Turkey. It is seen that studies in this field are very few. Furthermore, this subject has not been given importance sufficiently in our training system. It is considered an important necessity that more studies on learning strategies should be conducted and programs should be implemented oriented towards the strategy learning in physics. Due to small number of studies in physics and differing results of

gender studies we are compelled to suggest that there is need for more studies about strategy learning and gender.

It is recognized that literature on the effects of gender on strategy use focused on mathematics and foreign language. For instance, Sheorey (1999) investigated Indian college students' language learning strategies. It was found that female students used learning strategies significantly more often than male students and that students' cultural and educational background has affected the strategies they have used. Oxford, Park-Oh, Ito, and Sumrall (1993) determined that females tended to use cognitive, social, and affective strategies more often than males. Gallagher and De Lisi (1994) reported that female students used more traditional problem solving strategies than male students in a mathematics class. Male students were found to use more untraditional strategies. The present study focuses on learning strategy instruction in physics.

In this study, gender effects on strategy use of student teachers in an introductory physics course were examined. The following research question was posed: Are there significant differences among the student teachers' strategy use according to their gender in an introductory physics course?

2. METHOD

2.1. Participants

The participants of this study consisted of 75 second-grade student teachers (strategy group, n=37, male: 25 and female:12; control group, n=38, male: 25 and female:13) who were enrolled in the Department of Elementary Mathematics Education (EME) of Faculty of Education in Dokuz Eylül University in Izmir (Turkey). All the participants who were enrolled in a Physics II course (a spring semester course) were included in this study.

2.2. Research Design

In this study, pretest-posttest quasi-experimental design with equivalent control group was used. There were one control and one experimental group, namely, the strategy group. Since the classes were equivalent, they were assigned randomly as strategy and control groups. The strategy group received strategy plus traditional instruction and the control group received only traditional instruction (i.e., without the strategy instruction emphasis). Both groups were tested before and after the intervention to measure their learning strategy use.

2.3. Data Collection

The data of this study were collected by Learning Strategies Scale Used in Physics (LSSUP). This scale was developed as a part of this study to determine the learning strategies students use in physics classes. Scale contains 5 options of "Always", "Often", "Sometimes", "Rarely" and "Never" with Likert-type items. Factor analysis was carried out to determine the dimensions of the scale. Items in the scale are grouped in 7 dimensions and can explain 51 % of total variability. The names of the dimensions are as

follows: complex elaboration (α=0.90, 18 items), comprehension monitoring (α=0.77, 6 items), complex rehearsal (α=0.78, 7 items), basic organizational (α=0.68, 5items), basic elaboration (α=0.74, 4 items), complex organizational (α=0.78, 3 items), and requesting assistance (α=0.65, 3 items). The items of the scale were numbered as 5, 4, 3, 2, and 1 starting from Always to Never. Cronbach's Alpha reliability coefficient of the scale is 0.93.

2.4. Procedure

The study was conducted during the spring semester in an introductory Physics II course. The duration of the study was eight weeks from March to May. Pretest measures of physics achievement and strategy use were collected in the first week of the spring semester. In order not to influence the natural atmosphere of the classes students were not noticed about the study. The total instruction time for the control and the experimental groups was the same. During the intervention, the strategy group received explicit strategy plus traditional instruction in whole-class format for four class hours (45-minute) a week. Before starting the planned treatment of the subjects, training was given on *questioning strategy, summarizing strategy* and *graphic organizers* in the process of research. Ciardello's TeachQuest technique (1998) was used in the instruction of the questioning strategy. In order to teach summarizing strategy Rule-Based Summarizing technique developed by Brown et al. (1981) was used. Classical treatment steps are applied during instruction of graphic organizers used for the purpose of summarizing in the study. This training was carried out in eight class hours (360 minutes) in a period of one week. While the strategy training was applied at strategy group, no study relating strategy instruction was carried out in control group. During this period, conventional teaching methods were used in the control group concerning the topics in strategy training program. During experimental treatment, lecture method was used in both groups; furthermore questioning and summarizing tasks were applied in the strategy group. During the experiment, subjects studied the *Questioning* and *Summarizing* Sheets prepared by the researcher (GSS).

2.5. Analysis of Data

The collected data from the Learning Strategies Scale used in Physics were analyzed by SPSS. Frequency (*n*), percentage (%), mean (*M*), standard deviation (*SD*), and Variance Analysis (ANOVA) were employed.

3. RESULTS

In order to examine gender effects on strategy use, firstly, student teachers were divided into four groups according to their gender. The groups were as follows: Strategy Group (female), Strategy Group (male), Control Group (female), and Control Group (male). Then, means and standard deviations of premeasurement scores of "Learning Strategies Scale Used in Physics" were calculated (see Table 2).

Table 1 Means and Standard Deviations for the Premeasurement Scores

Sub-scales	Groups	n	M	SD
Complex Elaboration	Strategy Group (female)	25	58.28	7.62
	Strategy Group (male)	12	60.00	11.80
	Control Group (female)	25	56.60	8.63
	Control Group (male)	13	59.61	6.29
Comprehension Monitoring	Strategy Group (female)	25	18.72	3.40
	Strategy Group (male)	12	18.58	3.17
	Control Group (female)	25	19.24	4.20
	Control Group (male)	13	18.15	2.91
Complex Rehearsal	Strategy Group (female)	25	24.20	3.44
	Strategy Group (male)	12	22.91	3.63
	Control Group (female)	25	25.08	4.68
	Control Group (male)	13	25.84	3.91
Basic Organizational	Strategy Group (female)	25	19.16	2.65
	Strategy Group (male)	12	16.83	2.40
	Control Group (female)	25	18.20	4.17
	Control Group (male)	13	16.77	3.39
Basic Elaboration	Strategy Group (female)	25	14.68	2.64
	Strategy Group (male)	12	13.41	3.26
	Control Group (female)	25	14.04	3.50
	Control Group (male)	13	12.31	2.32
Complex Organizational	Strategy Group (female)	25	9.80	2.87
	Strategy Group (male)	12	8.58	2.99
	Control Group (female)	25	8.88	2.99
	Control Group (male)	13	8.84	2.76
Requesting Assistance	Strategy Group (female)	25	9.68	2.92
	Strategy Group (male)	12	9.50	2.54
	Control Group (female)	25	10.20	2.78
	Control Group (male)	13	10.38	1.98
Scale	Strategy Group (female)	25	154.52	17.77
	Strategy Group (male)	12	149.83	24.32
	Control Group (female)	25	152.24	21.76
	Control Group (male)	13	151.92	15.58

Variance Analyses were conducted to determine if there were significant differences between the means of the groups. Results are presented in Table 3.

Table 2 Results of Variance Analyses for Premeasurement Scores

Sub-scales	Source of Variance	Sum of squares	df	Mean Square	F	Significance
Complex Elaboration	BG	129.03	3	43.01	0.58	No Sign. Diff.
	WG	5190.11	71	73.10		
	T	5319.14	74			
Comprehension Monitoring	BG	10.93	3	3.64	0.28	No Sign. Diff.
	WG	914.20	71	12.87		
	T	925.14	74			
Complex Rehearsal	BG	63.89	3	21.29	1.32	No Sign. Diff.
	WG	1138.45	71	16.03		
	T	1202.34	74			
Basic Organizational	BG	70.45	3	23.48	2.11	No Sign. Diff.
	WG	789.33	71	11.11		
	T	859.78	74			
Basic Elaboration	BG	51.30	3	17.10	1.88	No Sign. Diff.
	WG	644.08	71	9.07		
	T	695.38	74			
Complex Organizational	BG	17.42	3	5.80	0.68	No Sign. Diff.
	WG	603.25	71	8.49		
	T	620.66	74			
Requesting Assistance	BG	8.27	3	2.75	0.38	No Sign. Diff.
	WG	509.51	71	7.17		
	T	517.78	74			
Scale	BG	193.09	3	64.36	0.16	No Sign. Diff.
	WG	28363.39	71	399.48		
	T	28556.48	74			

***Note*:** BG=Between Groups, WG=Within Groups, T=Total (*p<0.05)

Analysis showed that there were no significant differences between the groups' strategy use in all sub-scales and in the whole scale. Thus, all groups were equal on the aspect of strategy use before the intervention. Mean and standard deviation values of scores of students obtained from LSSUP and sub-scales were calculated (see Table 4) and Variance Analyses were conducted to see if the differences between means were significant. Results of Variance Analyses are given in Table 5.

Table 3 Means and Standard Deviations for the Postmeasurement Scores

Sub-scales	Groups	n	M	SD
Complex Elaboration	Strategy Group (female)	25	67.40	8.56
	Strategy Group (male)	12	64.50	8.66
	Control Group (female)	25	57.04	8.93
	Control Group (male)	13	61.38	7.17
Comprehension Monitoring	Strategy Group (female)	25	21.04	3.63
	Strategy Group (male)	12	19.33	2.60
	Control Group (female)	25	19.64	3.99
	Control Group (male)	13	20.61	2.78
Complex Rehearsal	Strategy Group (female)	25	26.08	3.54
	Strategy Group (male)	12	24.83	3.97
	Control Group (female)	25	25.80	4.71
	Control Group (male)	13	25.38	3.66
Basic Organizational	Strategy Group (female)	25	23.64	2.37
	Strategy Group (male)	12	19.91	4.27
	Control Group (female)	25	18.92	3.54
	Control Group (male)	13	16.92	2.66
Basic Elaboration	Strategy Group (female)	25	18.84	1.92
	Strategy Group (male)	12	16.25	2.73
	Control Group (female)	25	14.04	3.22
	Control Group (male)	13	13.00	2.48
Complex Organizational	Strategy Group (female)	25	12.92	2.99
	Strategy Group (male)	12	10.25	1.55
	Control Group (female)	25	9.08	2.54
	Control Group (male)	13	8.92	2.46
Requesting Assistance	Strategy Group (female)	25	10.84	1.84
	Strategy Group (male)	12	9.75	2.09
	Control Group (female)	25	10.72	2.18
	Control Group (male)	13	10.85	1.14
Scale	Strategy Group (female)	25	180.76	15.81
	Strategy Group (male)	12	164.83	14.47
	Control Group (female)	25	155.24	20.88
	Control Group (male)	13	157.07	18.80

Table 4 Results of Variance Analyses for Postmeasurement Scores

Sub-scales	Source of Variance	Sum of squares	df	Mean Square	F	Significance
Complex Elaboration	BG	1409.44	3	469.81	6.52	Sign. Diff.*
	WG	5115.03	71	72.04		
	T	6524.48	74			
Comprehension Monitoring	BG	36.68	3	12.22	1.00	No Sign. Diff.
	WG	868.46	71	12.23		
	T	905.14	74			
Complex Rehearsal	BG	14.08	3	4.69	0.28	No Sign. Diff.
	WG	1170.58	71	16.48		
	T	1184.66	74			
Basic Organizational	BG	476.50	3	158.83	15.58	Sign. Diff.*
	WG	723.44	71	10.18		
	T	1199.95	74			
Basic Elaboration	BG	412.81	3	137.60	19.75	Sign. Diff.*
	WG	494.57	71	6.96		
	T	907.38	74			
Complex Organizational	BG	229.86	3	76.62	11.55	Sign. Diff.*
	WG	470.85	71	6.63		
	T	700.72	74			
Requesting Assistance	BG	11.20	3	3.73	1.01	No Sign. Diff.
	WG	260.34	71	3.66		
	T	271.54	74			
Scale	BG	9380.29	3	3126.76	9.64	Sign. Diff.*
	WG	23015.71	71	324.16		
	T	32396.00	74			

Note: BG=Between Groups, WG=Within Groups, T=Total (*p<0.05)

As shown from Table 5, on the sub-scales of Complex Elaboration, Basic Organizational, Basic Elaboration, Complex Organizational and on the whole scale there were significant differences among the groups, but, not on the sub-scales of Comprehension Monitoring, Complex Rehearsal and Requesting Assistance. In order to find out the source of differences Scheffé Test was executed. Results are presented in Table 6.

Table 5 Results of Scheffé Test

Sub-scales	Groups	SG (female)	SG (male)	CG (female)	CG (male)
Complex Elaboration	SG (female)				
	SG (male)				
	CG (female)	Sign. Diff.*			
	CG (male)				
Basic Organizational	SG (female)				
	SG (male)	Sign. Diff.*			
	CG (female)	Sign. Diff.*			
	CG (male)	Sign. Diff.*			
Basic Elaboration	SG (female)				
	SG (male)				
	CG (female)	Sign. Diff.*			
	CG (male)	Sign. Diff.*	Sign. Diff.*		
Complex Organizational	SG (female)				
	SG (male)	Sign. Diff.*			
	CG (female)	Sign. Diff.*			
	CG (male)	Sign. Diff.*			
Scale	SG (female)				
	SG (male)				
	CG (female)	Sign. Diff.*			
	CG (male)	Sign. Diff.*			

Note: SG: Strategy Group, CG: Control Group *($p<0.05$)

With respect to results of Scheffé Test in Table 6, difference between female students in the control and the strategy groups for sub scale of Complex Elaboration was found statistically significant. With respect to sub-scales of Basic Organizational and Complex Organizational, strategy use of female students in strategy group is more statistically significant than the other students. Regarding the Basic Elaboration sub scale, difference between the female students in the strategy and male and female students in the control group is significant. The differences in these stated scales were found advantageous for the female students in strategy group. Furthermore, with respect to Basic Elaboration sub-scale, there is significant difference between male stu-

dents in the strategy and male students in the control group in favor of male students in the strategy group.

4. DISCUSSION

It was established that female students have more benefits in Basic Organizational and Complex Organizational scales from the strategy instruction than the male students. In this study, it was observed that female students were more compatible and eager on participating questioning and summarizing activities and that they were trying to ask higher order questions and summarize using different graphic organizers than the male students. From results and observations of the study, it is suggested that female students did not change their learning habits unless trained and guided in strategy use by their teacher, however when they were trained directly, they were more compatible than male students about leading their training routes and sustainability of them. This conclusion supports the results of Zambo and Follman (1994), Cekolin (2001) and Huffman (1994), as well as interpretation of Wee, Baacquie, and Huan (1993) which states that female students are likely to be more dependent on orientation of the teachers in physics courses. Considering these results, we may suggest that strategy training programs should be arranged so that males as well as females should be able to benefit from them.

The study showed that female students in strategy training group use training strategies especially in Complex Elaboration, Basic Organizational, Basic Elaboration, and Complex Organizational scales generally more often than male students. Within the scope of the strategy program, questioning, and summarizing and graphic organizers are strategies that enable knowledge processing and organization of what is learnt. The use of these strategies during instruction and application processes has helped students in processing and organizing knowledge. Training and using of the strategies during research serve the students in elaboration and organization of the knowledge. For this reason, it is considered that strategies in the context of program are far more effective in developing the use of strategies available in elaboration and organizational groups.

5. IMPLICATIONS

This study provides some evidences of the gender effects on student teachers' strategy use in an undergraduate physics course. In comparison, explicit learning strategy instruction was more effective in developing strategy use than traditional instruction. According to the results of this study, the following suggestions are made: 1. Physics instructors should consider using explicit learning strategy instruction in their classes to develop students' learning and study skills. 2. Further research is needed in different educational settings to determine the effects of strategy instruction on different learning outcomes (e.g. learning satisfaction, self-efficacy beliefs, motivation to learn). 3. In designing strategy training programs, gender factor should be considered and the programs should be arranged so that male students should also get profit like female students. 4. The long term effects of gender on using strategies should be studied with different groups and fields.

6. REFERENCES

Austin, L. B., & Shore, B. M. (1995). Using concept mapping for assessment in physics. *Physics Education*, *30*(1), 41-45.

Brown, A.L., Campione, J.C., & Day, J. (1981). Learning to learn: On training students to learn from texts. *Educational Researcher*, *10*, 14-24.

Cekolin, C. S. (2001). The effect of self-regulated learning strategy instruction on strategy use and academic achievement. Retrieved April 20, 2008, from http://www. southalabama.edu/coe/bset/idd/dis/cekolin.htm

Ciardiello, A. V. (1998). Did you ask a good question today? Alternative cognitive and metacognitive strategies. *Journal of Adolescent & Adult Literacy*, *42* (3), 210-219.

Gallagher, A. & De Lisi, R. (1994). Gender diffrences in scholastic aptitude test – mathematics problem solving among high-ability students. *Journal of Educational Psychology*, *86*(2), 204-211.

Harper, K. A., Etkina, E., & Lin, Y. (2003). Encouraging and analyzing student questions in a large physics course: meaningful patterns for instructors. *Journal of Research in Science Teaching*, *40*(8), 776-791.

Huffman, D. W. (1994). The effect of explicit problem-solving instruction on students' conceptual understanding of Newton's Laws. Dissertation, University of Minnesota.

Oxford,R., Park-Oh, Y., Ito, S., & Sumrall, M. (1993). Learning a language by satellite television: What Influences Student Achievement?. *System*, *21*(1), 31-48.

Sheorey, R. (1999). An examination of language learning strategy use in the setting of an indigenized variety of English. *System*, 27, 173-190.

Wee, A. TS, Baacquie, B. E., & Huan, A. CH. (1993). Gender differences in undergraduate physics examination performance and learning strategies in Singapore. *Physics Education, 28*(3), 158-163.

Weinstein, C.E., & Mayer, R.E. (1986). "The Teaching of Learning Strategies", in *Handbook of Research on Teaching*, edited by M C Wittrock, New York Macmillan, 1986, pp. 315-327.

Weinstein, C.E., Ridley, D.S., Dahl, T., Weber, E.S. (1989). *Educational Leadership* 46, 17-19.

Zambo, R., & Follman, J. (1994). Gender-related differences in problem solving at the 6 th and the 8th grade levels. *Focus on Learning Problems in Mathematics*, 16 (2), 20-38.

THE RELATIONSHIP BETWEEN SCIENCE PROCESS SKILLS AND ACADEMIC ACHIEVEMENTS OF PRE-SERVICE SCIENCE TEACHERS

Bulent AYDOGDU, Omer ERGIN
Dokuz Eylul University, Buca Education Faculty, Department of Science Education.
E mail: bulent.aydogdu@deu.edu.tr; omer.ergin@deu.edu.tr

▼ Abstract

The purpose of this research was to investigate the relationship between science process skills and academic achievement of pre-service science teachers. General survey model was used in this research. Participants of this research are randomly selected from 100 pre-service science teachers at first, second, third and fourth grade of Science Education Department in Education Faculty within academic years the 2005-2006. The data were collected through personal information form and "Science Process Skills Test-SPST" adapted by researchers by examining studies related to this field. Results showed that there was a moderate positive correlation (r= 0. 54) between science process skills and academic achievement of pre-service science teachers. Besides, results showed that there was a moderate positive correlation (r= 0. 44) between science process skills and academic achievement of pre-service science teachers whose science process skills was higher than mean score; moreover results showed that there was a moderate positive correlation (r= 0. 39) between science process skills and academic achievement of pre-service science teachers whose academic achievement was higher than mean score**.** Overall, results suggest that; the more science process skills students acquire the more academically successful they are. However; it is possible that successful students could demonstrate low science process skills which are not accordance with their academic achievement measured by General Point Average (GPA). That discordance is likely to indicate that the group of students who have higher academic achievement but lower science process skills compensate their insufficiency by memorizing.

Key Words Science Process Skills, Academic Achievement, Primary School.

1. INTRODUCTION

Science process skills are needed to better understand the content of science of students. Science educators recommended that elementary science education be sequenced beginning with development of process skills, then science content coursework, and then fieldwork experiences (Scharmann, 1989). Acquisition of the science

process skills should be a major goal of science instruction (NSTA, 1971). If these skills are not well developed and, for example, relevant evidence is not collected, or conclusions are based selectively on those findings which confirm initial preconceptions and ignore contrary evidence, then the emerging concepts will not help understanding of the world around (Harlen, 1999).

Science process skills are described as follows by the researcher. According to Çepni, Ayas, Jonhson and Turgut, (1997) science process skills facilitate learning in science, teach student research methods, help student to be active, develop students' responsibility to take part in their own learning, and increase their permanent learning. Ostlund (1992) has defined that the science process skills are the most effective mean to obtain information about the world around and to arrange this information. Science process skills are categorized into two types as basic and integrated process skills by Yeany et al. (1984). Basic process skills provide a foundation for learning the more complex integrated skills.

Basic and integrated process skills are grouped in the following way (Yeany et al., 1984; Germann et al., 1996):

Basic Process Skills:

1. Observing
2. Classifying
3. Communicating
4. Measuring
5. Using space/time relations
6. Using numbers
7. Inferring
8. Predicting

Integrated Process Skills:

1. Posing questions
2. Controlling variables
3. Interpreting data
4. Formulating hypothesis
5. Defining operationally
6. Experimenting

There are a few studies related to studying the relationship between science process skills and academic achievement. Some studies indicated that there was a positive correlation between students' science process skills and academic achievement at university level (Helseth, Yeany, Barstor, 1981; Walkosz ve Yeany, 1984; Sittirug, 1997; Şaşmaz ve Tatar, 2006). In addition, some other studies showed that there was a positive correlation between science process skills and academic achievement of primary school level (Germann, 1994; Aydoğdu, 2006).

On the other hand, Sittirug (1997) emphasized that there is not complete agreement about the relationships among science process skills, cognitive development, attitude toward science, and academic achievement. Therefore, this study might be important to obtain information as regard with examining the relationship between science process skills and academic achievement of pre-service science teachers.

2. RESEARCH QUESTIONS

The research questions posed for this study were as follows:

1. Is there a statistically significant relationship between science process skills and academic achievement of pre-service science teachers?

2. Is there a statistically significant relationship between science process skills and academic achievement of pre-service science teachers whose science process skills were higher than mean score?
3. Is there a statistically significant relationship between science process skills and academic achievement of pre-service science teachers whose academic achievement were higher than mean score?

3. METHODOLOGY

General survey model was used in this research (Karasar, 1999). Participants of this research are randomly selected 100 pre-service science teachers at first, second, third and fourth grade of Science Education Department in Education Faculty within academic years the 2005-2006.

4. DATA COLLECTING TOOLS

The data were collected through personal information form and "Science Process Skills Test-SPST" developed by researcher by examining studies in this field (Enger & Yager, 1998; Dana, 2001; Ergin, Şahin and Ongel, 2005; Anonymous, 2006). Personal information form consists of only grade level and student achievement (General Point Average-GPA) which was collected from the students' files kept in the faculty. According to university student achievement regulations, maximum student achievement score is 4. SPST consists of achievement test (10 items with multiple choice questions) and 4 scenarios. Achievement test section of SPST used in the study was by the Mason City School, August 1993; in the lowa Assessment Handbook (Dana, 2001 quoting from Enger & Yager, 1998) was used. Translation and adaptation into Turkish of the achievement test section of SPST were carried out by researcher. Scenario section of SPST was benefited from studies in this field (Ergin, Şahin and Ongel, 2005; Anonymous, 2006). Achievement test items also require writing the reason down for the each 10 items. SPST measures steps of science process skill related to making observation, classification, making inferences, predicting, controlling variable, interpreting data and measurement, formulating a hypothesis, and experimenting. 60 science education teachers participated in the reliability analysis of the SPST. The reliability analysis of SPST showed that cronbach's alpha of the scale is 0.70. One item of the multiple choice questions of SPST was eliminated as a result of factor analysis because of low factor loading (0.30). Thus, SPST includes achievement tests consisting 9 items each having 2 points and 4 scenarios each having 4 points. The maximum point that can be taken from the SPST is 34 points.

5. DATA ANALYSİS

Data analyzed by using SPSS 11.0 statistics program. Data calculated with descriptive statistics as mean, standard deviation and analyzed by using Pearson correlation.

6. FINDINGS

This section includes the findings related to the problem of the study according to the data obtained by the research.

Table 1 Descriptive Statistics of Science Process Skills and Academic Achievement Scores of All Pre-Service Teachers.

	N	$\bar{X}$	Std. Deviation
Science Process Skills	100	21,780	4,547
Academic Achievement	100	2,687	,431

When examining Table 1, it can be seen mean score and standard deviation of science process skills and academic achievement scores of all pre-service teachers.

Table 2 Correlation between Science Process Skill and Academic Achievement of Pre- Service Teachers.

		Academic Achievement
Science Process Skills	Pearson Correlation	,538*
	Sig. (2-Tailed)	,000
	N	100

*Correlation is significant at the 0.01 level (2-tailed).

According to Table 2, there is a positive medium level and significant correlation between science process skills and the academic achievement of all pre-service science teachers attended study (r=0.538, p<.01).

Table 3 Descriptive Statistics of Science Process Skills and Academic Achievement of Pre-Service Science Teachers Whose Science Process Skills were higher than Mean Score.

	N	$\bar{X}$	Std. Deviation
Science Process Skills	46	25,760	3,184
Academic Achievement	46	2,884	,424

When examining Table 3, it can be seen descriptive statistics of science process skills and academic achievement of pre-service science teachers whose science process skills ($\bar{X}$:21.780 and up) were higher than mean score.

Table 4 Correlation between Science Process Skills and Academic Achievement of Pre-Service Science Teachers Whose Science Process Skills were higher than Mean score.

		Academic Achievement
Science Process Skills	Pearson Correlation	,436*
	Sig. (2-Tailed)	,002
	N	100

*Correlation is significant at the 0.01 level (2-tailed).

According to Table 2, there is a positive medium level and significant correlation between science process skills and academic achievement of pre-service science teachers whose science process skills were higher than mean score (r=0.436, p<.01). According to the result, we can say as science process skills are increased, thus the academic achievement is increased. When the determination coefficient which is the square of correlation coefficient (r^2=0.19) is taken into consideration, it can be said that %19 of the total variance in students' academic achievement is originated from the science process skills

Table 5 Descriptive Statistics of Science Process Skills and Academic Achievement of Pre-Service Science Teachers Whose Academic Achievement were higher than mean score.

	N	$\bar{X}$	Std. Deviation
Academic Achievement	51	3,037	,226
Science Process Skills	51	24,0196	4,49662

When examining Table 5, it can be seen descriptive statistics of science process skills and academic achievement of pre-service science teachers whose academic achievement ($\bar{X}$:2.687 and up) were over the mean score.

Table 6 Correlation between Science Process Skills and Academic Achievement of Pre-service Science Teachers whose Academic Achievement were higher than Mean Score

		Science Process Skills
Academic Achievement	Pearson Correlation	,387*
	Sig. (2-Tailed)	,005
	N	100

*Correlation is significant at the 0.01 level (2-tailed).

According to Table 6, there is a positive medium level and significant correlation between science process skills and academic achievement of pre-service science teachers whose academic achievement were over the mean score s. (r=0.387, p<.01). According to the result, we can say as academic achievement are increased, thus the science process skills is increased. When the determination coefficient which is the square of correlation coefficient (r^2=0.15) is taken into consideration, it can be said that %15 of the total variance in students' science process skills is originated from the academic achievement.

7. CONCLUSION AND SUGGESTIONS

Results showed that there was a moderate positive correlation (r= 0. 54) between science process skills and academic achievement of pre-service science teachers. Some studies indicated that there was a positive correlation between students' science pro-

cess skills and academic achievement at university level (Helseth, Yeany, Barstor, 1981; Walkosz ve Yeany, 1984; Sittirug, 1997; Şaşmaz ve Tatar, 2006). In addition, some other studies showed that there was a positive correlation between science process skills and academic achievement of primary school level (Germann, 1994; Aydoğdu, 2006). Besides, results showed that there was a moderate positive correlation (r= 0. 44) between science process skills and academic achievement of pre-service science teachers whose science process skills was higher than mean score; moreover results showed that there was a moderate positive correlation (r= 0. 39) between science process skills and academic achievement of pre-service science teachers whose academic achievement was higher than mean score**.**

Overall, results suggest that; the more science process skills students acquire the more academically successful they are. However; it is possible that successful students could demonstrate low science process skills which are not accordance with their academic achievement measured by General Point Average (GPA). These findings are important because this situation may indicate that pre-service science teachers who have a good level of science process skills don't need to make a rote memorization whereas; the teachers which have lower science process skills have to compensate their gap of skills through rote memorizing. Therefore, we can conclude that having high level of science process skills has a significant effect on acquiring knowledge. As a result of, pre-service science teachers need to get assistance to acquire the science process skills. Besides, they must be provided with an opportunity to use these skills in teaching and learning environment.

8. REFERENCES

Anonymous, 2006. Process Skills. http://www.mrconant.org/. (Reaching date: 10.06. 2006)

Aydoğdu, B. (2006). Ilköğretim Fen ve Teknoloji Öğretiminde Bilimsel Süreç Becerilerini Etkileyen Değişkenlerin Belirlenmesi. (Unpublished master thesis): Dokuz Eylul University, Institute of Educational Sciences, İzmir.

Dana, L. (2001). The effects of the level of inquiry of situated secondary science laboratory activities on students' understanding of concepts and the nature of science, ability to use process skills and attitudes toward problem solving. (Unpublished doctoral dissertation), University of Massachusetts Lowell.

Çepni, S., Ayas.A, Johnson. D., and Turgut, M.F.(1996). Fizik Öğretimi.Ankara: Milli Eğitimi Geliştirme Projesi Hizmet Öncesi Öğretmen Eğitimi Deneme Basımı, 31-44.

Enger, S.K. & Yager, R.E.(Eds.). (1998). Iowa Assesment Handbook. Iowa City: Science Education Center, The University of Iowa.

Ergin, Ö., Şahin, E.Ş. ve Öngel, S.E. (2005). Kuramdan Uygulamaya Deney Yoluyla Fen Öğretimi. İzmir:Kanyılmaz Matbaası.

Germann, P.J. (1994*).* Testing a Model of Science Process Skills Acquisition: an Interaction with Parents' Education, Preferred Language, Gender, Science Attitude, Cognitive Development, Academic Ability, and Biology Knowledge. Journal of Research in Science Teaching. 31 (7): 749-783.

Germann, P.J., Haskins, S., & Auls, S. (1996). Analysis of nine high school biology laboratory manuals: promoting scientific inquiry. Journal of Research in Science Teaching, 33 (5). 475-499.

Harlen, W. (1999). Purposes and Procedures for Assessing Science Process Skills**.** Assessment in Education. 6 (1): 129-144.

Helseth, E.A., Yeany, R.H., & Barstor, W. (1981). Predicting science achievement of university students in the basis of selected entry characteristics. Paper presented at the annuel meeting of the National Association for Research in Science Teaching, Catskills, Ellenville, NY. http://www-sa.ebsco.com (Reaching date: 10.01.2006)

Karasar, N. (1999). Bilimsel Araştırma Yöntemi: Kavramlar, İlkeler, Teknikler**.** Ankara: 3A Araştırma Eğitim Danışmanlık Ltd.

NSTA [National Science Teachers Association] (1982). S*cience-Technology-Society: Science Education for the 1980s*. Washington DC:Author.

Ostlund, K.L. (1992). Science process skills: Assessing hands-on student performance. New York: Addison-Wesley.

Scharmann, L.C. (1989). Developmental influences of science process skill instruction. Journal of Research in Science Teaching, 26(8), 715-726.

Sittirug, H. (1997). The Predictive Value of Science Process Skills, Attitude towards Science, and Cognitive Development on Achievement in a Thai Teacher Institution**.** Unpublished PhD Thesis, University of Missouri-Columbia.

Şaşmaz, F.Ö. ve Tatar, N. (2006). The Relationships between Science Process Skills and Academic Achievements of Candidate Teachers of Science in Primary Education. 3. Uluslararası Öğretmen Yetiştirme Sempozyumu. 4-6 May 2006. Çanakkale.

Walkosz, M., & Yeany, R.H. (1984). The Effects of Lab Instruction Emphasizing Process Skills on Achievement of College Students Having Different Cognitive Development Levels. (Eric: 10.11.2006)

Yeany, R.H., Yap, K.C., & Padilla, M.J. (1984). Analyzing heirarchial relationship among modes of cognitive reasoning and integrated science process skills. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. New Orleans, LA.

AN APPROACH TO DEVELOP PHYSICS STUDENT TEACHERS' SKILLS OF USING INSTRUCTIONAL TECHNOLOGY

Yasemin DEVECIOGLU, Ali Riza AKDENIZ, Guner TURAL DINCER
Karadeniz Technical Universtiy
Fatih Faculty of Education Department of Secondary Science and Math.
Education, 61335. Sogutlu/Trabzon.
yasemindeveci19@hotmail.com

▼ Abstract

It is very important to develop student teachers' skills and knowledge during the pre-service teacher education process. In this study, the effectiveness of the approach in which student teachers' gained the skills of developing and using Teacher Guided Materials (TGMs) based on integration of technology on physics education in Special Teaching Methods Course-II (STMC-II) for pre-service Physics teachers was evaluated. The study was conducted with 33 physics student teachers in KTU. Student teachers were required to develop and present TGMs, which were based on principles of special teaching approaches and techniques and integration of technology through instruction. The data of the study gained from semi-structured interviews conducted with 14 student teachers, observations of the lessons conducted by the each student teacher and document analysis of the student teachers' diaries collected during the term.

The studetn teachers stated that STMC-II was a very helpful experience to gain teaching skills. It is believed that these all activities, which are designed and performed in the classroom by student teachers during STMC-II course, will not only prepare them to their teaching but also help them to gain basic experiences that they will need in their future career. At the end of the process it is concluded that all of the student teachers gained nearly whole defined aims –skills and knowledge- of the STMC-II. The implementation process should be organized very well to have advance of gaining many skills together.

Key Words Physics Student Teacher, Special Teaching Methods Course-II, The Skills of Developing Teacher Guide Materials and Integration of Technology.

1. INTRODUCTION

Teacher education institutions are affected by recent technologic advances. They have tried to restructure their education programs and classroom facilities in order to train the teachers of future skillfully (Rizza, 2000; Devecioglu, 2004). This restructuring process requires integration of technology into existing context in order to

provide learners with knowledge of specific subject areas, to promote meaningful learning and to enhance professional productivity (Strudler&Wetzel, 1999; Tomei, 2005; Baslanti, 2006; Yaman, 2007). One of the courses is Special Teaching Methods Course-II (STMC-II) to integrate technology into physics teaching to gain main teaching skills in pre-service teacher education programs (YOK, 1998). STMC-II has a crucial importance in terms of gaining pedagogical knowledge, skills and attitudes for student teachers. That course can be accepted as a kind of bridge to connect theoretical knowledge into practice. During that course student teachers are expected to gain experience on teaching practice. In this way they can enhance their main abilities and develop positive attitudes toward teaching. That course aims to train student teachers to know and apply contemporary teaching/learning principles to content teaching (Devecioglu, 2004; Devecioglu&Akdeniz, 2005; Devecioglu& Akdeniz, 2007; Devecioglu, Akdeniz&Ayvaci, 2007). This course is conducted on the ninth terms of physics teaching department in the faculty of education in Turkey. After process of content knowledge education for six terms, student teachers take pedagogical content knowledge until the end of their fifth years. That course aims student teachers' pedagogical development by the working of all materials and documents for sustainable development (Karamustafaoglu, 2003; Devecioglu, 2004; Devecioglu& Akdeniz, 2006). During that course, student teachers as learners should be actively involved in the process to learn teaching. This active involvement aims at developing learners' attitudes and particularly their motivation towards teaching. One of the main characteristics of that course is that gaining the skills of using instructional technology (IT) during physics teaching (Devecioglu, 2004; Devecioglu& Akdeniz, 2007; Devecioglu&Akdeniz, 2008). Student teachers experience using technology during the applications of the course. There are many studies on defining the profiles of the using computer and internet among student teachers-the effects of technology and using of technology during learning/teaching process and the development of student teachers' skills (Strudler&Wetzel, 1999; Bauer&Kenton, 2005; Toprakci, 2007; Yildirim, Nas&Ayas, 2007; Akbulut, 2008; Gulbahar, 2008). It is very important to use and integrate computer resources into classroom practices during instruction (Gos, 1996). However, there are not enough studies on defining of the level and success of integrating new technologies into pre-service teacher education programs. Desiring technology-competent teachers for 21st century classrooms, we have to inquire the utilization of technology in teacher education institutions (Yildirim, 2000; Devecioglu, 2004; Yaman, 2007; Devecioglu&Akdeniz, 2008; Devecioglu&Yildirim, 2008). Given the importance of access to technology, technology-competency and effective integration of technology, an understanding of how instructors and pre-service teachers in a faculty of education perceive technology can help institutions of higher education to successfully integrate, in relation with the current ICT usage (Strudler&Wetzel, 1999). Understanding the factors contributing to the utilization of technology and the possible relations of these factors will lead us to educate technology-competent teachers. Under the light of these facts, the main purpose of this study was to examine factors that contribute to preservice teachers' utilization of technology and suggest recommendations regarding to the effective utilization of technology during physics

teaching. This study contributes to draw an understanding of how student teachers can gain the skills of successfully integrating technology during the Applications of STMC-II.

2. RESEARCH QUESTIONS

The main purpose of this study is to figure out the effectiveness of the approach implemented to gain the skills of developing and presenting teacher guide materials based on integration of technology into instruction process in STMC-II for physics student teachers in the Fatih Faculty of Education at Karadeniz Technical University in Trabzon-Turkey. This study specifically focuses on the following research questions: Ø Is there an approach for student teachers to develop their skills to integrate technology as learning and teaching tool during STMC-II? Ø What behaviors did student teachers develop during the course under the implemented approach? Ø What kind of problems did they meet during their instruction with technology? Ø What are student teachers' suggestions to gain the skills of integrating technology to physics teaching?

3. METHODOLOGY

Case study research design was used. STMC-II was conducted by scientific methods in pre-service physics teacher education program. This study offers a different approach to gain the skills of developing and using teacher guide materials which are used by student teachers during the course process. The sample of the research is 33 last-year (ninth terms) physics student teachers attending to Physics Teaching Department in the fall term of 2007-2008 academic years. The approach implemented from the beginning of the course was determined as following stages:

- High school physics subjects (units) were distributed among the groups of student teachers. These physics subjects were; force, current, energy, motion, heat and temperature, light, electrostatics, impulse and momentum, Newton's Motion Laws.
- Students were required to develop teacher guide materials, which were based on the principles of constructivist learning, different instructional techniques and integration of technology.
- Each group defined students' misconceptions on their own subjects.
- Each groups' materials were examined and feedbacks gave to enrich the effectiveness of these materials. During that course student teacher shared their ideas and explored the other studies and researches, technological developments and applications. Classroom discussions were conducted during the course about findings and studies of each group.
- Each student teacher presented their materials in one class hour. During the teaching practice in the classroom the presenter student teacher pretended as a real teacher and the other student teachers behaved as real students during this mini teaching in STMC-II. Student teachers had all

opportunities to use computers, overhead projector, internet and projector during their mini teaching. The skills of using technology for professional development of physics student teachers are evaluated during that course.

4. DATA COLLECTION

The data of the study was obtained from interviews, semi-structured observation forms and document analysis of the teacher guide materials that were prepared by student teachers. Moreover, student teachers' diaries were examined. During the mini teaching practice student teachers were observed by a semi-structured observation form. They were evaluated in terms of using IT in their teaching. Their recorded behaviors were summarized. Interviews were conducted with 14 student teachers chosen randomly. Student teachers ideas about the implemented approach to gain the mentioned skills were defined by interviews. The student teachers answers were transcript and analyzed qualitatively. Document analysis was done to evaluate student teachers' materials and diaries in terms of using IT. According to document analysis of student teachers diaries the gained skills were summarized. In their diaries, they recorded their behaviors gained during that course and mini class teaching on STMC-II from beginning to the end of the course. The diaries were examined to find out their improvement on using of technology for physics teaching.

5. FINDINGS

The data gained from the instruments were examined in terms of the effectiveness of the approach to gain the skills of developing and presenting teacher guide materials based on IT for physics student teachers.

5.1. The Data Gained From The Student Teachers' Interviews

The interviews' data were summarized on three items: the improvement of the student teachers, their problems they encountered during the implementations, and their suggestions on that circumstance.

According to data gained from interviews, the majority of the student teachers believed that using technology is very important for physics teaching. Some of the student teachers mentioned that using IT during instruction was more enjoyable and easy after learning to use in teaching. For instance, using online database, instructional software, electronic presentations and animation software facilitated their concept teaching. One of the student teachers said that he founded many online databases with animations to concrete and to illustrate the relationships between physics concepts. Half of the student teachers admitted that they were not very well during their mini teaching practice. Some of the student teachers thought that to prepare different teaching materials based on IT needs more time. Some of the student teachers stated that instead of preparing new teaching materials, such as worksheets, PowerPoint Presentations, animations, models etc., to use they preferred to use a prepared one on subject teaching. Besides, they stated that researching to find prepared materials from internet or library was gained them to explore various data sources.

According to their ideas, they learned how to reach and arrange the information for their needs on their field. Particularly, all of the student teachers were agreed that they would develop their skills by the time and experience. According to their ideas, lack of confidence and understanding affected the student teachers attitudes during that integration process of IT into mini teaching practice. Nearly all of the student teachers recommended that these kinds of activities should be obligatory during pre-service teacher education. Otherwise, they could not do these kinds of activities and gain the skills. They thought that the approach implemented in STMC-II was very effective to gain main teaching skills and motivate them for teaching profession. Besides, some of the student teachers were agree on the idea that the mini teaching was a good practice to manage a class and contributed to their skills development. Their attitudes were also positive using computer on their teaching. During STMC-II by the implemented approach, the student teachers had an opportunity to notice the importance and facilities of using IT's on physics teaching. Besides, the student teachers stated that they had gained high motivation and self-confidence for their future careers.

5.2. The Data Gained From Observations

According to the data of the observations, the student teachers mostly chose computer, overhead projector, projector, internet browsers and Web pages to use in their materials during mini teaching practice. However, some of the student teachers had opportunity to illustrate some physics subjects such as circuit, force and motion, heat and temperature by using Web pages and electronic presentations; they did not use and integrate technology as a teaching and learning tool.

At the beginning of the course it was very difficult for student teachers to use two or three teaching methods and materials together during their instruction. They usually preferred traditional teaching approaches. After the critiques and recommendations at the end of each mini instruction, student teachers tried to enhance their course time and developed more instructive materials for better teaching. One of the important findings is that student teachers are not successful enough to combine the skills gained from the other pedagogical courses. They lacks of experience using the knowledge integrating on practice. Some of the student teachers were incapable of developing and using worksheets, slides, power-point presentations for their instruction. Furthermore, they had problems while using these materials. While using one material, they forgot or were unable to pass throughout the other material. By the middle of the course nearly most of the student teachers started to use computer and overhead projector in their mini teaching. At the end of their mini teaching each student teachers were evaluated for their teaching on following points: * Organize transition of each materials and instructive actions effectively, * Keep in control class management, *Use the blackboard effectively,* Use worksheets, computer, overhead/projector, internet, animation software,* Use attractive materials for students' interests,* Use different teaching methods such as brainstorming, concept map etc.

5.3. The Data Gained From Document Analysis

Student teachers' materials evaluated in terms of using various I.T. Most of their materials were acceptable to have variation on paper. It is found that they were more successful on paper than their mini teaching practice. The examinations of the student teachers' diaries showed that at the beginning of the course, they had written the following behaviors, such as; ✓ Searching for developing different teaching materials, ✓ Noticing the importance of using various materials in physics teaching, ✓ Searching for student misconceptions on definite physics subjects etc…

It was observed that in time, the number of the student teachers' written behaviors increased. Some of the mentioned behaviors as following such as;

✓ Understanding the importance of using IT in physics teaching, ✓ Observing varied teaching practices by using various teaching methods together, ✓ Using blackboard effectively, ✓ Integrating technology into physics teaching, ✓ Using internet databases to illustrate physics concepts etc…

6. CONCLUSIONS/IMPLICATIONS

It is a fact that professional development of physics student teachers is very crucial in pre-service teacher education (Brooks&Sikes, 1997). They should gain the skills of integrating theory into practice on main teaching competencies (Knapper, 2001; Yaman, 2007). The findings of this study showed that during the STMC-II, the activities aiming to help student teachers to develop, gain, and measure the desired behaviors were mostly achieved. STMC-II and the implemented approach were very effective on gaining the skills of developing and using teacher guide materials based on integration of technology into teaching and improving pedagogical development of the physics student teachers. It is believed that the activities, which were designed and performed in classroom by teacher candidates in STMC-II, would not only prepare them to their teaching but also help them to gain basic experiences that they will need in their future career. The implementations contributed to student teachers' utilization of IT. At the end of the course, it is concluded that they gained the skills as following:

❖ Prepare and implement learning materials according to constructivist learning principles, ❖ Choosing the appropriate teaching methods for the physics subject**,** ❖ Using different teaching techniques together on both preparing and presenting teaching materials, ❖ Integration of technology in physics learning/teaching, ❖ Developing materials and implementing these materials during instruction, ❖ Determining students' misconceptions on physics subjects, ❖ Developing content and pedagogical content knowledge, attitude and interest, ❖ Motivating her/himself through teaching, ❖ Evaluating him/herself about the mini teaching practice on the course…

The results obtained through this study showed that teaching materials prepared according to constructivist learning principles by student teachers increased their academic success, skills and attitudes toward teaching profession. The student teachers stated that they developed their content and pedagogical content knowledge on physics education, attitude and interests towards teaching profession. These results showed that the course and the implemented approach were very effective on the improvement of the physics student teachers. Usage of content and pedagogical content knowledge

together with contemporary teaching approaches forced the student teachers to be more active on developing teaching skills on physics teaching. These results showed that the course and the implemented approach were very effective on the improvement of the physics student teachers (Devecioglu, 2004; Devecioglu&Akdeniz, 2007). Moreover, the approach was very affirmative experience for them before Teaching Practice. Thus they felt self-confidence for further studies (Chen, 1986; Hunt&Bohlin, 1993; Arnez&Lee, 1990; Levine&Donitsa-Schmidt, 1998; Yaman, 2007).

On the other side, there was a limitation for the student teachers that they usually preferred to use prepared teaching materials for example web-based animations, PowerPoint Presentations. In this case, they could not improve their existing behaviors and skills on planning and developing technology-based instructional materials. It can be said that they were able to present their founded teaching materials.

This kind of implementations will promote the development and dissemination of theoretical knowledge and professional practice knowledge on physics education and integration of technology into education. It is a real that successful integration of technology into teaching requires not only the knowledge on technology and its potential but also the skills to plan and implement a good teaching. At the end of the paper there is a model for future studies to gain the skills of developing and using materials based on IT for student teachers in physics teaching. In order to maintain student teachers' pedagogical development contemporary teaching/learning strategies should be implemented. According to that model student teachers should focus intensively on material development through concept teaching. There are the steps of the model to follow during STMC-II;

- Firstly, the goals of the course should be defined.
- Student teachers should be informed about these goals aimed to gain main teaching characteristics.
- It is definitely emphasized that student teachers should direct to develop different materials.
- Feedback is very important to enrich their skills during that course.
- Student teachers should be able to connect theoretical and practical knowledge together. Thus they can improve themselves on teaching.
- In order to develop their practical knowledge and motivation, strategies and instructional programs should be organized effectively. They should be directed and trained to implement more teaching practice on real classes.

Consequently, it is thought that this kind of implementations should be discussed between education authorities for better implementations for pre-service teacher education. The implemented approach could be revised again and developed to gain more skills of integrating technology into physics teaching. In order to gain the skills of using IT in teaching practice, physics student teachers should improve their exist skills fairly good. Education institutions should train teachers who are technology-competent and effectively use and integrate technology into their teaching activities.

7. REFERENCES

Akbulut, Y. (2008). Exploration of the Attitudes of Freshman Foreign Language Students toward Using Computers at a Turkish State University. The Turkish Online Journal of Educational Technology-TOJET January 2008 ISSN: 1303-6521 volume 7 Issue 1 Article 2.

Baslanti, U. (2006). Challenges in preparing tomorrows teachers to use technology: lessons to be learned from research. The Turkish Online Journal of Educational Technology – TOJET ISSN: 1303-6521 v:5-1 Article 4.

Bauer, J. and Kenton, J. (2005). Toward Technology Integration in the Schools: Why it isn't happening. Journal of Technology and Teacher Education 13(4), 519-546.

Brooks, V. and Sikes, P. (1997). The Good Mentor Guide, Initial Teacher Edu in Secondary SchoolsPhiladelphia: Open University Press.

Chen, M. (1986). Gender and Computers:The Benefical Effects of Experiences on Attitudes. Journal of Educational Computing Research. 2, 265-282.

Devecioglu, Y. (2004). Fizik Öğretmen Adaylarına Rehber Materyal Geliştirme ve Uygulama Becerilerinin Kazandırılmasına Yönelik Bir Yaklaşım, K.T.Ü Fen Bilimleri Enstitüsü, Yayımlanmamış Yüksek Lisans Tezi: Trabzon.

Devecioglu, Y. and Akdeniz, A.R. (2006). Öğretmen Adaylarına Materyal Geliştirme Ve Uygulama Becerilerinin Kazandırılmasına Yönelik Uygulamaların Değerlendirilmesi. Milli Eğitim, Yıl: 35, sayı: 172 (91-105).

Devecioglu, Y. ve Akdeniz, A.R. (2007). The Effectiveness of the Special Teaching Methods Course-II to Develop the Planning and Presenting Skills of Student Teachers. XIII World Congress of Comparative Education Societies, the Faculty of Philosophy of Sarajevo University, 03-07 September 2007.

Devecioglu, Y. Ve Akdeniz, A.R. (2008). Fizik Öğretmen Adaylarının Öğretim Teknolojilerini Kullanma Davranışlarının Gelişiminde Etkili Faktörler Ve Bir Model Önerisi. 8th International Educational Technology Conference IETC-2008, 6-9 Mayıs 2008, Eskişehir.

Devecioglu, Y. Ve Yıldırım, N. (2008). Fizik Ve Kimya Öğretmen Adayları İçin Önemli Bir Kazanım; Öğretim Teknolojilerini Bilme Ve Kullanma. 8th International Educational Technology Conference IETC-2008, 6-9 Mayıs 2008, Eskisehir.

Gos, M.W. (1996). Computer anxiety and computer experience: A new look at an old relationship. Clearing House, 69(5), 271-277.

Hunt, N.P.; Bohlin R.M. (1993). "Teacher Education Students' Attitudes Toward Using Computers". Journal of Research on Computing in Education. 25 (4), 487-497.

Karamustafaoğlu, O. (2003). Fen Bilgisi ve Fizik Öğretmen Adaylarının Kazanmaları İstenen Becerileri Yansıtabilecekleri Ortamların Düzenlenmesi, K.T.Ü. FBE., Yayınlanmamış Doktora Tezi: Trabzon.

Knapper, C. (2001). The Challenge of Educational Technology. International Journal for Academic Development. 6 (2), 93-95.

Levine, T. And Donitsa-Schmidt, S. (1998). Computer Use, Confidence, Attitudes and Knowledge: A Casual Analysis. Computers in Human Behavior. 14 (1), 125-146.

Strudler, N. B. & Wetzel, K. (1999). Lessons from exemplary colleges of education: factors affecting technology integration in preservice programs. *Educational Technology Research and Development*, *47*(4), 63-81.

Tomei, L. A. (2005). Taxonomy for the Technology Domain. USA: Information Science Publishing.

Toprakçı, E. (2007). The profiles of the using of the internet for study purposes among university students. The Turkish Online Journal of Educational Technology-TOJET, 2007 ISSN: 1303-6521 v:6-3, Article 13.

Yaman, M. (2007). The competence of physical education teachers in computer use. The Turkish Online Journal of Educational Technology, TOJET, October 2007. ISSN: 1303-6521. Volume 6 Issue 4, Article 5.

Yildirim, N., Er Nas, S. and Ayas, A. (2007). Kimya öğretmen adaylarının öğretim teknolojilerini kullanabilme durumlarının portfolyo ile değerlendirilmesi. I. Ulusal Kimya Eğitimi Kongresi Kimya Eğitiminde Yeni Ufuklar, 20-22 Haziran 2007, İstanbul.

Yildirim, S. (2000). Effect of an Educational Computing Course on Preservice and Inservice Teachers: A Discussion and Analysis of Attitudes and Use. *Journal of Research on Computing in Education. 32(4)*, 479-495.

YOK. (1998). Eğitim Fakülteleri Öğretmen Yetiştirme Programlarının Yeniden Düzenlenmesi, Mart, Ankara.

A GLIMPSE INTO GRASSMATE – A RESEARCH CAPACITY-BUILDING PROGRAM IN SOUTHERN AFRICA

Oyvind Mikalsen
University of Bergen, Department of Chemistry, Allegt. 41, 5007 Bergen, Norway
E-mail: oyvind.mikalsen@kj.uib.no

▼ Abstract

This paper describes a research capacity-building program working in Sub-Saharan countries. In the first phase, from 1996 – 2000, eight students from South-Africa, Zimbabwe and Mozambique participated in the field of mathematics education. Seven students of this cohort have successfully completed their PhD degrees. The second phase included science and technology education and comprised 20 students from 10 Sub-Saharan countries. The program terminated in 2006 and of this cohort 15 students have graduated for PhDs and one student for a Master's degree.

The focus of the paper is to give a brief description of the project, which includes the background of the project, its operation, its perspective with respect to ownership of research projects, the nature of the scholarly products and insights emanating from evaluation reports by the students and the supervisors. The students are bringing forwards factors that might contribute towards the improvement in the quality and relevance of such programs. Two factors highlighted in this paper are "contribution towards the improvement in the quality of such programs", and "relevance of such programs".

The initial research capacity development was via the engagement of students in doctoral degree studies where the major outcome was the production of a thesis manuscript which were evaluated and examined by experts from institutions outside the degree-awarding institution. Later on the capacity development was elaborated to include joint research and publication by students and mentors, which was deemed to be very fruitful by both parts.

The paper concludes by arguing that a mixture of student- and supervisor-generated research projects is necessary but not sufficient for sustainability of a research culture.

Key Words Science- and mathematics education, sustainability, Southern Africa.

1. INTRODUCTION

The first phase of the program *Graduate Studies in Science, Mathematics and Technology Education* (GRASSMATE) originated in 1996 after a couple of years with nego-

tiations between the University of Bergen (UiB), Norway and the University of the Western Cape (UWC) in South Africa. The University of Zimbabwe (UoZ) and the University of Eduardo Mondlane in Maputo, Mozambique (EMU) were also partly involved in the negotiation phase.

The second phase of the GRASSMATE project was officially launched in 2002, but already in 1999 the two coordinators of the project carried out a survey among the universities in the Sub-Saharan countries to find out the needs and interests for a doctoral project in science and mathematics education and on prospective candidates from their institutions to engage in such programs. Most of the invited institutions responded and more than 50 prospective doctors'- and masters'- candidates were listed. The planned project had a limit of 20 students, and in order to cope with this increase of students more researchers had to be included. At the end 13 researchers were engaged in the program. Five researchers from the North were coming from four different institutions; UiB (2), University of Oslo (1), the University of Agder (1) and the University College of Volda (1). The eight researchers from the South were coming from four institutions; UWC) (5), UoZ (1), Makerere University (1) and the University of Dar-es-Salaam (1). Thus the network of researchers was spread to various countries and various places not only North-South but also within the North and within the South.

The program has been funded by the *Norwegian Centre for International University Cooperation* (SIU) through *The Norwegian Council of universities' Committee for Development Research and Education* (NUFU) over 14 years (including the negotiation time) by a total of 10 millions NOK, comparable to approximately 2 millions US $. The project was all the time a sandwich program, in the first phase with mathematics education as the field of research, while the second phase included science and technology education as fields of research. (For more details about the project see http://www.uib.no/People/pprsk/GRASSMATE/ and Julie, Mikalsen and Persens, 2005).

The program phrased two sub-goals to the capacity-building: 1) achievements of PhDs and 2) building a network of researchers in science and mathematics education.

2. PROGRAM OPERATION

The GRASSMATE project might be described as a North/South – South research capacity building program within the field of science, mathematics and technology education. The development of research capacity was done through the provision of doctoral studies for students in Sub-Saharan countries. The research projects the students embarked upon were within their fields of interests although some students also chose research projects within broader international projects. Three students chose research projects in the Relevance of Science Education (ROSE) project (http://folk.uio.no/sveinsj/ROSE_abstract.htm), one student's project formed project of the *Relevance Of School Mathematics Education* (ROSME) project while the rest of the students selected their own research projects.

The students registered at UWC in South Africa and residential seminars were held twice a year in Cape Town. These seminars lasted from two to three weeks and the non-residential research work such as data collection, writing, and so forth were

done at the home institutions. For the females this structure was advantageous because experience has shown that whenever there is a choice in a family the females are the ones most likely to take responsibilities for home and children, often limiting them from taking further education. In the GRASSMATE program they could stay in the home culture except for the seminars in Cape Town.

The residential seminar comprised mini-courses of ± 20 hours duration and research supervision was supplied by supervisory team. Each student had an assigned team of three supervisors/advisors. The supervisory team normally consisted of an academic from the institution where the students are registered (UWC), one from Norway and, where possible, one from the student's home country. Each student had about five supervisory meetings during the seminars during which the student had the opportunity to in-depth discussion of her/his work and progress. These sessions lasted between one and two hours. Overall students had between 6 and 10 hours of formal supervision during the residential seminar sessions.

During the initial phase of the program students were required to make presentations of their ongoing work to the rest of the group - supervisors and fellow students. During these presentations two students were appointed as respondents to lead the discussion on the presenting student's work. Copies of the presentation were circulated prior to the presentation and after the responses from the appointed respondents, the discussion was opened to everyone in the group. The seminars culminated with students commenting on their experiences and work-plans.

In the last two years of the project period the project focused on the joined research and publication. The idea here was to maintain a network of researchers in the actual field. Thus it is hoped that the ideas and the research work laid down in the project will remain after the project terminated. *Sustainability* is normally defined as the situation where the program will be taken over by the state or institution upon completion. In this way the results of the project will hopefully endure sustainability for years. But sustainability could also be viewed differently; the Southern African researchers have had their doctoral education in the North and the work in GRASSMATE can be seen as a re-investing in further research capacity development.

In addition to the academic part of the program, social aspects were provided to strengthen the community in a less formal environment. This was deemed important since the students and supervisors came from different countries and opportunities had to be provided for everyone to "get to know" each other in an informal setting.

3. EVALUATION OF THE PROGRAM

Informal evaluations of the program were conducted after each residential seminar. These were through individual discussions with the students and with the students as a group. A formal evaluation was conducted in September 2006. Students were asked to complete a questionnaire comprising five selected areas and an open section. The selected areas were: Expectation on the project before starting up; Volume of courses and teaching; Quality and amount of supervision and guidance; Access to literature and internet resources at the registering and home institutions; Functionality of the student-groups and Adequacy of financial assistance.

The focus of the evaluation revolved around the two factors; Contribution towards the improvement in the quality of such programs, and Relevance of such programs.

3.1 Contribution towards the improvement in the quality of such programs

Preparedness of the students. The students were asked of their preparedness when entering the program. With preparedness we are thinking of two aspects, basic knowledge in research methodology and ICT, and workload.

Since all of them (except one) had a Master's degree as background, it would have been expected that the basic research methodology was relative clear. This was not the case. On paper the students were qualified for a doctoral study, but in practice they lacked crucial skills that would normally be assumed from masters' training. A majority of the students expressed a general wish for more relevant courses, specified as research methodology and related topics, especially when starting up the project. Some concepts turned out to be difficult and needed extra effort to work out. An example was the concept of theoretical framework, as expressed by one student in the following excerpt:

> *The concept that became a nightmare for all of us was "theoretical framework". This was not a familiar word at all. When we asked about it all we were told was that this is what we have to use in analysing our data. If one's analysing skills are that low as when we came here it was very difficult to make any connection at all.*
>
> *Now when looking back on the road that I have taken to my destination, I find that it has been this rocky path that I took that makes me feel very proud. Being asked the right questions at the right time (by our supervisors), referring to relevant literature, designing one's study, all these have been the ingredients to success. If one is a PhD student and I is fed with research methods, when are they going to wean from this spoon feeding, how will they assess their success?*

Another factor is the *workload expected* from the individual student. Did the students really know how much work is expected when entering the project? Two groups were disclosed; those working seriously and hard from the very beginning, and another group being pleased with only being a member of the project. The last group expected more spoon-feeding in contrast to the first group, and had sometimes to be told that the supervisory group expected more progress between the seminars. Most of the students committed fully into the doctoral study, as worded by one as:

> *It is a pity that one will be granted a part time study leave as in my case but still be given a full load of work. I did most of my GRASSMATE work at my home. I had to work everyday from 12 midnight to around 4:00 in the morning and still got to work to perform my full duties. This was very tough but in most cases I was thinking of the rewards of this hard work.*

The except is telling that the home institution was not prepared to ease the student from the workload even if she was given half-time study leave. This was a general issue and might be seen as an expression of the teaching situation at some universities

and colleges in the South; it is impossible to find substitute teacher at this level. One would benefit if there was any way of getting the students free for a couple of weeks to do their research work undisturbed. GRASSMATE tried to let the students stay for extra weeks in connection with the seminars. This was dependent on the home institutions, but the project had a good experience on this matter.

Five students were interviewed by an external researcher. Two of these had completed their PhDs; two were nearing completion; and one had joined the program more recently. On the question of workload they were of one opinion about the stress. Finding undisturbed time to work was a constant struggle, because of the need to balance it with the competing demands of the work at their home institutions and their personal, family, and social needs. Participants carved out time in the early morning, after work, into the evenings, and/or over weekends. They commented that this was when classes were finished, students were not knocking on their doors, computers were free, Internet access was available, and/or children were asleep.

The challenge of language. English is the second or third language of the participants – both among students and supervisors. Portuguese, isiXhosa, SeSotho, Afrikaans and Norwegian are the major first languages. Even if this might have caused problems for example with the academic writing, it has not hampered the communication within the daily supervision or the dialogue between the members of the supervisory teams.

Electronic communication. Especially E-mail has been frequently used to communicate between the various stakeholders in the project. This has been working satisfactory for most participants, but in some occasions the lines have been down leaving the participants isolated. The same applies to telephones and faxes. Very often we find that one communication mean down leads to all communication is down.

3.2 Relevance of GRASSMATE

By choosing a sandwich model we were able to reach the females in these countries, who otherwise often are left out of such programs. When selecting students we managed to take up nine female students out of a total of 20 students.

The GRASSMATE project organised travel, upkeep and accommodation for the workshops for all the students. The project did not provide money for the field work, which disappointed some of the students. But despite this all the students express their satisfaction with the opportunities GRASSMATE has given to the individuals, as expressed under:

> *The opportunity to study at PhD level is deeply appreciated as this is practically beyond reach for most of the students from very low income countries.*

Another (female) student gave the following excerpt:

> *I think GRASSMATE has provided a very good opportunity for us to study part-time through a sandwich program that I find it difficult to ask for more. This made it possible for us to look after our families. However, if there is room for projects like GRASSMATE to improve on the support maybe an increase in the research and book grant would be most welcomed.*

The other replies go in the same directions. Full support for three years would probably mean that GRASSMATE would be able to support fewer people than in the sandwich program. Especially the female students argue that the three year full time program would be suitable for students with less family commitments such that the student support they could get would be sufficient for the student and maybe a small family. Other argued that the sandwich structure worked very well since most of them had full-time jobs at their institutions and most of them had family responsibilities.

The students were anchored at UWC. This was done to emphasise that the project was implemented for African students and the field work should be motivated for challenges found in Africa. In this way the project has managed to have PhDs of great value for the countries where the students are coming from. Some of the research done in the various countries through GRASSMATE are now published in a book, Holtman,L *et al.* (Eds.), 2008.

Putting together a group of students from ten different countries turned out to be a nice experience, as expressed by one student as:

> *The PhD-student group functioned very well. This was in terms of peer-review; suggestions on other relevant literature; one-to-one bouncing of own ideas and reflecting on them; a shoulder to cry on; and friendliness; networking etc.*

This is also a valuable outcome for a continent in development.

4. SUMMARY AND CONCLUSION

The GRASSMATE project has spent a large amount of money on implementing the ideas laid down for the project. The natural questions then arise as: Has the money used been worthwhile? Could the utilisation have been better?

The two sub-goals can be used as indicators

The first indicator is the number of PhDs achieved. Altogether 28 students have been involved in the project and by March 2008 23 students have achieved a PhD and one student a Master's degree. Thus the result of the project is on a very high achievement level for competence building, at every standard one could use.

The other indicator, building a network among science and mathematics educators, is more difficult to measure. But both the informal feedback given by the full assembly and the products of joint publications assure us that also the network building has been working nicely between the various countries in the South and South-North.

The cross cultural and continental perspective has had a special impact on the project. The participants have learned a lot outside the professional work, leading to a personal development for the people involved. Also the researchers and the institutions involved have been enriched by the project.

Exchanges of researchers between UiB and UWC have been extensive; three Professors from UWC have been Guest Professors at UiB for a total of 16 months, one Professor from UWC was Adjunct Professor at UiB for eight years. He is now a Professor at the University of Agder in Norway. One Professor from UiB was Extraordinaire Professor for three years and guest Professor for ½ year at UWC.

Valuable links have been established between researchers in the North and the South. The project has played a tremendous role in creating new relationships both professionally and socially. Despite the cultural diversity and background and varied temperaments there have been no serious conflicts or misgivings that could hinder future collaboration. Programs like GRASSMATE have the potential to bridge the gaps between academics and educational professionals across the world to the advantages of children in both poor and rich countries. The diversity of the group contributed positively to students' development.

A major experience is that without mutual trust one cannot run a program like this. The research group must play together like the musicians in an orchestra. To create a sustainable research group one should include the social part as an additional important factor to the individual skills of the researchers. Without a social strong human environment one can not succeed for years without tension building up and sometimes poisoning the atmosphere.

REFERENCES

Julie, Mikalsen and Persens, (2005): The "complex reality" of research capacity development in mathematics education in Southern African development community countries. *International Journal of Educational Research*, **25**, pp. 591-601.

L. Holtman, C. Julie, O. Mikalsen, D. Mtetwa and M. Ogunniyi (Eds.) (2008): *Some Developments in Research in Science and Mathematics Education in SubSaharan Africa: Access, Adoption, Adaptation, Localization.* UWC.

ACKNOWLEDGEMENTS

We are grateful to the *Norwegian Centre for International Cooperation in Higher Education* (SIU) for funding the GRASSMATE program through the program *Norwegian Council for Development Research and Higher Education* (NUFU).

DIFFERENT STUDENT TYPES IN COUNTRIES WITH DIFFERENT WELFARE LEVELS: IMPLICATIONS FOR SCIENCE TEACHING

Fredrik Jensen, Svein Sjøberg, Fazilat Ullah, Camilla Schreiner
University of Oslo
fredrikj@subterminal.net, svein.sjoberg@ils.uio.no,
f@zilat.com, camilla.schreiner@naturfagsenteret.no

▼ Abstract

How does a country's level of development affect young people's *interests* in science and technology?

Our research aim was to do a comparative analysis of students' interests in science and technology, where we compare countries with different levels of development. We base our analysis on data collected in the ROSE (The Relevance of Science Education) survey, which is an international project that has collected data on 15-year-old students' orientations towards science and technology. By Cluster Analysis, we separated the students in each country in groups, or typologies, which responded in similar ways to the items. Such student typologies were developed for students from countries with different levels of development. Two countries had a low level of development (Uganda and Ghana), two countries had a medium level of development (Malaysia and Trinidad and Tobago) and four countries had a high level of development (Norway, Sweden, Finland and England).

We found a strong relationship between countries' level of development and the kinds of student types that appeared. The results are striking: The higher level of development, the more pronounced and the more gender specific the student types were. We interpret our findings in the light of sociological theories of modernity. And understand the different student typologies as signs of each country's youth culture. In less developed countries the main life project is to secure the fundamental material needs for survival, i.e. basic levels of nutrition, shelter, economy etc. In other words, in less developed countries the main project is to make a way out of poverty, while in modernized countries, youth's main project is identity construction. Our findings may have implications for what kind of science curriculum is best suited in different types of countries to meet the needs as well as the interests of the learners.

Key Words student types, interests, youth culture

1. INTRODUCTION

This paper is based on two master theses – Ullah (2008) and Jensen (2008). In our research we use data from the ROSE project (The Relevance of Science Education),

an international comparative study of 15-year-old students' perceptions of science and science education (http://www.ils.uio.no/english/rose/). As each of our two theses shed light on youth's interests in science and technology in different types of countries, with different levels of development, we found it fruitful to make a comparison of our findings. This may provide an understanding of patterns of youth culture and how young people's interests in science and technology may be understood and interpreted in different kinds of countries.

2. RESEARCH AIMS

In order to attain a deeper understanding of students' orientations towards science in the countries that we have studied, we wanted to group the students, within each country, in clusters with similar patterns of interests in science and technology. In this way we could examine not only the general characteristics and level of students' interests in science and technology in each country, but we could also explore different types of science students' interests within each country. We are clearly aware that there are and always will be individuals and differences between one and each of the students, but our aim is not to study the individuals, but to look at general trends in youth cultures.

Because we wanted to compare countries with different levels of development, we used Human Development Index as a guide when we decided which countries we wanted to include in our study. The Human Development Index is designed by the United Nations Development Programme (UNDP), and is monitoring average national achievement in three dimensions of human development: health, education and economy. The HDI value is a summary measure of these three dimensions, and provides a measure of a country's level of development.

Our joint research aims can be summed up as the following:

- To develop student typologies, based on students' interests in science and technology, for a few countries with respectively a high, medium and low HDI value.
- To make a comparison of the student typologies in countries with respectively high HDI values, and lower HDI values.

3. METHODOLOGY, DATA AND ANALYSIS

We base our study on data from the ROSE project, and have used data from eight different countries: Norway, Sweden, Finland, England, Malaysia, Trinidad and Tobago, Ghana and Uganda. We chose these particular countries because they represented different development levels, and because they had data of good quality. All the selected countries have more than 600 cases, and the gender distribution for each country is fairly even. Also, the ROSE teams in each of these countries have to a large extent followed the ROSE organizers guidelines for data collection (Jensen, 2008; Ullah, 2008).

3.1. The 108 ACE ROSE items

The ROSE questionnaire contains about 250 variables. In this analysis we only explored the A, C, and E (in short ACE) parts of the questionnaire, all addressing the

question "How interested are you in learning about the following?" followed by a total of 108 different items. The 108 items cover different topics relevant for science and technology, but also a few topics that one normally would associate with neither science nor technology – for example astrology or so called alternative medicine. The students responded by marking their degree of interest on a Likert scale with four response categories, which reaches from 'not interested' to 'very interested'.

3.2. K-Means Cluster Analysis

We grouped the cases within each country by using 'K-Means Cluster Analysis' in the statistical software SPSS (Statistical Programme for the Social Sciences). This procedure "[…] identifies relatively homogeneous cases, without any preconceived notion of what they have in common." (Schreiner, 2006, p. 116). For our analysis this meant that we could find groups of students with similar responses to the ACE items in the ROSE questionnaire.

With this method, we had to manually define the numbers of clusters before we ran the analysis. This means that the method demands careful consideration when one chooses the number of clusters that might possibly represent different student types. In order to choose the "right" number of clusters, we made the following criteria: We wanted to end up with a manageable number of clusters, the clusters had to be substantially interpretable, and they should not overlap – each cluster had to be particular.

4. FINDINGS

In most of the countries we studied, we let each cluster represent one student type. In the countries with high HDI value – i.e. Norway, Sweden, Finland and England – the student types were pronounced and to some degree gender specific. For these countries we ended up with four clusters that represented respectively four student types. Detailed scrutiny of the response pattern indicated that these student types were exactly the same in all the four countries. In more detail:

We identified two 'unselective' student types, which were not gender specific. These two groups represent, respectively, an overall high and a low level of interest in most topics related to science and technology. Students in these categories do not distinguish very much between different sorts of items, but display a more overall, respectively high or low, level of interest in more or less everything.

The other two student types are selective and gender specific, and we name them respectively 'selective girl' and 'selective boy'. These selective groups are very different from each other in their interest in different types of items. It is most striking how these two groups are highly gendered. While one group contains nearly only girls, the other contains nearly only boys – although the gender was not at all an 'input' in the statistical analysis. When looking at the items in detail, we find that the 'selective girl' is interested in what is stereotypically considered to be feminine topics, while the 'selective boy' is interested in typically masculine topics. The themes human biology (the body, health, exercise etc.) and mysteries (ghosts, astrology, alternative medicine etc.) are dominating the top interests of the 'selective girl'. The universe, spectacular phenomena (such as explosions, disasters etc.), inventions and technology comprises the themes that dominates the top interests of the 'selective boy'.

In the countries with low HDI values – i.e. Uganda and Ghana – the clusters were not very distinct. When clustering these cases, all clusters showed quite similar traits – a generally high level of interest in most of the ACE-items. We found it unreasonable to interpret these clusters as gender specific. Both boys and girls show the same type of interests. One can perhaps state that in these countries there are mainly two different student types, which respectively represents two different levels of interest. These students show most interest in subjects as technology (computers, mobile telephones etc.) and health (diseases, drinking water, first aid etc.).

In Malaysia and Trinidad and Tobago, which are countries with a medium HDI value, we found clusters with characteristics that fit well in-between the student types of respectively developed and less developed countries. For Malaysia and Trinidad and Tobago, we chose four clusters. Three of them are unselective and represents respectively three different levels of interest in most of the ACE items. The last cluster is to some degree gender specific, it contains 84 % boys for Malaysia, and 86 % girls for Trinidad and Tobago. These response profiles resemble to some degree the 'selective boy' and 'selective girl' student type's response profiles in the countries with high HDI.

It is also important to mention that along with the two countries with low HDI, generally the students from Malaysia and Trinidad and Tobago show more interest in all subjects compared to countries with high HDI. The overall mean score for the ACE-items is 3,2 for Uganda. (The response scale reaches from 1 to 4, where 1 represents 'not interested' and 4 represent 'very interested'.) Trinidad and Tobago, Malaysia and Ghana have an overall mean score about 2,9 and all of the four countries with high level of development (Norway, Sweden, Finland and England) have an overall mean score about 2,4.

Table 1 The countries' HDI value (UNDP, 2007) and overall ACE mean score.

Country	HDI value (2005)	ACE overall mean score
Uganda	0,505	3,2
Ghana	0,553	2,9
Malaysia	0,811	2,9
Trinidad and Tobago	0,814	3,0
England	0,9461	2,5
Finland	0,952	2,4
Sweden	0,956	2,4
Norway	0,968	2,4

In summary, our findings led us to the conclusion that there is a relationship between countries' HDI value and the kinds of student types that appear. I.e. the higher HDI value, the more pronounced and the more gender specific the student types were. Also, the students of less developed countries show a higher general level of interest in science and technology, compared to the countries with higher HDI values.

5. INTERPRETATIONS AND IMPLICATION

We interpret our findings in the light of sociological theories of modernity. And understand the different student typologies as signs of each country's youth culture. In less developed countries the main life project is to secure the fundamental material needs for survival, i.e. basic levels of nutrition, shelter, economy etc. In other words, in less developed countries the main project is to make a way out of poverty, while in modernized countries, youth's main project is identity construction (Giddens, 1991); These differences are clearly reflected by the different student types' interests in science and technology among the different countries we have explored.

We believe that students (and adults, too!) learn the taught subject matter easier, or at least show more motivation and interest, if it feels relevant and interesting to them. Consequently our findings may have implications for what kind of science curriculum is best suited in different types of countries to meet the needs as well as the interests of the learners.

REFERENCES

Giddens, Anthony. (1991). *Modernity and Self-Identity. Self and Society in the Late Modern Age.* Cambridge: Polity Press.

Jensen, Fredrik. (2008). *Velstand øker avstanden mellom jenter og gutter? En sammenlikning av ungdoms interesser i naturfag på tvers av fire vestlige land, basert på undersøkelsen ROSE (The Relevance of Science Education). [Prosperity increases the distance between girls and boys? A comparison of youths' interests in science across four Western countries, based on the ROSE survey (The Relevance of Science Education)].* Published master thesis, Faculty of Education, University of Oslo, Oslo.

Schreiner, Camilla. (2006). *Exploring a ROSE-garden: Norwegian youth's orientations towards science – seen as signs of late modern identities.* Published doctoral dissertation, Faculty of Education, University of Oslo, Oslo.

Ullah, Fazilat Siddiq. (2008). Små kjønnsforskjeller blant ungdom i mindre moderniserte land? 15-åringers interesser i naturfag på tvers av fire ikke-vestlige land, basert på prosjektet ROSE (The Relevance of Science Education). [Small gender differences among youth in less modernized countries? 15 year old's interests in science across four non-Western countries, based in the project ROSE (The Relevance of Science Education)]. Published master thesis, Faculty of Educatioin, University of Oslo, Oslo.

UNDP. (2007). Human Development Report 2007/2008. *Fighting climate change: Human solidarity in a divided world.* Accessed 18th of January 2008, from http://hdr.undp.org/en/media/hdr_20072008_en_complete.pdf

ACKNOWLEDGMENTS

Our study was based on data that's collected by a number of ROSE participants from different corners of the world. We would therefore like to express special thanks to the following ROSE organizers, for making our study possible: Jane Mulemwa (Uganda), Ishmael Anderson (Ghana), Suan Yoong (Malaysia), June George (Trinidad and Tobago), Edgar W. Jenkins and N.W. Nelson (England), Jari Lavonen (Finland), Anders Jidesjö and Magnus Oscarsson (Sweden).

QUANTITATIVE REASONING AND PROBLEM-SOLVING STRATEGY FOR SECOND GRADE CHILDREN IN CROSS-CULTURAL RESEARCH

Chen Ching-Shu
Taiwan Tainan University of Technology The Center For Teacher Education
tg0002@mail.tut.edu.tw

▼ Abstract

The purpose of the research is to explore the second graders' concept of numerosity development and quantitative reasoning. For this purpose, there are two stages of trials for the children. The first trial is concrete objects. After three months, the children accepted the second trial of half concrete objects. However, to understand how the process of solving problems of children is necessary, the researcher observed how children used strategies to discriminate numerosity. After that the researcher interviewed students.

The research sample came from second graders of Taiwanese and Hawaii Elementary schools. Each place had 20 students. In addition, in order to understand whether numerosity discrimination strategy in children was the same as adult's or not? The sample included 20 adults. The result of the research showed that Taiwanese and Hawaiian children reached up to a 90% rate of correct answer in the trial of real objects. But in the trial of half concrete objects, the rate of correct answers was down to 65%, especially when children compared two quantities of 5:6 ratios. As for strategy, the strategies of the children who completed correct answers were the same as the adult who did whole correct answers. Because their discrimination was not influenced by distance effect, they could judge the numerosity correctly. However, the children who got 90% correction were impacted by distance effect but not influenced by the size of the object. The research suggests that teachers give children real objects to estimate or discriminate the quantities of in their lives.

Key Words quantitative concept, numerosity, cross-cultural research, and child mathematics

1. INTRODUCTION

It is a common skill for people to use quantitative reasoning to estimate numerosity in daily life. For example, as adults try to estimate the number of cars in a parking lot and children try to figure out how many jellybeans are in a jar, they use quantitative reasoning to take a count. Even though children know how to do simple number operations; basically, they need the capacity of quantitative reasoning to complete them successfully. Furthermore, before understanding number sequence and recognizing

numeric symbols, quantitative reasoning is necessary.

1.1. Quantitative Reasoning

Quantitative reasoning has received the least attention from researchers until recently when scientists are paying more attention. How does a child estimate numerosity without counting before learning the formal operation? "How many" is usually a question of numerosity estimation (Sowder, 1992)? According to previous research, they found that preschoolers already have number sense so they can estimate quantity, compare number magnitude or do simple number operations.

Generally, children of quantitative reasoning depend more on cognitive performances with age. And it seems confusion is reduced in children's quantitative reasoning with growing older. Sophian (2000) noted that five-year old children have developed well enough in number sense. They can discriminate numerosity correctly without counting. As for 7-8 year old second graders of Elementary school, they may perform better than five-year old children, for their cognitive development is in the concrete operational stage (7-11 years).

1.2 Operational Children Reasoning

Their concrete operational children are capable of reversible thought only if they operate physical objects. Piaget (1952) identified that the concrete operational child begins to think logically. In addition, concrete operations allow children to order objects in terms of more than one dimension. Children at the concrete operational stage can solve conservation tasks. The operational thought is reversible. The concrete operational child can operate an action, and then go back to the original condition. But the limitation of this stage of cognitive development is that operations are only carried out on concrete objects, and limited to two characteristics at the same time. Hence, if the research design concrete and half concrete objects for second graders to discriminate numorisity with two characters how will second graders solve problems with strategies in quantitative reasoning?

2. QUANTITATIVE COMPARISON WITHOUT NUMER COUNTING

Quantitative reasoning relies on cognitive skill. Sowder (1991) contended that people need a mental reference unit that is a mental picture or feel for the size of units to form numerosity estimation. Bright (1976) thought good estimators have a well-developed set of mental reference units, for instance, use an estimate of area or linear estimates in an area formula, or estimate the numbers of square units that would fit within the boundaries. Sophian (2007) noted that comparison numerosity can be accepted along with quantities as well as length, area, volume and mass. In addition, without any reference to number, children could use one to one correspondence to compare all the elements of the two collections. It meant that children apply correspondence relations to compare numerical quantities without number counting. In her previous research, she (2000) has showed that the concept of ration may have influenced children to perceive relations within and between objects.

2.1 Numerosity Estimation

Lipton and Spelke (2005) provided evidence that adults discriminate well numerosities at about a 1.15 ratio (4 vs. 6 and 8 vs.12 elements, but not 4 vs. 5 or 8 vs.10). The researches also showed five-year-old children comprehend tasks with numerosities 20-120 applying a linear relation between number words and non-symbolic numerosities. In general, adults estimating numerosity are influenced by a "distance effect" in the trial task, because distance effects are a function of the ratios of pairs of numbers (Gallistel & Gelman, 2000). Children also are impacted by distance effects in numerosity estimation. However, it is less difficult for them to discriminate arrays in a 1:2 relationship than arrays in a 2:3 relationship (Huntley-Fenner & Cannon, 2000). Quite a few researches supported that children 7- or 8-years of age perform well on problems in numerical ratios but the ratios to be evaluated corresponded to distinct spatial configuration (Dixon & Moore, 1996; Fischbein, 1990; Kieren, 1988; Mack, 1990; Moore, Dixon & Haines, 1991, Nunes, Schliemann & Carraher, 1993; Piaget & Inhelder, 1975; Reyna & Brainerd, 1994; Singer, Cohn & Resnick, 1997; Sophian, 2000). So, select the appropriate type of quantitative comparison for a given problem and allow whatever quantitative features are particularly salient to dominate their reasoning. Then to explore the differentiation clearly between the different ethnics of second graders is interesting.

2.2 Research Purpose and Question

Hence, the present research will explore how second graders discriminated numerosity and quantitative reasoning with two experiments in different ethnics. The research questions are as follow:

1. Did second graders of different ethnic groups use different strategy to discriminate numerosity?
2. How did students perform in order to discriminate numerosity under different sizes of objects?
3. How did students discriminate numerosity under a different ratio of numbers of objects?

3. METHODOLOGY

In the research, two stages of trials are given for second graders of Taiwan and Hawaii to test their quantitative reasoning ability. The first trial is to estimate numerosity of concrete objects. After three months, the children accepted the second trial of half concrete objects to discriminate numerosity. However, in order to understand the process of solving problems by children, observation and interview were conducted to know how children used strategies to discriminate numerosity.

3.1 Participants

The participants came from second graders in Taiwan and Hawaiian Elementary schools. Each place had 20 students. The average age is about 7.8 years old. About gender, they were even: twenty girls and twenty boys. In addition, in order to understand whether quantitative reasoning strategy in children was the same as in adults, the sample included

20 adults who were recruited from different ethnic groups such as, Chinese, American, Hawaiian, Japanese and Korean. Gender was equal in adults. Their degrees are bachelor, master and doctor. They only accepted experiments B to estimate numerosity

3.2 Materials

The first trial had real objects for making children compare two sets of aggregate amounts to understand which amount is larger as a quantitative representation of an array. Each array of objects was spread on a table with 30 x 21 cm of area. And the amount of each array of objects followed 2:3 or 5:6 ratio. The objects serving as stimuli included plastic shells, bells, fish, blue birds, pink birds, apples and bears. There were eight problem sets in experiment A.

Table 1 Experiment A- plastic objects array

1.	20 fish (2.5 x 2 x 0.5) cm	vs.	30 blue birds (4 x 3 x 1)cm
2.	20 frogs (2 x 1.5 x 0.8) cm	vs.	30 apples (diameter 8cm x 2)cm
3.	20 pink birds (2x 1.8 x 0.5) cm	vs.	24 bears (2 x 1.8 x 2.5)cm
4.	20 shells (1.3 x 0.8x 0.8) cm	vs.	24 bells (diameter 5cm x 1.8)cm
5.	20 bear (2 x 1.8 x 2.5) cm	vs.	30 pink birds (2 x 1.8 x0. 5)cm
6.	20 bells (diameter 5cm x 1.8) cm	vs.	30 shells (1.3 x 0.8 x 0.8)cm
7.	20 blue birds (4 x 3 x 1) cm	vs.	24 fish (2.5 x 2 x 0.5)cm
8.	20 apples (diameter 8 cm x 2) cm	vs.	30 frogs (2 x 1.5 x 0. 8)cm

In Experiment B, each array had two groups of different stickers which had a different size, ratio (5:6; 2:3), and different pictures of animal stickers which included turtles, apples, bears and frogs. In addition, even the same animal had different pictures.

Table 2 Experiment B- animal stickers array

1.	O 20 fish (1.8 x 1) cm	vs.	R 24 frogs (2.5 x 2) cm
2.	O 24 fish (1.4 x 1) cm	vs.	R 20 turtles (1.8 x 1.2) cm
3.	R 20 apples (1.6 x 1.2) cm	vs.	O 24 turtles(1.8 x 1.2) cm
4.	O 30 fish (1.5 x 2) cm	vs.	R 20 apples(2 x 1.5) cm
5.	O 30 bears (2 x 1.5) cm	vs.	R 20 fish (1.8 x 1) cm
6.	R 20 grogs (2.5 x 2) cm	vs.	O 30 turtles(1.8 x 1.2) cm
7.	R 24 fish (1.5 x 1) cm	vs.	O 20 frogs (2.5 x 2) cm
8.	O 20 bears (2x 1.5) cm	vs.	R 24 turtles (1.8 x 1.2) cm
9.	R 24 apples (2 x 1.5) cm	vs.	O 20 fish (1.5x 1.3) cm
10.	O 20 turtles (1.5x 2.2) cm	vs.	R 30 fish (1.5 x1. 8) cm
11.	O 20 fish (1.5 x 1) cm	vs.	R 30 apples (2 x 1.5) cm
12.	R 30 frogs (2 x 1.3) cm	vs.	O 20 bears (2 x 1.5) cm

O Oval R Rectangular

Experiment B materials arrangement is a paired amount of stickers which is composed of two types of objects and they are asked to judge whether each type of item could be greater. Present the items in a spatially separated oval or rectangular area on A4 size papers. The amount in each group follows 2:3 or 5:6 ratios in arranging the objects on display for the children. Those objects comprised different sizes and pictures of animal stickers. There were twelve problem sets which were combined into a file, so that it was convenient to test the children for comparison numerosity.

3.3 Procedure

Participants were tested individually by a female experimenter in a single session with each child that took 5 minutes for Experiment A and also 3 minutes for Experiment B. During the process of the experiment, the children were asked not to count but to use eye tracking to reason quantitatively and solve problems.

The problems were intermixed and presented in an order that was randomized independently for each individual. Participants were simply asked which of the two pair amounts was just like the bigger one. No feedback was given about the correctness of responses, but children were reminded that either the left or the right alternative could be the bigger one and that they needed to look carefully at both alternatives to identify the correct one. Furthermore, in two experiments, second graders and adult participants were asked to compare different ratios' aggregate amount in collections including between 20 and 30; or 20 and 24 objects.

4. FINDING AND DISCUSSION

4.1 Finding

The result of the research showed that Taiwanese students' quantitative reasoning was not different from Hawaiian students' in real objects. Taiwanese and Hawaiian children reached up to a 90% rate of correct answers in experiment A. Taiwanese students got 93.13% and Hawaiian 92.50% correct answers. But in experiment B, the performance of the students in the two schools was significantly different in discrimination numerosity. Hawaiian students had a 76.50% correct rate; Taiwanese students got up to a 90% correct rate for experiment B. Furthermore, the correct rate of some problems was down to 65%, especially in 5:6 ratio aggregate amount because it was difficult for the students to compare one set with a big size but a small amount versus another set with a small size but a big amount of objects. Under the conditions, Hawaiian students declined greatly in numerosity estimation of 5:6 ratios. In the first problem of the array, Taiwanese got 80% correct, but Hawaiian were down to 25% correct. As for the rate of the second problem, Taiwanese had an 85% correct rate but Hawaiian had only a 30% correct rate. The reason why Hawaiian students got such a low number correct was because a distance effect influenced their performance. Without doubt, the visual factors impacted the Hawaiian students' performance in estimation numerosity of half concrete objects. So, in the trial of quantitative reasoning, the visual influence will be considered in judging numerosity for the operational stage child.

4.2 Discussion

Discussing the strategy of discrimination numerosity, the strategies of the children who completed correct answers were the same as the adults who did all correct answers. The clue in tracing the array was, these children could not focus on the object occupied space to estimate numerosity, but they quickly detected each row which composed the number of items. Because their discrimination was not influenced by distance effect, they could judge the numerosity correctly. However, the children who got 90% correct were impacted by distance effect but not influenced by the size of the object. The children judge aggregate amount with the objects' density and space but not size. In the aspect of higher wrong rate judgment, students had never developed their strategies in discrimination numerosity.

5. CONCLUSIONS

In two experiments, Taiwanese and Hawaiian children made accurate quantity judgments of concrete objects. However, their judgments were no less accurate when both response alternatives differed in spatial configuration which was oval or rectangular areas from close ratios (2:3 or 5:6) of objects. Experiment A showed that students from both schools had comparable performance and no ethnic-related differences in the reasoning for concrete objects of numerosity. Experiment B found that these ethnic-related differences were due to close ratio amounts between 20 versus 24 items or size of items in half concrete objects by second graders.

The findings suggest that the concept of ratio may have important foundations in the way second graders perceive relations within and between objects. Furthermore, student and adult participants' estimation performance was influenced by physical features of stimuli only for very close ratios of displayed numerosities. So, it is natural that the mind is able through the eye to estimate any large number of objects without counting them successfully. And for the further understanding of how participants accomplish numerosity estimation tasks and the effects of aging in this domain are discussed.

6. IMPLICATIONS

The research suggests that teachers give children real objects to estimate or discriminate the quantities of in their lives. The implications for mathematics teaching: in helping children to make judgments about aggregate amounts, students need to practice estimating numerosity under the influence of distance effect..

7. REFERENCES

Bright, G. W. (1976). Estimating as pat of learning to measure. In D. Nelson & R. E. Reys (Eds.), *Measurement in school mathematics*: 1976 yearbook (87-104). Reston, VA: NCTM.

Dixon, J. A., & Moore, C. F. (1996). The developmental role of intuitive principles in choosing mathematical strategies, *Development Psychology, 32*, 241-253.

Fishchbein, E. (1990). Intuition and information processing in mathematical activity, *International Journal of Educational Research, 14*, 31-50.

Gallistel C. R., Gelman, R. (2000). Non-verbal numerical cognition: From reals to integers. Trends in Cognitive Sciences, 4(2), 59-65.

Huntley- Fenner, G., & Cannon, E. (2000). Preschoolers' magnitude comparisons are mediated by a preverbal analog mechanism. Psychological science, 11(2), 147-152.

Kieren, T. E. (1988). Personal knowledge of rational numbers: Its intuitive and formal development. In J. Hiebert, & M. Behr, Number concepts and operations in the middle grades (pp. 162-181). Hillsdale, NJ: Lawrence Erlbaum.

Lipton, J. S. & Spelke, E. S. (2005). Preschool children's mapping of number words to nonsymbolic numerosities. *Child Development, 76(5)*, 978-988.

Mack, N. (1990). Learning fractions with understanding: Building on informal knowledge, *Journal for Research in Mathematics Education, 21*, 16-32.

Moore, C. F. Dixon, J. A. & Haines, B. A. (1991). Components of understanding in proportional reasoning: a fuzzy set representation of developmental progressions. *Children Development, 62*, 441-459.

Nunre, T. Schliemann, A. D. & Carraher, D. W. (1993). *Street mathematics and school mathematics*, Cambridge: Cambridge University press.

Piaget, J. P. (1952). The origins of intelligence in children. International Universities Press, New York.

Piaget, J., & Inhelder, B. (1975). *The origin of the idea of chance in children*, New York: Norton.

Reyna, V. F., & Brainerd, C. J. (1994). The origins of probability judgment: A review of data and theories. In G. Wright, & P. Ayton, Subjective probability (pp. 239-272), New York: Wiley.

Singer, J. A. Kohn, A. S. & Resnick, L. B. (1997). Knowing about proportions in different contexts. In T. Nunes, & P, Bryant, Learning and teaching mathematics (pp. 115-132).East Sussex, UK: Psychology Press.

Sophian, C. (2000a). From objects to quantities: Developments in preschool children's judgments of aggregate amount. *Developmental Psychology,* 36*,* 724-730.

Sophian, C. (2007). Rethinking the starting point for mathematics learning. In O. N. Saracho & B. Spodek (Eds.), *Contemporary perspectives in early childhood education: Mathematics, science and technology in early childhood education* (pp. 21-44). Information Age Publishing.

Sowder J. (1992). Estimation and number sense. In Douglas A. Grouws(Ed). *Handbook of research on mathematics teaching and learning* (pp.371-389). NY: MacMillan Publishing Company.

8. ACKNOWLEDGEMENTS

I would like to thank Professor Sophian and Hawaii University of Elementary School to help me to collect data and Taiwan NSC and Fulbright Foundation grants.

THE USE OF OBSERVATION FORM TO ASSESS STUDENTS' LEARNING PROCESS ON SCIENCE LABORATORY COURSE

Meryem Nur AYDEDE, Teoman KESERCİOĞLU

Dokuz Eylül University, Faculty of Education, Department of Science Education, Izmir, Turkey, teoman.koglu@deu.edu.tr, mnur.aydede@deu.edu.tr

▼ Abstract

The purpose of this study is to determine the science education undergraduate students' opinions to assess learning process via student observation form on IFN 336 Science Laboratory Course. The study was implemented in Izmir, Turkey in 2006-2007 education period. Horizon of the research covers the students who study at Dokuz Eylül University. 46 students who are in IFN 336 Science Labrotory Course were included in the sample of the research. IFN 336 Science Labrotory course was chosen for the study. Open-ended laboratory activities were used during the science laboratory course. The study lasted 10 weeks. Open ended student negotiation form were used to collect data in the study and content and frequency analyses method was used to analyse the data. In the end, qualitative data analysis showed that many students were pleased to use observation form during the science laboratory course.

Key Words Observation form, science laboratory course, learning process

INTRODUCTION

Today many countries are trying to invert their current education systems into a system in which the students are more active. The reason of that effort is having the conviction that it is impossible to grow up persons who can think, investigate and resolve within the conventional education systems in which the students are passive individuals. The new approaches which are offered to be used in the new system of science education need to be adapted into the science education lesson which is very important for the future of a country.

A school laboratory investigation is defined as an experience in the laboratory, classroom, or the field that provides students with opportunities to interact directly with natural phenomena or with data collected by others using tools, materials, data collection techniques, and models (NRC 2006, 2006). Recent educational developments such as constructivism and multiple intelligence theories as well as society oriented new trends engendered radical change in traditional approaches of instruction and assessment. Altering assessment practices is likely to affect curriculum, teaching methods, and students' understanding of the meaning of their work. For this reason, alternative assessment approaches are needed in assessing both learning process and learning product. Because many students directly memorize facts, words, tasks, and

other information, direct instructional procedures could be used to prepare students for other more conceptual activities. Observation forms could be used to teach students high level thinking skills (Ross and Stevens, 2003).

Since changes in assessment are believed to directly influence changes in the classroom, a newly designed assessment system must accurately measure and promote the complex thinking and learning goals that are known to be critical to students' academic success and to their eventual sustained achievement and contribution to their communities.

Alternative assessment includes a variety of measures that can be adapted for different situations. Nowadays, one of the alternative assessment techniques used in various disciplines such as mathematics, science and social sciences and so forth is the "observation form" (Birgin, Baki, 2007, 1). Therefore, it is important to investigate how the assessment actually works and search of interpretations and perceptions of assessment practices must play a major role in the learning process (Govaerts, et al., 2005). Thus, direct observation and recording of actions help students to be accountable for their learning process and actions (Hope, 2005). If observations of practice are to fulfill the role assigned to them by regulators, they need to approximate to 'pure observations' so that the observer witnesses the student's practice just as it is at that point in time (Humphrey, 2005). And one of the necessary area of using observation forms are laboratories.

METHOD

The study was organized according to qualitative research approach which is used for a specific attitude based on researches' openness and reflexivity (Flick, 2006) and using words as data to describe human experience or behavior. The research was conducted for 10 weeks on undergaraduate science education students in Izmir spring semester of the 2006-2007 education period. At the beginning of the study, an awareness-raising program was applied to the study group in order to assist their adaptation to student observation form approach. This awareness program also covered activities helping students in the studygroup to develop behavior suitable for the method applied during the experimental period. Lessons were performed by the researcher. Observation forms were performed by the observer who was a master student in depertmant of science education in Dokuz Eylül University

Dependent and Independent Variables: In this context, it was aimed to test the effect of independent variables (using observation approach), on dependent variables (student opinions).

Study Group

Horizon of the research covers the students who study at Dokuz Eylül University. 46 students who were in IFN 336 Science Labrotory course were included in the sample of the research. In the research we interviewed the students categorizing them according to their general average points of success. The students are considered as successful, medium and weak. The students who have general average points between 3,5 and

4 were esteemed as successful; the students who have general average points between 2,5 and 3,5 are esteemed as medium and finally the students who have general average points between 2,0 and 2,5 were esteemed as weak. The sample was chosen according to maximum variety principle, one of the purposeful sampling methods. 15 students who were interviewed were chosen through a random draw from 46 students.

Research Questions

The main purpose of this study is to investigate the effectiveness of observation forms on students' learning process on "Science Laboratory Course" of undergraduate students. Other questions associated with the main purpose are as follows:

What are the opinons of the experimental group about;

- using observation forms on science laboratory course?
- barriers of using observation form on science laboratory course?
- benefits of using observation form on science laboratory course?

Data Collection Tools

In the study, 'Student Negotiation Form' was developed by the researchers to collect data.

Student Negotiation Form: In the research, negotiation forms were used for two purposes. First one is the step of preparing measurement instrument. The other was to find out the opinions of the research group students about using student observation form on science laboratory course. In the researh, the steps below were followed: While developing the form, local and foreign literature was reviewed and the students' opinions were taken. By means of the data gained from the literature review and students' opinions, the items for trial have been composed. The pilot application of the items which were revised according to experts' opinions has been carried out with undergraduate science education students. Reliability was done on trial items.

Data Analysis: Content analysis and frequence analysis methods were used to determine science education undergraduate students' opinions to use observation form on science laboratory course.

RESULTS

Qualitative data analysis showed that the students who participated the research stated matters about using an observation form as: students were pleased to use observation form during the science laboratory course (n=2), observation form enhanced their interest towards the learning subject (n=6), the form prompted them to make preparation before the lesson (n=5), although at first they thought that it wouldn't work, later they realized that this was a useful method (n=3), By using observation form many students increased their feelings of personal control over their learning and ability to apply their knowledge (n=8).

Students stated matters about advantages of using an observation sheet as: they learned better with this process evaluation (n=14), the forms prompted them to ac-

tive participation (n=6), this method enhanced the positive attitude towards studying lesson (n=2), students learned scientific process skills better with this method (n=3), with this form they could see their shortages more easily (n=2), It decreased rote memorizing (n=3) and It increased their interest towards the lesson (n=1).

Students stated matters about the preventing factors from using the observation sheet in the biology laboratory course as: observation method is sometimes frustrating (n=4), the first applications are generally uneasy (n=2).

REFERENCES

Flıck, U. (2006). *An Introduction to Qualitative Research*. (third edition). London, Thousand Oaks: Sage

Birgin, O., Baki, A. (2007). The Use of Portfolio to Assess Student's Performance. *Turkısh Scıence Educatıon.* 4(2), p:75-90

Govaerts, M. J. V., Van Der Vleuten, C. P. M., Schuwırth, L. V. T., Muıjtjens, A. M.M. (2005). The Use of Observational Diaries in In-Training Evaluation: Student Perceptions. *Advances in Health Sciences Education.* 10:171–188

Hope, A. (2005). Panopticism, play and the resistance of surveillance: case studies of the observation of student Internet use in UK schools, *British Journal of Sociology of Education.* 26(3), pp. 359–373

Humphrey, C. (2005). Observing Students' Practice (Through the Looking Glass and Beyond), *Social Work Education*, 26 (7), pp. 723–736

National Research Council (NRC). 2006. America's lab report: Investigations in high school science. Washington, DC: National Academy Press.

Ross, A. H., Stevens,K. B. (2003).Teaching Spelling of Social Studies Content Vocabulary Prior to Using the Vocabulary in Inclusive Learning Environments: An Examination of Constant Time Delay, Observational Learning, and Instructive Feedback, *Journal of Behavioral Education,* 12(4). pp. 287–309

THE EFFECT OF USING SCIENTIFIC VOCABULARY IMPROVING ACTIVITIES ON STUDENT ACHIEVEMENT IN SCIENCE AND TECHNOLOGY LESSONS

Efe GUCLUER, Teoman KESERCİOĞLU

Dokuz Eylül University, Faculty of Education, Department of Science Education, Izmir, Turkey, teoman.koglu@deu.edu.tr

▼ Abstract

This research was made to determine the effect of scientific vocabulary improving activities on the success of science and technology lessons. The research has been made on the 7th grade students who go on their education in the city of Agri in the first term of 2007-2008 education year. Experiment and control groups have been chosen in 7th grade A and B classes in this research. Digestive system unit has been taught to the students of experiment group by using scientific vocabulary improving activities (vocabulary games, scientific stories, word wall, illustrated dictionary, science diaries), on the other hand; the students of control groups have been taught the way which has been suggested by the textbooks advised by Ministery of Education. The worksheets used in the research were developed by the researcher. Independent t-test was used to analyze the data that obtained from the pre and post-tests results of both groups. In the end of the research students of experiment who was taught by using scientific literacy improving activities were determined more successful than the students of control groups.

Key Words Science education, scientific vocabulary improving activities

1. INTRODUCTION

It is aimed to ensure that, students learn about their close and remote environment in which they live through elementary school science education from the points of living, physical and geological views. Students learn asking questions, making research, determining problems, making observation, making examination, establishing hypothesis, making experiments, collecting data, analyzing them and making generalization with conclusions (Can, 2004).

Moore, Moore, Cunningham, and Cunningham (1986) stated that "biology is not about plants and animals. It is the language of plants and animals… astronomy is not about planets and stars. It is a way of talking about planets and stars. Language is a tool for learning, communicating and thinking (Vygotsky, 1978). As students apply vocabulary skills, they are able to read, write and think in scientific terms (Casteei & Isom, 1994). To develop these critical comprehension skills, teachers should help students to expand and enrich their reading and vocabulary skills (Johns & Lenski, 1997).

VOCABULARY INSTRUCTION

Students' reading comprehension consists of many components (Irwin,1991). The most important components are that students totally learn the concepts by the way meaning, reading and writing (Snow et al, 1998). The most important component to understand a text in the textbook is the learning ability of students' scientific vocabulary (Mullis, Campell & Farstrup, 1993; Rosenshine & Meister, 1994)

However, most traditional vocabulary instruction methods in content area fails to increase comprehension (Nagy; 1998). Nagy (1998) describes that traditional vocabulary instruction has three important problems. The first problem of traditional method is to lead students to memorize words and concepts instead of learning. The scientific concepts that are learned by memorizing causes artificial learning.

The second problem of the traditional vocabulary lessons is about the content of the concepts that are taught (Nagy, 1998). Just a few sentences are given related to vocabulary and whole meaning is restricted to these sentences. Thus, learning of students is limited just to the sentences which are given by the teachers (Shatz & Baldwin, 1986).

The third problem area in the teaching of vocabulary is partial word knowledge. Teaching vocabulary should provide a deep meaning. A good vocabulary teaching should provide to learn new vocabulary and concepts (Nagy; 1998).

Some of the most important problems faced by researchers on education are that, students' scientific vocabulary is limited, students do not have sufficient skills for reading papers and they cannot understand scientific papers, which are read by them at school. These problems are caused by insufficiently developed scientific literacy (Thelien, 1991). Because students' scienctific literacy level is low, they are limited in making arrangements relevant to the texts existing in their science books (Roe et al, 1995). One of the most important problems, which elementary and high school science teachers complain about, is that, most of the students cannot properly understand the texts, which are read by them (Lloyd & Mitchell, 1989). However, according to Roe et al (1995), the reason is that, science books are not written suitable for that, students learn the words facilitating understanding science books.

The objective of this study is to examine the effects of using activities developing students' scientific vocabulary in scientific teaching according to the lesson activities recommended by Ministry of National on students' success in science.

2. METHOD

2.1 SAMPLE

The sample of this study consist of 56 students who are 7th grade students from Şeref Saraçoğlu primary school in the city of Ağrı in the first term of 2007-2008 education year. The experiment group student's who were taught subject with vocabulary techniques about scientific literacy consist of 28 students and the control group student's who were taught subject with the way that was suggested by Minister of Education consist of 28 students about. In the sample classes the 7-A class was determined control and the 7-B class was determined experiment group. The election was made by toss of coin.

2.2 INSTRUMENTS

Worksheets and activities about digestive system unit and achievement test to collect the experimental data about study has been prepared by the researcher.

The digestive system unit achievement test used in the research was developed by the researcher. The achievement test includes the titles as digestive system organs, the organs that help digestive and the health of the digestive system. The pilot study of the test was applied on 122 students and it was re-arrenged after item analyses. The Cronbach Alfa coffecient of achievement test has been found 0.81. As a result the test consists of 22 items that every item has four options.

Table 2.1.1 The digestive system achievement test reliability results

Test	Number of items	KR–20
"Digestive System" Unit Achievement Test	22	0.81

2.3 PROCESS

This study was conducted in Şeref Saraçoğlu Primary School in the city of Ağrı during the first semester of 2007-2008 education year. Before the application, the pre-test was applied to 7-A and 7-B classes and it was shown that there is no significant difference between control and experiment groups.

Teaching of the digestive system unit started in both of the groups at the same time. The duration of the teaching time was determined as 12 hours and it has been finished in both groups at the same time. Digestive system unit has been taught to the students of experiment group by using scientific vocabulary improving activities (vocabulary games, scientific stories, word wall, illustrated dictionary, science diaries), on the other hand; the students of control groups have been taught the way which has been suggested by the textbooks advised by Minister of Education.

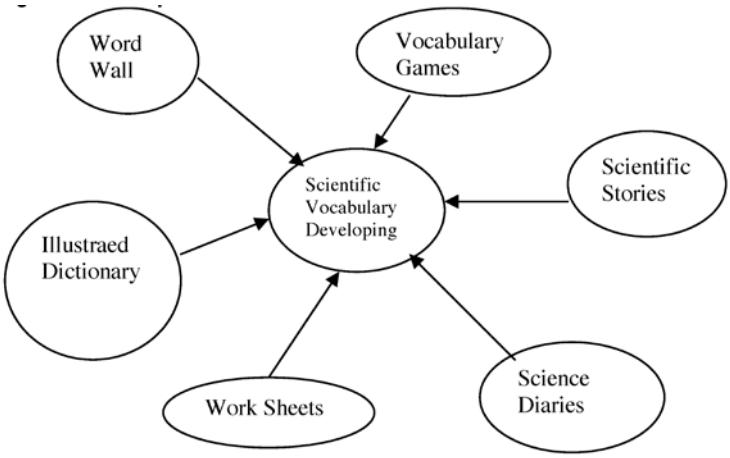


Figure 1 The experiment design of experiment group

The experiment group students worked in groups. Before the application class environment was re-arranged to enable students work in groups. Before the lesson; students were informed about activities and homework. At the end of the study, the test which had been applied as pre-test was re-applied as the post-test to control and experiment group students at the same time.

3. DATA ANALYSIS AND FINDINGS

The data analysis was made by using independent t-test and the statistical results were obtained by using SPSS program. At the beginning of the study a pre-test was applied to determine if there is a difference between control and experiment groups student's knowledge level about digestive system. The t-test analysis results which obtained by using the pre-test scores were given the table 3.1 below.

Table 3.2.1 The t-test results of experimental and control group student's pre-test scores

Group	N	X	SS	t	p
Control	28	3.00	1.465	.91	.928
Experiment	28	2.96	1.477		

Table 3.1 shows there is no significant difference between control and experiment groups' student's pre-test results before application. It is shown that the knowledge level of control and experiment group student's about subject are similar before the experimental study.

The results of t-test score which was taken by post-test to determine if there is significant difference between control group students who were taught the subject by traditional methods and experiment students who were taught the subject by scientific vocabulary development activities are shown at table 3.2

Table 3.2 The t-test results of experimental and control group student's post-test score

Group	N	X	SS	t	p
Control	28	8.21	3.67	-8.642	.00
Experiment	28	16.85	3.80		

Table 3.2 shows that there is a significant difference between control and experiment group student's post-test results. In addition there is an 8.64 score difference between control and experiment groups post-test scores. According to this result, the experiment group's student achievement increased at significant level than the control group students' achievement.

4. RESULTS AND CONCLUSIONS

It was found that at the end of the study, a significant variation occurred between post-test scores of the students of the test group in which the activities developing

students' scientific vocabulary were employed in teaching "digestion system" and the students of the test group were taught according to Science and Technology. This variation was in favor of the test group in which the activities developing students' scientific literacy were employed.

According to this result, using activities developing students' vocabulary knowledge in science teaching is a more effective method in increasing lesson successes of students compared with the activities recommended by science and technology program.

Armstrong, (2000) investigated the integration of reading vocabulary techniques effects on achievement in 6th grade students and he determined students' achievement whose scientific literacy skills has been developing are higher than the other students' achievement.

Kristina (1992) studied the effects of using scientific reading texts in science teaching on students' understanding scientific concepts and concluded that, such texts are useful for students to understand scientific concepts more effectively. These results also may prove the result of this study.

According to the results, which were obtained in the study applied on 7th grade test group students by using activities developing students' scientific vocabulary in science teaching, the following may be recommended:

- The essential objective of the existing science and technology program is to make the students scientific literate. Science and technology teachers should have been trained on their job about what scientific literacy is and how it can be developed.
- It should be observed during education process whether students learn reading, writing and using scientific terms properly or not which are taught according to the existing science and technology program.

REFERENCES:

Moore, D., Moore, S., Cunningham, P., & Cunningham, J. (1986). Developing readers and writers in the content areas. New York: Longman.

Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University.

Casteei, C.P. & Isom, B.A. (1994). Reciprocal processes in science and literacy learning. The Reading Teacher. 47. S38-S4S.

Johns, J.L., & Lenski, S.D. (1997). Improving reading: A handbook of strategies (2nd ed). Dubuque, IA: Kendall/Hunt.

Irwin, J.W, (1991). Teaching Reading Comphrehension Process (2nd ed..). Boston: Allyan and Bacon

Snow, C.E., Burns, M.S & Griffin, (Eds.), (1998). Preventing Reading Difficulties in Young Children. Washington dc: National Academy Press.

Mullis I,V., Campell, J.R, & Farstrup, A.(1993). National Assessment of Educational Progress, 1992 – Reading Report Card for the Nation and States

Rosenshine. B & Meister, C. (1994). Reciprocal Teaching: A review of research. Review of Educational Research, 64(4), 479-530

Nagy, W.E. (1998).Teachin Vocabulary tı Improve Reading Comprehension. Urbana. IL:National Council of Teachers of English

Schatz,E.K. & Baldwin, R.S. (1986). Context Clues are Unreliable Predictors of Word Meanings. Reading Research Quarterly, 31, 429-453

Thelen, J. (1991). Foreword. In CM. Santa & D.E. Alvermann (Eds), Science learning: Processes and applications. Newark, DE: International Reading Association.

Roe, B. D., Stoodt, B. D., & Burns, PC. (1995). Secondary school reading instruction: The content area (5th ed.). Boston: Houghton Mifflin.

Lloyd, C, & Mitchell, J. (1989). Coping with too many concepts in science texts. Journal of Reading: 32, 542-549.

Armstrong J.C (2000) The Integration Of Reading Vocabulary Techniques With Scientific Terminolgy İn A Sixth Grade Classroom. P:16

Krista, A (1992) The Effect of a Textual Reading Activity at Different Phases in the Science Learning Cycle on Comprehension of Science Concepts, www.erg.sabanciuniv.edu/iok2004/bildiriler/Tuba%20Can.doc

ACKNOWLEDGEMENTS

Thanks for TUBİTAK for supporting my studies

GOING UP ALLEYS TO SEE IF THEY ARE BLIND: THE USE OF PROBLEM SOLVING AS A BASIS FOR TEACHING UNDERGRADUATE SCIENCE PROGRAMMES

Dr O Kelly* and Dr R L Cutting*

**Faculty of Education, University of Plymouth, Douglas Avenue, Exmouth, UK EX8 2AT*

Email: orla.kelly@plymouth.ac.uk

▼ Abstract

Traditional, practical based methods for teaching science are a widely adopted approach in science teaching at all academic levels in the UK and Ireland. However, increasing concern over the prescriptive nature of such approaches has recently led to alternative methods being adopted. Problem-based learning (PBL) is one such alternative approach, and is characterised by its student-centred approach. This paper describes a similar approach whereby student learning in a first year undergraduate science programme was moved away from practical replications of the 'known' to group explorations of the 'unknown'. Delivered entirely though a series of problem solving units, the students and staff (for the problems were frequently beyond the staff specialist knowledge) were all involved in a programme that provided an alternative learning experience in science. The effectiveness of the approach was evaluated through reflective diaries (both staff and students), questionnaires (at critical points across the year) and by a series of semi-structured interviews. Initial results suggest that the students felt that their understanding of science as a process had been enhanced and that confidence in designing and conducting experiments had improved. Staff reflections were initially uncertain, both in terms of the learning taking place and the new role, best defined as 'knowledgeable friend'. However, as the course progressed so these concerns were negated and indeed, replaced by a genuine sense of legitimate group learning. The paper concludes that problem solving can play an important role in developing students' confidence in scientific method, but is also contributory to the development of methods that are inventive, imaginative and exploratory.

Key Words Problem-based learning, Practical work, Undergraduate science

1. INTRODUCTION

Science is a compulsory part of the UK National Curriculum and as such has a rather captive audience. Once the constraints of compulsion are removed however, a trend of steady decline has emerged over the last decade. Indicators include the significant decrease in numbers choosing to study the physical sciences on post-16 courses, (BBC

2006; UCU 2006) and the decline in numbers choosing science at degree level causal to 10 UK universities closing chemistry departments for lack of demand (UCU, 2006). Furthermore, a recent report by the Royal Society (2008) points out a relative fall in the proportion of students enrolled on doctoral degrees in science despite a marked increase in the general recruitment of masters and doctoral students.

Even at the very highest level of science research the data flatters to deceive. In a recent editorial Carlton and Andrass (2008) point out a so-called trend of 'down shifting' in UK science, a trend away from so called 'revolutionary science' that which is paradigm shifting to 'normal science' that which is an "incremental extrapolation of existing paradigms" (Carlton and Andrass, 2008: p466).

Precise reasons for this decline are indisputably complicated but George (2006) suggests that students interest in science may be influenced by their attitude to it, this being variable by age, peer attitude, and gender as well as social background and geographical influences (UCU, 2006). It also appears to be influenced by its delivery in schools and colleges. The influential UK Parliamentary Standing Committee on Science and Technology recently described current GCSE courses (16+) in the UK as *"overloaded with factual content, containing little contemporary science and have stultifying assessment arrangements,*" the committee's report continued *"Coursework is boring and pointless. Teachers and students are frustrated by the lack of flexibility. Students lose any enthusiasm that they once had for science.*" (Parliamentary Standing Committee on Science and Technology, 2002)

In a Higher Education Institution, the students progressing onto science courses have presumably not been put off, nor have they lost their enthusiasm, but what awaits them at degree level? Often more of the traditional expository style practical methods that are widely utilised at all academic levels in the UK and Ireland for teaching science. Such methods however, are described as presenting knowledge, particularly where the teacher, or lecturer, is comfortable with that knowledge (Tan, 2004). In such cases this knowledge based content can be seen as being 'owned' by the lecturer and being passed on at his, or her, behest. In such instances, practical laboratory work may become nothing more than simple verification of stated theory. Criticisms of this approach include that its 'recipe' style nature "*gives no room for the planning of an experiment*, *it is an ineffective means of building concepts*" and "*is unrealistic in its portrayal of scientific experimentation.*" (Johnstone and Al-Shuaili 2001 p 46) Such an approach may be identified as 'student centred' in the sense that the student has responsibility for the determination of results, but such work is confined by a pre-determined methodology and normally a margin of acceptable error within which results should fall. This type of teaching methodology will be familiar with many who have studied science over the last decade and beyond. Such an approach may produce competent graduates, who have an undoubted knowledge base and are confident in prescribed laboratory procedures but reduces the opportunity for invention and creativity. In the UK concerns relating to the delivery of science are expressed at governmental level.

"Science should be the most exciting subject on the school curriculum: scientific controversies and breakthroughs hit the headlines every day. But school science can be so boring it puts young people off science for life. GCSE science students have to cram in so

many facts that they have no time to explore interesting ideas, and slog through practical exercises which are completely pointless. This is a disaster: we need to encourage a new generation of young scientists." UK Parliamentary Select Committee on Science and Technology (2002).

In the last decade, problem based learning (PBL) has become a prevalent curricula advance (Tan, 2004:p170) and since the publication of the General Medical Council's `*Tomorrow's Doctors*' (1993, GMC, London) PBL has been widely adopted in Medical Schools in the UK and has more recently formed the focus for much of the delivery in the so called "new" medical schools set up since 2002. Here there has been a shift in focus from the traditional, didactic method of teaching, where the lecturer is the expert, transmitting knowledge to the students, with coverage of content the focus, to a student-centred style, where students are problem solvers, the lecturer is in a coaching or facilitating role, and the problem is the focus of the learning from which content is derived. (Tan 2004) This follows similar developments in North America where research into the effectiveness of PBL in medical education is well established. A number of meta-analyses suggest that such PBL is at worst, the equivalent of other more traditional methods (Albanese and Mitchell 1993 and Vernon and Blake 1993). The reasons for the effectiveness of such approaches are elusive, but may relate to different learning styles. PBL encourages what Petty (2006) has described as 'deep learning'; a constructivist approach where learning is achieved by adapting and building on prior knowledge, skills and concepts, thereby allowing the learner to seek meaning for themselves and not the meaning as constructed by their teacher.

More recently, PBL is receiving much attention in physics, chemistry and biology education. (Freitas, Jimenez, & Mellado 2004;Ibanez-Orcajo & Martinez-Aznar 2007;Kelly & Finlayson 2007;Lee 2007) The benefits of this problem-based approach, particularly in science, are summarised well by Tan (2004):

- Bridges the gap between theory and practice
- Enables development of real world competencies – which are strongly linked with the scientific method
- Promotes a constructivist approach to learning, which is extensively practiced in science teaching (Driver 1983).

In problem-based approaches, understanding is achieved through engagement with the problem and the learning environment; this activates prior knowledge and stimulates further learning. Knowledge evolves through collaboration with peers, tutors and resources with reflection on their learning a key element. The tutor acts as a facilitator of the whole process. (Tan 2004)

2. RESEARCH QUESTIONS

Arising from dissatisfaction with the traditional approach initially adopted with the delivery of a first year undergraduate module entitled 'Foundation Science' we decided to adopt and monitor a PBL approach to the entire unit. This paper seeks to examine the experience of a cohort of undergraduate science specialist students en-

rolled on an Initial Teacher Training programme at the University of Plymouth who experienced this alternative approach, compared with the experience of those who took the traditionally delivered module the previous year. To frame the study the following primary research questions were proposed:

- Do problem solving units in science increase students' confidence in scientific method?
- Do problem solving units in science support development of students' knowledge and understanding of science concepts and principles?
- Do tutors facilitating the units have to be experts in the field of study?

3. METHODS

Interviews and questionnaires were conducted with the student cohort that was to take the new PBL module. These were used to ascertain the whole group's experience of, and attitudes to, science prior to coming to University. A second questionnaire was carried out at the conclusion of the programme. Throughout the module, the students were encouraged to keep a reflective diary of each session and to include critical reflections on their own learning. A reflective diary was also kept by a member of the staff team, new to PBL, detailing their experience of this delivery.

Structured interviews were also conducted, in small groups, at strategic points across the academic year. These were based around five primary questions which the student's were asked to talk around;

- To discuss their school experience of science
- How did their first year at University compare with their school experience?
- What were their personal highlights and lowlights of the module?
- Did they feel well prepared for progression?
- What were their views on the role of the staff?

The previous year's cohort (who had completed the traditional module) was also interviewed. Again a series of general questions were asked exploring similar topic areas to those listed.

4. RESULTS AND DISCUSSION

The interviews appeared to show a dichotomous experience of post 16 school sciences. Some reported more practical laboratory work as the basis for delivery; others reporting far more theoretical work had been carried out. One constant however, was that practical work was either conducted to verify theory, or, as a vehicle for assessment. Furthermore, practical procedures were frequently given out and then simply followed. Only one student reported a session when the students had to design an experiment. The students generally reported enjoying science, but again all felt that the onus was placed heavily on preparation for examinations, rather than on producing enquiring and inventive science students. Only in their assessed project work, which was conducted independently, as part of the Advance Level assessment, did any of the students report any decision relating to design, or methods.

Verification of the above finding appears in the initial questionnaire given out to the new cohort, where, despite having completed and presumably achieved good grades in Advance Level Science, only 4 out of 22 felt confident in science. Figure 1 shows that this increased to 13 by the end of the module. This represents a significant shift in the profile of this cohort in terms of their confidence in the scientific method. Evidence from a problem-solving task given to the students at the end of the module supports this.

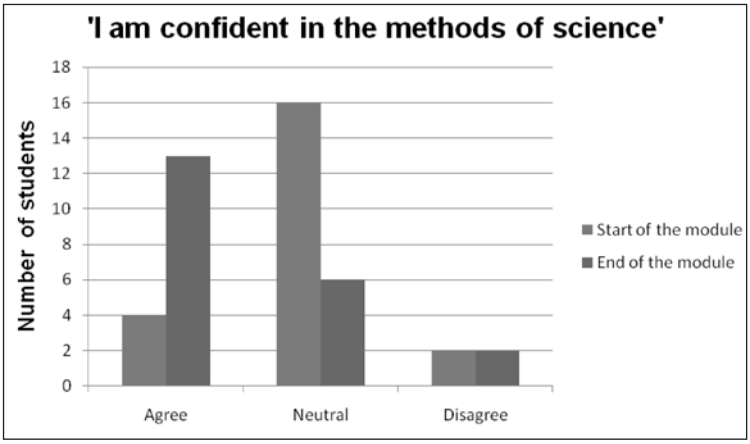


Figure 1 Overview of the responses to the statement 'I am confident in the methods of science' at the start and end of the module.

In relation to their transfer into Higher Education, the cohort that experienced the more traditional approach generally commented that it was what they had expected. It presented challenges, but these were based on issues surrounding their lack of certain subject knowledge. A number reported that they felt their school science had been more challenging and a number expressed concern over the relevance of much of the content to potential teachers. In contrast, the cohort experiencing the PBL method thought that the module was highly relevant. They also reacted positively to the very new challenges that such an approach presented to them. One group, for example, frequently refer to the creativity that the module required. Another aspect that was commented on was the group work element of the module. This seems to have been a key component to its success, with 86% of the students agreeing that working in groups enabled them to learn in a positive and supportive environment and verified by the results from the statement 'I did not like working in groups' with 86% disagreeing. The co-operative group based nature of the PBL activities was often commented on in the reflective writing and despite occasional references to negative issues (be it dominance/absence of a member, or disagreement within the group as to how to proceed) by the conclusion of the course, many of these issues had been resolved by the groups and the co-operative (and supportive) nature of such learning was highlighted as a very positive outcome.

However, the students also report a feeling of frustration with the problem-solving process (48% strongly agree/agree) and 81% reveal feeling more aware of the challenges faced by scientists. Despite the students enjoying the module and reporting favourably about furthering their knowledge and understanding and confidence in scientific methods, 48% report neither in favour nor against the statement 'I would have preferred the tutors to provide more traditional science teaching'.

In relation to 'nature of science', the students, revealed through the structured interviews, that they all saw science as something important, although this seemed to be more a sense of importance rather than anything that was precisely defined. Generic comments such as "It changes the world, "It creates; it's everywhere" "We can understand everything through it" were common place. In terms of its societal role, a general ambivalence was expressed; there was a particularly strong trend across the cohort expressing the view that science was capable of both 'good' and 'bad'. An ill defined, yet strong sense of its importance tempered by the view that many of the problems we look to science to solve, are the products of science itself is a succinct synopsis of the students view.

One further point of interest was that the questionnaire responses suggested that the cohort enjoyed the module (90% strongly agree/agree with 'I enjoyed the module'). However, during the interviews a more intriguing response emerged. Students did not particularly see the study and practice of PBL in science as any more enjoyable or 'fun' as traditional science teaching, they did however express a very positive engagement with the issues and problems set them. The module presented them with significant challenges, which required the acquisition of new skills and much greater self guided learning. It did not, therefore, compromise academic rigour, a complaint levelled at other forms of science engagement (Dawkins, 1998).

The role of the lecturers was an interesting aspect to these interview responses. In the staff reflective diary there is reference to the student's evident frustration and the difficulty of staff resisting the temptation to offer solutions. The student perception was very different, in that a number talked in positive ways about the changing role of the tutor.

"*I definitely feel that when you did your short presentation on transistors and things, (The other tutor) was sat there and was asking questions as well. It made me feel more relaxed…it made me feel like you're a person – you're not some sort of like godly know-all creature*"

Entries in the staff reflective diary comment on the difficulty in coming to terms with this new role. Initially, staff concerns related to learning (specifically as to whether learning outcomes were being met) and the challenge of a different type of tutor role.

"*I'm finding this quite difficult now. It's not giving up 'the power' of knowledge, or a sense of being undermined by not knowing answers, the problem for me is a sense of not helping. You come into teaching to help people learn, to support them, to nurture them. To stand back and let them struggle, however laudable the outcome, is very difficult. I just wanted to say 'Look, do it like this'. Standing back is very difficult for me.*"

At other times both tutors felt 'out of their depth' when supporting students in science areas outside of their specialist fields. The debate continues as to whether tutor expertise in PBL makes a difference (Gilkison 2003). Albanese (2004) suggests that 'perhaps the real issue is not whether tutors should be content experts, but what is the minimum content expertise and group facilitation expertise needed by tutors to be effective'. Successful learning in PBL is said to lie in the interactive nature of its sessions and effective group facilitation. Intriguingly, staff reviews did show that after an initial reticence, there has been an increasing confidence with this approach. Indeed, as this confidence grew, so the staff felt increasingly emancipated and confident in their own ability as scientists, as opposed to science teachers.

Furthermore, while staff enthusiasm for the new PBL delivery was high, by the end of the second unit, concerns were being expressed about the content of the new module. Best reflected by the comment:

"I'm beginning to have real doubts about this now. What are the students actually learning here? It seems to me that they're gaining arbitrary skills in random techniques, but where's the core knowledge? Where's the structure to hang this all on?"

Reflective comments, at this later stage, did not question the change in perceived pedagogic role, but rather questioned the efficacy of students learning. However, these two points may be closely related. While the tutor, new to the approach, was not troubled by the change in status from 'knowledge expert', they did question whether the students were learning, regularly having to resist, at least initially, falling back to a familiar lecture format. The implicit association of 'learning' with traditional delivery is reinforced on a number of occasions in their reflective diary by references to the possible inclusion of more theory lectures to 'underpin' the PBL work.

In terms of progression, the group who had completed the 'traditionally' delivered module, felt underprepared for their second year of study. They felt that the module had left them "standing still" in the sense that it had been revisiting much of the content that they had covered previously in their pre-university studies. While it had been a useful consolidation of their prior knowledge, they were also in general agreement that they could not see the relevance of such a (pure science) module, when they were to be teachers in Primary education.

In contrast, the group taught through PBL reported the inverse. They generally felt well prepared to progress into their second year and most could clearly identify the relevance of the approach, although less so with the actual problems set. When asked to rate their level of agreement with 'I don't think I learned very much of relevance on this module' all the students either disagreed or strongly disagreed.

5. CONCLUSIONS

We live in a time of science and yet, as a subject for study in the UK, at nearly all levels of instruction from secondary schools to universities, the numbers opting to specialise in physical sciences have fallen. Furthermore, of those that have chosen this route, some have a potentially damaging view of science. This was demonstrated in an online science discussion with the students who followed the traditional module, where questions were posted each week. One week students were asked 'Will science save the world'. Worryingly, of the 22 responses all were uniquely negative. Indeed

over half suggested that science had been causal in many of the Earth's problems be they social, political or environmental. These are views which could be transferred to our next generation of scientists.

The reasons for such a decline in popularity and (possibly) the perceived status of science are undoubtedly complicated and require further, potentially multi-factorial, research. However, engaging students at all levels in what Tan (2004: p170) describes as "bridging the gap between theory and real world" may be one potential contribution in addressing this decline. McParland (2004) also describes PBL as being effective in promoting more positive attitudes to subjects (McParland, 2004: p860).

From this research it is suggested that PBL is an effective mode to increase students' confidence in the science method and to some extent their knowledge and understanding of science concepts and principles. The latter needs further research, considering longitudinal data, in particular with relation to retention of knowledge and understanding and its application to other problems. It is suggested that the science PBL tutor does not have to be an expert but does have to be competent in science methodology and in group facilitation.

Overall, this approach is one which has presented challenges for both staff and students, not only in terms of traditional teaching methods, but also in the functional relationship between students and staff within a learning environment. This new approach has undoubtedly promoted the confidence and skills of students (and staff) to think in scientific ways. By grounding science in problems, it has enhanced the idea of science as a method for finding solutions to problems, rather than being the cause. Working through often multi-faceted problems fosters a sense of the possible and by placing the students in that process allows them to apply their own intuitive sense of appropriate and inappropriate methods. An important by-product is the emergence of far greater onus on ethical and environmentally benign research protocols. Such approaches may well have the potential to produce an inventive, imaginative and ethically sound generation of science graduates, equipped to meet the very real problems of the future.

It is common in spoken English to use the term 'challenge' to describe the issues of the future. In the context of future global issues it is a misuse of the word, as ultimately a challenge may be declined. Resolving the problems of the future is not optional; it has become an immediate necessity. Such truisms however, are little more than vacuous statements without realistic strategies to achieve them. Therefore it is necessary to equip our future generations of scientists with the skills, knowledge and understanding to become competent and confident problem-solvers to combat the many issues, problems and challenges we will undoubtedly face.

6. REFERENCES

Albanese, M.A. (2004) Treading Tactfully on Tutor Turf: Does PBL Tutor Content Expertise Make a Difference? *Medical Education,* Vol. 38 Pg 918-920

Albanese, M.A. & Mitchell, S. (1993) Problem-based learning: A review of the literature on its outcomes and implementation issues. *Academic Medicine* Vol. 68 (1) Pg 52-81

BBC (2006) *Schools Letting Down UK Science*. [avialable online at http://news.bbc.co.uk/1/hi/education/4780017.stm accessed 05/05/08

Carlton and Andrass (2008) 'Down-shifting' among top UK scientists? – The decline of 'revolutionary science' and the rise of 'normal science' in the UK compared with the USA. *Medical Hypotheses* **70** pp.465–472

Dawkins, R. (1998) *Unweaving the Rainbow: Science, Delusion and the Appetite for Wonder.* Allen Lane, London

Driver, R. (1983) *The Pupil as Scientist?* Open University Press, Philadelphia

Freitas, I. M., Jimenez, R., & Mellado, V. (2004) Solving Physics Problems: The conceptions and Practice of an experienced teacher and an Inexperienced Teacher. *Research in Science Education* Vol. 34 (1) Pg 113-133

General Medical Council (2003) *Tomorrow's Doctors* [available on line at http://www.gmc-uk.org/education/undergraduate/GMC_tomorrows_doctors.pdf accessed 10/5/08]

George, R. (2006) A Cross-domain Analysis of Change in Students Attitudes towards Science and about the Utility of Science. *International Journal of Science Education*. Vol 28 No.26 pp.571 - 589

Great Britain. Parliament. House of Commons (2002) *Select Committee on Science and Technology: Science Education from 14 to 19* (Third Report of Session 2001-02, HC 508-I)

Gilkison, A. (2003) Techniques used by 'expert' and 'non-expert' tutors to facilitate problem-based learning tutorials in an undergraduate medical curriculum", *Medical Education*, vol. 37, no. 1, Pg 6-14

Ibanez-Orcajo, M. T. & Martinez-Aznar, M. M. (2007) Solving problems in genetics, Part III: Change in the view of the nature of science. *Research in Science Education*, Vol. 29 (6) Pg 747-769.

Johnstone, A.H. and Al-Shuaili, A. (2001) Learning in the laboratory; some thoughts from the literature. *University Chemistry Education*, Vol. 5 (2) Pg. 42-51

Kelly, O. & Finlayson, O. E.(2007) Providing solutions through problem-based learning for the undergraduate 1st year chemistry laboratory**.** *Chemistry Education Research and Practice*, vol. 8 (3) Pg 347-361

Lee, Y. C. (2007) From a museum demonstration to problem solving: promoting the construction of concepts, *Physics Education*, Vol. 42 (4) Pg. 378-384

McParland, M., Noble, L, M. & Livingston, G. (2004) The effectiveness of problem based learning compared to traditional teaching in undergraduate psychiatry. *Medical Education* **38** pp. 859 - 867

Petty, G. (2006) *Evidenced Based Teaching.* Nelson Thornes

Royal Society (2008) *A Higher Degree of Concern.* Policy Document 02/08 January 2008 [available at http://royalsociety.org/displaypagedoc.asp?id=28988 accessed 08/05/08]]

Tan, O. S. (2004) Students' experiences in problem-based learning: three blind mice episode or educational innovation? *Innovations in Education and Teaching International*, Vol. 41 (2) Pg 169-184

UCU (2006) *Degrees of Decline. Core science and mathematics degree courses in the UK 1998-2007*. University and College Union.

Vernon, D. T. and Blake, R. L. (1993) Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine*, Vol. 68 Pg. 550-563

PEDAGOGICAL EVALUATION OF PROTOTYPE 2 OF THE AUGMENTED REALITY LEARNING PLATFORM BASED ON THE RESULTS ACHIEVED DURING THE SECOND ARiSE SUMMER SCHOOL

Vincentas Lamanauskas, Rytis Vilkonis, Renata Bilbokaitė
Natural Science Education Research Centre, Siauliai University, Lithuania
E-mail: v.lamanauskas@ef.su.lt; vilkonis@yahoo.com; renatabaibokait@yahoo.com

▼ Abstract

The process of creating a teaching/learning platform based on the idea of Augmented Reality is an innovative technology aimed at implementing links between the real and virtual world. The technology developed by the ARiSE project focuses on offering conditions for customers not only to observe a combined view (real and virtual) but also to directly interact with the real world (real objects). It is likely that the approach learning by doing is more effectively realized in the educational process.

Chemistry – is the most important component in modern science education. The weak interest of the youth to natural sciences, and especially - to chemistry, is one of the most acute problems of the present education. Didactical scenario 2 for AR teaching /learning platform is dedicated for teaching introductory course of chemistry. The first stages of testing have shown, that the given platform effectively can be used for teaching of chemistry.

The article introduces a didactical scenario of teaching/learning module 2 - The Structure of the Atom, Periodic Table, Chemical Compounds and Reactions – prepared for implementation using the AR platform. The paper presents the classification of real objects and virtual augmentations and describes students' possibilities of communication and collaboration applying the platform.

Key Words science education, modern ICT, Augmented Reality technology, teaching / learning platform, didactical scenario.

INTRODUCTION

General background

In the developing knowledge-based society information technologies play a particularly significant role. However, even the most advanced technologies will not give a necessary effect, if their usage in the educational system is not adequate to the current development of technologies and increased educational needs (Lamanauskas, Vilkonis, 2006). The implementation of new technologies in the educational process raises new possibilities for both teacher and learner, enhances education quality and makes the educational process itself more versatile. We should adapt the most newest technological development for school practice.

Augmented Reality teaching /learning platform is an innovative technology aimed at implementing links between the real and virtual world. The technology developed by the ARiSE project[5] focuses on offering conditions for customers not only to observe a combined view (real and virtual) but also to directly interact with the real world (real objects). It is likely that the approach *learning by doing* is more effectively realized in the educational process. According to Azuma (1997), AR supplements reality, rather than completely replacing it. AR systems are featuring an integration of real and virtual (computer generated images) into real environments, real time 3D interaction and targeting all senses (visual, auditory and haptic).

The primary purpose of the international research project ARiSE (Augmented Reality in School Environments) is to test pedagogical effectiveness of introducing augmented reality (AR) into the comprehensive school and creating remote collaboration between classes around the AR display systems. Project "ARiSE" will develop an AR teaching/learning platform and associated pedagogical scenarios of use, enabling teachers to promote new teaching practices for teaching scientific and cultural content in primary and secondary school. The aim of the project is to offer to the group of students the possibility of „playing"with virtual objects and thereby to perform learning by doing instead of learning by reading.

Augmented-Reality-Teaching Platform: interactive AR display system

The heart of the Augmented-Reality-Teaching Platform is the interactive AR display system and the software operating it. Starting from an existing AR display, that was created for museums and is available on the market since 2003, the new display system will evolve with a few but important modifications needed to overcome its 'museum legacy' (DofW, 2005).

The Augmented-Reality-Teaching platform (consisting of display system and software) will raise teaching technology for basic, middle, and high schools to a new level of possibilities. The platform itself is built with standard PCs and some extensions (Picture 1).

a) **b)**

Picture 1 The module of the AR teaching /learning platform from the front (a) and from the back (b). (at IAIS institute, Fraunhofer, Germany; http://www.iais.fraunhofer.de/)

5 The given scientific research is carried out in pursuance of 6FP international research project „Augmented Reality in School Environments" /ARiSE/, http://www.arise-project.org

With the help of augmented reality (AR) a class can work in a team collaboratively and benefit from state of the art technology. Real objects are superimposed with virtual images to better explain processes in 3 dimensional setups. Students interact with the AR-system and with each other making learning a team-work experience and not a teacher's show. Even remote collaboration with classes from other countries will be possible by using video conferencing capabilities of the system (Müehl, 2005). The students (users) using the AR teaching /learning platform must wear stereo glasses and headphones.

The platform will be based on existing open eLearning software with a user-centred interface added on to it which allows innovative use of augmented reality in schools. It has a strong focus on collaborative use on different levels.

Pedagogical evaluation of learning modules

Creating teaching/learning modules and constructing didactical scenarios of practicing the modules is one of the main conditions to use the above mentioned innovative technology in the educational practice. The pedagogical evaluation of the created AR learning platform is very important. The evaluation conclusions and recommendations produced on the basis of findings are used for a further improvement of the product (Lamanauskas, Pribeanu, Vilkonis, Balog, Iordache, Klangauskas, 2007).

Prototype 2 of the AR learning platform was first tested during the second ARiSE summer school. To create and improve Prototype 2, the module *The Structure of the Atom, Periodic Table, Chemical Compounds and Reactions* focusing on learning chemistry was employed. The module included an introductory part (the symbols used in the module and possible manipulations were presented) and three lessons: lesson 1 was compiled from two, lesson 2 – from eight and lesson 3 – from two tasks. The real objects in the module were colourful rubbed balls and a plastic periodic two-way table of chemical elements. The tool of interaction was only used for choosing lessons and tasks. Prototype 2 concentrates on individual learning.

Methodology of Research

General research background

Methods include observation and a verbal questionnaire (sectional interview).

The Procedures of Evaluation

The used questionnaire is a **structured sectional interview.** The interview was carried out testing the Prototype 2. The respondents' opinions were recorded filling in the interview forms. Data includes opinions, evaluations and recommendations of the students - users of the new teaching/learning platform; data source reflects the learners' positions, based on personal experience. The surveyed data is assessed applying the method of content analysis.

The evaluation interview of Prototype 2 included 13 questions:

- Should the worked-out AR learning platform help with better acknowledgement of chemistry, for example the structure of the atom, the periodic table, how and why chemical compounds are formed, the differences between atoms and molecules, the differences between coefficients and indexes in the equations of chemical reactions?
- Should the worked-out AR learning platform help with completing practical tasks, for example to put down chemical formulae and reaction equations, to distinguish between atoms and molecules, to identify ionic and other types of compounds?
- Should the worked-out AR learning platform stimulate students' interest in chemistry?
- Should the worked-out AR learning platform used at school encourage the students to more actively participate in chemistry classes (stimulate attending lessons and participating in different practical activities)?
- Is the platform a better tool for learning chemistry in comparison with other types of computer-based training aids (educational software, the Internet etc.)?
- Was the introduced virtual text useful to you?
- Were the virtual symbols useful when learning chemistry (the colour of the external electron layer of the atom, the red colour of the free electron, a picture of the colours of the external electron layers of the atom on the right of the screen)?
- Were the introduced tasks clear?
- Was the whole introduced information easy understandable?
- Was manipulating balls simulating atoms useful?
- Would it be useful to have a possibility of repeating audio information?
- What are the main points that made you to experience positive emotions in your work with the AR learning platform?
- What are the main points that made you to experience negative emotions in your work with the AR learning platform?

Observation takes place ***producing a film*** during the process of applying the new AR learning platform; data includes behavioural situations (patterns of behaviour, language) encountered by the students; data source suggests audio/video recordings.

Place and time of evaluation

Research was conducted on 24 – 28 October 2007 at the National Institute for Research and Development in Informatics - ICI Bucuresti. This educational establishment takes active participation in the Romanian information science and technology development and is the leading Romanian ICT research - development and innovation centre.

Participants

Gender of participants. Five user teams from three countries (Germany, Lithuania and Romania) with a total number of 20 students including 10 boys and 10 girls participated in the second summer school. Due to the specificities of the comprehensive school curriculum in different countries, the age of students varied. Lithuanian (form 9) and German (form 10) students were aged 16 whereas Romanians were 14 years old teenagers (form 8). None of them was familiar with the AR learning platform. All respondents hade covered the topic of the human digestive system and an introductory course in chemistry using traditional methods and learning aids.

Results of Pedagogical Evaluation

Analysis of the Interview Data

Considering each parameter, content assessment distinguished categories and subcategories. First, ARTLP (Augmented Reality Teaching/Learning Platform; simple – AR platform) suitability for learning chemistry was evaluated.

Table 1 Evaluation of the platform assisting in learning chemistry.

Category	Number of quotations	Subcategory	Number	Quotations
Useful	28	-	-	Yes
		-	-	Helpful
				Easier
Advantage of interactive visualization	18	Visualisation	12	Visible, Excellent animation, 3D
		Expository tool	6	Clear, clearer, Properly explains
Result of mental processes	16	Understanding	10	Understandable
		Cognitive knowledge	2	Better knowledge
		Memory	4	Memorise, Remember

The data included in Table 1 shows students' evaluations of platform usefulness learning chemistry. 14 learners stated that the platform was useful and the same number of the respondents confirmed such position by saying 'yes'. These are rather high results of the carried out assessment as reasoned evaluations – original quotations are presented forming expository categories and subcategories.

Category 1 contains two subcategories. First, the expository value of **the platform** is important to learning chemistry as it **helps children with understanding complex processes**. When the learners have no questions, they can easily perform the tasks and deal with further topics. Thus, clarity is an extremely weighty condition the transformation of which raises the value of the tool. Visualisation is another significant factor. Information about the tool should not be so clear without visualization. 3D interactive visualization very clearly reflects the objects hardly seen with the naked eye, and therefore children can better understand information. The elements of

chemistry become less complex and have associations with real objects. The students can observe and 'form atoms' themselves. Therefore, in order to complete the tasks, they must actively think and be actively involved. **Interactive visualization as an advantage ensures a clearer process of teaching chemistry**.

The next category indicates that interactive visualization stimulates the processes of thinking and thus creates conditions for understanding. The students better understand, acknowledge and master material. **Understanding shows that material was properly introduced implementing didactical purposes. Memory becomes actively involved – it is likely that information has been mastered for a longer time**. Consequently, the result of mental processes taking place during the period of learning is formed.

Table 2 Evaluation of help provided by the platform performing different tasks.

Category	Number of quotations	Subcategory	Number	Quotations
Useful	26	-		Yes, Helps, Useful
Innovative tool	11	Visualization	9	Visible, Animation, Clear picture
		Advantageous tool	2	More interesting than an ordinary lesson in the classroom, Board and chalk cannot be compared with the virtual picture
Processes of mental activity	9	Understanding	5	For understanding
		Memory	3	Remember
		Vision	1	Imagine
Conceptual concentration	6	Attention control	3	Easy concentration, Better to identify the organs
		Volitional development	3	Complete practical tasks
-	-	Cognitive knowledge	2	Solidified knowledge, I know

The data in Table 2 indicates how the students evaluated the tested platform that helped them with performing tasks. 14 in 20 children confirmed it did and 12 respondents found the platform useful for the process of learning.

The category '*innovative tool*' shows the usefulness of the platform which is a new and modern instrument able to transmit interactive visualization. The respondents agree that this tool is more advantageous than the rest. In such a way, the didactical features of the platform make corrections on the process of learning, encourages going deeper into chemistry and aspires to be interested in technology and the subject learnt.

The students think that the platform helps with acknowledging certain processes that obviously interrelate with thinking. The formed category *'processes of mental activity'* shows that the platform helped the schoolchildren with a better understanding of a topic. They could mentally reproduce the seen pictures a number of times and train memory. Moreover, the learners mentioned that the platform helped them with

imagining phenomena, compounds etc. during the process of learning. All this proves that that the platform intensifies the processes of mental and related activity.

The schoolchildren noticed that the use of the platform helps them with deeper concentration spending more time on performing and completing tasks. The students willingly fulfilled the tasks requiring mental and physical efforts as the balls imitating atoms had to be placed in the exact place in order to be identified by computer.

Table 3 Evaluation of the platform as a tool stimulating interest in chemistry.

Category	Number of quotations	Subcategory	Number	Quotations
Stimulation	16	Established fact		Yes
		Activation of senses	7	Visible, Can be touched
Forming mental models	11	Observing 3D pictures	2	3D
		Learning-by-doing	2	Interested in interaction with atoms, Can interact
Increasing motivation	20	Need for cognition	11	Interesting, Engaging, Will want more and more information
		Positive emotional states	9	Encourages, Stimulates, Attracts, Involves, Pleasure
Tool of post-modern culture	2	Interest in technologies	2	Something new, Likes computers

Table 3 reveals that 16 students think that the platform could stimulate students to study and be interested in chemistry. Such evaluation is very high as only 20 students participated in the survey. Three categories are distinguished. It can be maintained that the categories are of a causal expository format as they justify the fact of using the platform and its typical characteristics.

Activating senses is equal to the stimulation of sensations expressed through the identification of intensification. The more active are the senses the more information can be transmitted. The sense of sight imparts the major part of information as it is the strongest developed sense. Touching is the most poorly developed sense, and therefore is used as an additional tool of disclosing information. The children most frequently focus on strengthening the sense of sight as the process in the classroom mainly concentrates on giving visual information which is very useful. The observed chemical elements are reflected in students' consciousness and automatically form mental models. The students refers to it as to understanding and clarity, however, it proves only the level of perceiving the models. The more understandable is material the clearer is the scheme of forming mental models. The 3D objects are conditionally close to real objects, and therefore the students can easily know them. A teacher takes less risk that a child will fail to understand and wrong information will prevent him/her from improving knowledge.

The more intensively is a learner involved into activity requiring the efforts of conscious cognition the more knowledge s/he can obtain. Likewise in the course books,

the platform offers the possibility of observation; in addition, the student can learn producing certain movements and individually imitate forming molecules. In this case, schoolchildren have an increased interest in chemistry. Experienced learning is formed in children's consciousness which is decoded learning in childhood through games. The platform provides the possibility of conducting experiments and the learners accept them as childhood games which made to experience the lessons of socialization and life. The development of psychics is not impeded by the elements of the game, and therefore a child can freely think and critically evaluate the available information and encourage him/herself to search for new information. The elements of the game are always interesting if new and not applied in practice. The students are interested in the possibility of touching and forming a molecule as his/her personal experience has links with childhood when everything was touched and almost all information was received using the senses of touching and sight.

The following category in Table 3 discusses the increase of motivation. The subcategories 'the need for cognition' and 'positive emotional states' can be distinguished. The first one focuses on the sense of student's cognitive need. S/he must feel happy; otherwise a learner will not manage to advance him/herself and to satisfy the needs of self-expression and self-realization. The cognitive need is one of the most important factors that increases motivation and is characteristic of schoolchildren. The more it will be intensified the more willingness to learn they will have.

The last category is a reference to the post-modern culture outcomes for the process of students' education. The learners are the members of this culture and are interested in technology and everything related to this field. Hence, due to 3D interactive visualization, the need for cognition, positive emotions and personal technical value, the platform acts as a tool performing the function of motivation.

Table 4 Evaluation of the platform as a tool encouraging chemistry learning.

Category	Number of quotations	Subcategory	Number of quotations	Quotations
Assistance	17	-	-	Yes, Helps
Expression of motivation and aspiration	13	Interest in activity	7	Interesting, Encouraging, Will want to try
		Sense of stimulus	5	Stimulates, Attractive
Effect of positive emotions	3	Emotions	2	Pleasurable, Exiting adventure
		Emotion of wonder	1	Something new
Broad knowledge of nature	7	Knowledge acquisition	4	To learn faster/better
		Interaction with the elements of nature	3	Possibility of forming molecules, Possibility of individual practice, Can experience chemistry

Table 4 discloses that 17 respondents suppose that the platform should increase students' interest in chemistry and encourage their active participation in the process of learning. On the basis of the received answers, four categories were formed.

The category having the largest number of quotations is 'expression of motivation and aspiration'. It is subdivided into two sub-categories. The first one shows children's need for action; they feel interest and strive for implementing their purposes testing the platform. The interest acts as stimulus displayed through a wish to learn. Both subcategories are interrelated and thus have similar functions. **The students' evaluations suggest that the tool has a strong motivating aspect, and therefore a probability that the learners will be engaged in educational content significantly increases**.

The category dealing with positive emotions points out that the platform will attract the students as when using it they feel good emotions. Children usually remember good experience for a long time and want to repeat it. Such situation increases interest in chemistry as the latter subject will have associations with positive experience, the learners will try to undergo these feelings again and again and a wish to know more will grow. **Positive emotions open and strengthen the need for learning interesting things about complex phenomena**.

The students also evaluate the importance of knowledge acquired using the platform. The obtained information is better acknowledged as the structures of mental models are correctly formed which ensures a better understanding of educational content. **Understandable information is solidified during practical activities**.

The students learn interactively and a similar way of cognition is more acceptable than traditional teaching from course books.

Table 5 Evaluation of the AR platform in comparison with other tools.

Category	Number of quotations	Subcategory	Number	Quotations
Better than others	15	-	-	Yes
Motivation	8	Interactive visualization	6	3D, Virtual, Augmented reality
		Aspiration	2	Attractive, Very exiting
Mental practise	2	Attention concentration	1	Requires more attention
		Imagination	1	Can imagine
Effective process of learning	9	Interactive learning	6	Can feel, touch and move, Can be observed, Interactive
		Increase of learning pace	3	Faster learning, Can learn better
Didactical advantage of the tool	9	Better tool	5	Better than the Internet, A better tool, I should use this equipment
		Technical advantages	4	Integrated, Easier used tool, Can manipulate the balls, More modern

15 students think (Table 5) that this platform is a better learning tool than those used in the process of teaching. Five categories can be distinguished.

First, **learners positively evaluate the technical possibilities of the platform – motivation for qualitative visualization**. It's absolutely clear because high quality visual aids reflecting natural phenomena or elements are very rarely used in the educational process. 2D is the most frequently applied educational tool, and therefore students cannot obtain clear and purposeful view of the elements and start making mistakes in chemistry as a subject of studying. The schoolchildren really feel a wish to learn and growing aspirations for possibilities of the platform. Qualitative visualization prevents from errors in cognition.

Mental practice is actualized and becomes important because of activated processes necessary for thinking – attention control and concentration and imagination. In this case, the latter one helps in the processes of reflexion and repetition. Thus, **the use of the platform makes mental practice work more intensively**.

The students noticed that **the platform rather than other training aids increases the pace of learning**. It is determined by visually presented material. Moreover, the possibility of interactive learning intensifies the learners' abilities to perform complex tasks and understand chemical elements. **Such situation shows learning efficiency**.

The last category shows that the platform is a didactically more advanced instrument in comparison with other training aids. The students call it '*a better tool*' and point to technical specifications. All this only proves the undoubted usefulness of the platform in the educational process and underlines the importance of provided assistance for both student and teacher. **The platform as a teaching tool is evaluated as a better and more advantageous instrument the use of which is necessary and useful during the chemistry lessons in the classroom**.

Table 6 Evaluation of the usefulness of virtual text.

Category	Number of quotations	Subcategory	Number quotations	Quotations
Useful	14	-	-	Yes/highly useful
Expository function is implemented	11	Better understanding	7	Helped with understanding, Helped with remembering
		Practical references	4	Helped with completing exercises, Was clearer
Dissatisfied preconceived expectations	2	New information was expected	1	Information was knew for me
		More text was expected	1	There wasn't much text

Table 6 shows the evaluation of the usefulness of virtual text. 14 students found virtual text useful. The assessed data felt into two categories – one of those contain positive evaluations, the other one – negative. Positive evaluations were combined into two subcategories of '*better understanding*' and '*practical references*' which means that virtual text was useful as the learners better understood and remembered informa-

tion and completed tasks. It can be maintained that **in a way, virtual text implements the expository function and the schoolchildren use their evaluations to justify the quality of its realization**.

A negative evaluation was accepted as the students had preconceived expectations that virtual text would perform a bit different functions, for example new information or more text would be introduced. It is likely that similar expectations interrelate with increased aspirations for learning chemistry.

Table 7 Evaluation of the usefulness of virtual symbols.

Category	Number of quotations	Subcategory	Number of quotations	Quotations
Useful	23	-	-	Yes/helped,
				Was helpful
Faster information acquisition	16	Memory	6	Easier to remember, Did not forget, Can remember when observing, Fast to be memorised, Easier to master
		Facilitated learning	5	Facilitated work, Easier to complete tasks, Helps with a better understanding of the periodic table, Helps with identifying electrons
		Understanding	5	Helped with understanding, Facilitated the task
Motivation	13	Colourful picturesqueness	8	Colours helped with perception, Nice colours
		Aspiration	3	Balls are interesting, Attractive
		Visual possibilities	2	Better than a picture in a book, Possibility of arranging things individually

The data in Table 7 shows that virtual symbols were very useful for '*faster information acquisition*' and '*motivation*'. The majority of students noticed that **virtual symbols helped with remembering information**. They serve as visual information codes expressing certain things. The learners know a symbol and remember its meaning. It is very useful since remembering symbols is easier than reading notes of verbal information because it saves time as one symbol can have a meaning of one sentence. Memorizing information helps with facilitating the process of learning on the grounds that no difficulties appear with understanding text and distinguishing and performing tasks.

Motivation is also a very influential category and was established considering '*colourful picturesqueness*'. The brighter colours are shown the easier a child can memorise. These are animation shades noticed in the educational process and ensuring more accurate information motivating students. Analogously, the possibilities of picture improve students' motivation because picturesqueness plays a crucial role in teaching chemistry.

Table 8 Evaluation of task clarity

Category	Number of quotations	Subcategory	Number	Quotations
Didactically useful	37	Clear	30	Clear, Yes, Perfectly explained
		Purposeful	7	Picture and sound are brilliant, Simple, Precise, Interesting, Fast understanding
Technical interference	6	Interference of sound	3	Some problems with sound
		Interference of picture	3	The picture was flickering

The data in Table 8 indicates that the evaluation of task clarity disclosed two categories. The first one which is didactical usefulness adds clarity and purposefulness to the process of teaching. The tasks are adapted to the specificities of students' age (agree with the level of thinking, curriculum, abilities etc.). The schoolchildren maintain that technical interference prevented from understanding tasks but basically it wasn't the main point as similar problems will be hardly acceptable in the future.

Table 9 Evaluation of understandable information.

Category	Number of quotations	Subcategory	Number	Quotations
Relevant feedback	35	Acceptable information	27	Yes
				Easy to understand /understandable / acceptable
		Clarity	7	Clear, Accurately presented, Simple presentation, Properly explained
Importance of interactive visualization	6	Animation	3	Pictures helped, Perfect animation
		Audiovisual possibilities	3	Information could be seen and heard

Information provided in Table 9 displays the data generally understandable for the learners. First, '*relevant feedback*' can be noticed. It can be illustrated by information clarity and appropriateness for the students. The schoolchildren's answers illustrate that **due to interactive visualization, information was understandable** - they could practice, observe a clear picture, touch and form chemical compounds.

Table 10 Evaluation of the usefulness of manipulating balls as the models of atoms.

Category	Number of quotations	Subcategory	Number of quotations	Quotations
Usefulness	24	-	-	Yes, Was useful
Learning efficiency	16	Aspiration	8	Pleasurable, Interesting, Attractive
		Knowledge acquisition	8	For understanding purposes, Better to learn, Can imagine
Learning by doing	12	Activating the sense of touching	8	Because of the balls, Possibility of 'handling atoms', Can be touched
		Control	4	Possibility of manipulation, Possibility of controlling and changing atoms
Technical interference	3	Technical problems	2	Atoms sometimes used to fall
		Shortage of work practice with technology	1	Positions required changes to be recognized by the system

The usefulness of manipulating balls is positively evaluated (Table 10). 24 quotations were stating the fact of usefulness. Category 1 presents that manipulation is useful as in this case, teaching becomes more effective. Such situation engages students and the internal need for learning and be interested in chemistry appears. Aspiration makes impact on the intensiveness of learning and understanding becomes speedier. Knowledge can be mastered more effectively. Manipulating balls created a certain sense of reality that cannot be experienced using other tools. These processes include forming atoms and combining molecules. A student him/herself could form compounds and learn. Learning-by-doing added self-confidence, developed the senses of sight and touching, and therefore the process of information acquisition was faster. Some technical interference was established.

Table 11 Usefulness of repeating audio information.

Category	Number of quotations	Subcategory	Number of quotations	Quotations
Usefulness	13	-	-	Yes, Certainly
Relevant feedback	13	Higher quality of performing tasks	8	Can be heard several times, Possibility of correcting mistakes
		Faster understanding	5	One time was enough, It's clear what you need to do, Helps with remembering, Wide experience
-	-	Broken contact	2	Clarity sometimes was missed (contact problems)
		Revision is not required	2	Not for me, but for my children should be O.K., Not necessary for me

13 positive students' answers confirm that repeating audio information should be helpful (Table 11) because the tasks were completed more qualitatively – in case of mistake or misunderstanding, the learners were provided a possibility of hearing audio information several times. It works because hearing is not as properly trained as the sense of sight does, and thus the majority of schoolchildren can feel surprised or encounter misunderstandings due to the factors of unexpectancy and inexperience that are the methods to get necessary information. It is likely that repeating audio recording determines faster understanding as the students who failed to accept information try to repeat it until they get what they want. Such situation prevents from making mistakes, concern and misunderstanding which may rise more frequently in case audio material should be presented only once.

Some of the respondents pointed out that they did not require hearing repeated information as it was understood rather clearly.

Table 12 Evaluation of positive emotions.

Category	Number	Subcategory	Number	Quotations
Technological advantage	22	Interactive visualization	15	It's pleasure to combine atoms, Nice pictures/animation, Was convenient, Saw the structure of the atom, Elements could be used, Atoms and their interactions can be seen
Internal alterations in personal learning	18	The sense of Haptics elements	5	Possibility of manipulating balls, Entertaining balls
		Purposeful tasks	2	Precise tasks/explanations, Interesting tasks
		Rise of aspiration	8	Interesting experience/fascinating, Stimulates, New technology, Touches, Enormously liked, Very beautiful
		Ensured understanding	8	Better understanding of reactions/ exercises, Better understanding of a lesson, Easy to understand the structure, Useful for understanding, Everything is clearer in mind
		Broad knowledge of chemistry	2	Can experience chemistry
				Interactive

Table 12 shows the factors that made impact on positive emotions. The broadest category is '*technological advantage*' reflecting the advantage of the platform in comparison with other training aids used in the process of teaching. The category is close to that '*the sense of Haptics elements*' as the latter one has differences in high level of visualization and in possibility of performing certain manipulations touching balls. Therefore, the students feel positive emotions because work at the platform itself gives the learners pleasure.

The next important category relates to understanding. The respondents reflexively evaluated personal abilities and gained knowledge. The students admit they felt very well because they understood the topic. It's logical as every child wants to know and s/he most frequently looses a wish to learn if a topic is difficult to understand. In this case, the situation was created the other way round – having understood the topic and thus felt good enough, inquisitiveness, a wish to learn and attention devoted to the tool generating positive emotions were stimulated (subcategory '*rise of aspiration*').

The categories having a smaller number of quotations indicate that the students at the platform felt fine due to the satisfied aesthetical need (enjoyed tasks, animation) and purposeful and useful tasks that were clear, specified, did not cause any problems or troubles and did not prevent from the possibility of knowing and understanding the world of chemistry deeper.

All this confirms that **positive emotions were felt due to achieved success in understanding and performing tasks, having tested functioning of interactive visualization and elements of Haptics technology in learning and having discovered the need and opportunity to wider acknowledge chemistry**.

Table 13 Evaluation of negative emotions.

Category	Number of quotations	Subcategory	Number of quotations	Quotations
Technical disadvantages	23	Problems encountered using the ball	9	Difficult to manipulate balls sometimes, Complicated to reach a ball, Balls roll, Difficult to catch the right element sometimes, Balls are too big
		Problems with picture	7	No clear picture through the glasses, Reality and animation sometimes differed, Eyes got tired, Discontinuous picture
		Technical interference	7	Functioning interference, Interference of sound, Problems of control took plenty of time, Board needs to be pushed

The data provided in Table 13 discloses the factors that influenced negative emotions in practical use of the platform. The first distinguished sub-category explains that the children most frequently felt emotionally unbalanced when problems of using the ball appeared i.e. these difficulties were caused by technical interference which prevented from learning, reduced the pace of work, and therefore the students got worried and were striving for having the technical problems of controlling the platform solved. The second sub-category points to the problems with picture. Some learners found the quality of stereo glasses poor, the others encountered difficulties

with controlling technology. However, these rare problems did not have a major impact. The third category was established considering the reasons for experiencing negative emotions and referred to the single cases of technical interference taking place along the whole period of work.

The assessment indicates that all negative emotions were mainly related to technical interference. Such situation uncovers children's beliefs that technology should perfectly work. Post-modern culture and constant students' interaction with computers determine their preconceived point of view to the strict need for perfect technology.

Analysis of the dialogue data

In conclusion, it can be maintained that an overall pedagogical evaluation of Prototype 2 of the AR platform is positive. The majority of respondents agree that learning at the AR platform was interesting. A crucial moment is that using natural robber balls imitating atoms allowed performing different manipulations. Therefore, all surveyed participants stressed that the module of teaching chemistry was attractive, interesting, easily controlled and offering different ball manipulations. The schoolchildren from Romania strongly emphasized that ball manipulations were real feelings of personal activities such as performing, building etc. The respondents highlighted that forming a molecule/molecules was extremely engaging. The learners positively evaluated the order of priorities of didactic tasks. All students also underlined the possibility of interacting with the real object as one of the most valuable qualities. Traditional learning of chemistry requires vivid imagination i.e. to realize atoms and molecules as the key components of the micro-world.

The respondents naturally pointed to certain drawbacks. The majority of disadvantages were connected with technical interference. Due to the problems of uncompleted platform calibration, it was difficult to identify the required chemical elements. In some cases, the 3D objects were flickering i.e. the students asserted that the system sometimes was extremely 'sensitive' and 'unbalanced'. The place of a certain element marked with a ball in the periodic table should be established. The schoolchildren had some doubts about using the AR platform for learning purposes when a person had no elementary knowledge of chemistry i.e. if you know nothing about chemistry, extra information is required. The respondents fully agreed that chemistry was a difficult subject to learn. In some cases, the position of virtual objects did not conformed to the real periodic table. The technical problems of using stereo glasses (frequent breaks) and ergonomic difficulties (not for everyone can be adapted) were also noticed. Romanian schoolchildren emphasized that the construction of the AR platform itself looks 'cold' and 'metallic'. The only drawback addressed to the pedagogical evaluation was a request of German learners for introducing automatic error correction using the marking system which is characteristic of programmed teaching i.e. the students wished a general evaluation. However, the model of evaluation employed in the second ARiSE learning module is emphasized in modern and future school. Evaluation i.e. feedback information on the current result is natural and continuous. As the process of learning has links with searching and construction, misapprehension can be treated as a learning tool and counting mistakes should be pedagogically groundless. Having completed a task, the system orally informs about that a student

and offers to deal with the next exercise. From the point of view of modern pedagogy, counting and summarizing mistakes in the process of learning should be a backward step.

The conclusion of the assessed results obtained during the primary observation (shooting) of testing Prototype 2 reveals that technical interference, system delicacy and misbalance were the main factors preventing from following the process of learning. Not all students managed to complete all exercises. The problems of technical character are not commented or analyzed in this report as this is not the object of pedagogical evaluation. These are the issues accepted as the factors having a negative or positive impact on the process of learning. It has been noticed that inability to use the AR learning platform impedes the learning process. Such situation can be admitted in the normal course of events as technology has been applied for the first time. A special introductory learning module about the specificities of applying the AR learning platform should decrease the number of problems in the process of studying and allow the students to concentrate on learning issues. The possibility of repeated oral reading should facilitate the use of the AR learning platform and saved time because a learner should not drill the whole task from the very beginning in case s/.he forgot instruction or explanation. All problems of technical character narrowing student's working field should be solved maximally expanding the space of learning that allows manipulating real and virtual objects.

Conclusions

1. A pedagogical evaluation of the AR teaching/learning platform carried out during the second ARiSE summer school indicates that technology mainly agrees with the general, and specified needs of comprehensive school.
2. It can be maintained that a positive educational effect of the AR teaching/learning platform is noticed (referring to the respondents' evaluations based on gained experience of using traditional aids for learning chemistry, new experience obtained during the ARiSE summer school and observation/shooting the process of learning). The surveyed participants also pointed to the obvious possibility of perceiving, understanding and mastering information in a faster and more accurate way and indicated the opportunity to stay properly concentrated in the learning process. The offered content of learning and practical tasks highly motivated the students. There are no doubts it is attractive teaching/learning technology encouraging positive emotions (pleasure in performing tasks and observing the 3D picture, the individual possibility of controlling the system, manipulating real and virtual objects etc.). The possibility of interaction with real and virtual objects in the mixed environment was highlighted as one of the most valuable qualities.
3. A definite quality of the AR teaching/learning platform in terms of traditional resources for learning (course books, work books etc.) is interactive 3D visualization including haptics elements. The latter quality was fully disclosed within the evaluation of the learning module *The Structure of the Atom, Periodic Table, Chemical Compounds and Reactions* devoted to Prototype 2 of the AR teach-

ing/learning platform. It is quite acceptable because the use of suitable visualization aids is rather complicated in the process of teaching chemistry.

4. The results of pedagogical evaluation suggest that the introduced module of teaching *The Structure of the Atom, Periodic Table, Chemical Compounds and Reactions* (component of chemistry) completely agreed with the essential didactical requirements and students' age. The statement that an exhaustive preconceived knowledge in the examined field is not necessary for the users was given a positive evaluation. The AR platform creates possibilities of independent and individual learning.
5. The misbalance of the AR system, the size of stereo glasses, insufficient quality of knowledge and skills applying the platform of ART for learning purposes etc. had a negative impact on the process of learning.

REFERENCES

Azuma, R. (1997). "A Survey of Augmented Reality". *PRESENCE: Teleoperators and Virtual Environments,* Vol. 6, No. 4, p. 355-385.

Description of Work /DofW/. (2005). 6th Framework Programme - Priority 2 "Information Society Technologies", Call identifier: FP6-2004-IST-4; Proposal N° 027039 - ARiSE: Augmented Reality in School Environments (unpublished manuscript).

Lamanauskas V., Vilkonis R. (2006). *Internetas gamtamoksliniame ugdyme: situacijos analizė ir prognozės*. Mokslo studija. Šiauliai University press.

Lamanauskas V., Vilkonis R. (2007). Pedagogical Evaluation of the New Teaching/ Learning Platform Based on Augmented Reality Technology: Prototype 1. In.: V.Lamanauskas & G.Vaidogas (Eds.), *Science and Technology Education in the Central and Eastern Europe: Past, Present and Perspectives* (The proceedings of 6th IOSTE Symposium for Central and Eastern Europe). Siauliai: Siauliai University Press, p. 88-97.

Lamanauskas V., Pribeanu C., Vilkonis R., Balog A., Iordache D., Klangauskas A. (2007). Evaluating the Educational Value and Usability of an Augmented Reality Platform for School Environments: Some Preliminary Results. Proceedings of 4th WSEAS/IASME International Conference on Engineering Education (Agios Nikolaos, Crete Island, Greece, 24-26 July, 2007). *Mathematics and Computers in Science and Engineering*, Published by World Scientific and Engineering Academy and Society Press, pp. 86-91.

Müehl J.K. (2005). *Augmented Reality in School Environments (ARiSE)*. Project outline (Contribution to EU-Call IST4 within FP6, Call Identifier FP6-2004-IST-4) /unpublished manuscript).

EXPLORING THE PROGRESS OF PAS IN A MUSEUM ENTERPRISE

Shiho, MIYAKE
Faculty of Education, Kochi University, 2-5-1 Akebono-cho, Kochi, 657-8520, JAPAN
E-mail: smiyake@cc.kochi-u.ac.jp

▼ Abstract

As for social situation, such as people's aversion to science and encouraging of sustainable development of environment, it is increasingly required to carry out Public Awareness of Science (PAS) for social education facilities. In this research, an indicator of PAS achievement phases to evaluate how museum activities contribute to PAS will be found with focusing on a case study of a natural history museum in Japan.

The author carried out participating observation of lectures and events for the public in the Museum of Nature and Human Activities, Hyogo in Japan (MNHA). With the participating observation data among 21 months and document sources, it will be examined what kinds of characteristic phases occur in the progress to create the setting in which the public people take action spontaneously and continuously in the museum.

As a result of investigating in the MNHA, it is clarified that this museum successfully created the setting. The progress to create the setting in the museum is shown in five phases.

i. The museum shows their PAS concept in policy statement.
ii. The museum attracted individual learners and involved in museum activities organized by museum staff.
iii. Independent learning groups are created in the museum and the museum leads individual learners into the groups.
iv. Independent learning groups communicate with other groups.
v. Independent learning groups host an official museum activity for the public.

As well as this, if we focus on the leadership in the PAS progress, it is also found out that the subject changes from a museum to the public.

Key Words public awareness of science (PAS), learning community, museum, the Museum of Nature and Human Activities in Hyogo in Japan

1. INTRODUCTION

With anxiety of school children's losing interest in science, people's aversion to science has been a problem in Japan. It is increasingly required to carry out Public Awareness

of Science (PAS) for social education facilities in terms of sustainable development of environment (Ministry of Education, Culture, Sports, Science and Technology, Japan, 2005). As for this social situation, science museums and natural history museums, which have policy to provide educational activities for the public, attempt to develop various kinds of activities for people.

However, it has not been researched details about the way of how museum activities contribute to PAS. So far, several research reports of people's activities museums mainly focused on learning by visitors including school children (e.g. Lucas, 2000; Rennie, 2001; Nakayama *et al*., 2003). Falk & Dierking (2000), on the other hand, suggested communities of adult learners were also important audience in museums. With this in mind, to attract communities of adult learners may be significant task for the museum enterprise to promote PAS. It is also described that visiting to a museum and experiencing there stimulate people's interest towards science (Stocklemayer *et al*, 2001). Thus, it would be necessary to investigate how museum enterprises contribute PAS. One of the ways to approach this task may be to find an indicator of PAS achievement phases in a museum.

Therefore, in this research, an indicator of PAS achievement phases will be found with focusing on a case study of a natural history museum in Japan.

2. RESEARCH PURPOSE AND METHOD

2.1. Purpose

The purpose of this research is to find an indicator to evaluate PAS achievement phases in a museum. This kind of discussion has not been done to date, although it is noticed that museums promote PAS. Especially, there is little research on museum learning by adult communities. Therefore, I assume a setting in which "the public people take action spontaneously and continuously" as an indicator of PAS achievement. In this research, it will be explain what kinds of characteristic phases occur in the progress to create the setting for PAS.

2.2. Method

As a research method, the author carried out participating observation of lectures and events for the public in the Museum of Nature and Human Activities, Hyogo in Japan (MNHA) from April 2006 to December 2007. During the term, several leaflets and document sources of lectures and events for the public were also collected in the museum.

According to the participating observation data among 21 months and documents sources, first, contents of museum enterprises in the MNHA will be described in the section 3 as "FINDINGS". Second, based on the contents of the enterprises, the following two issues will be discussed in the section 4.

1. Progress to create the settings for PAS in the museum and the subject showing the leadership in the settings.
2. Phases based on the settings and the leadership to promote PAS.

Some enterprises for PAS in the MNHA will be shown in the next section. However, enterprises managed by the MNHA before 2006 will be also described. It is because

that an important opportunity, that is the organization reform in 2000, which led to promote PAS in the MNHA was found from the collected data in 2006. Therefore, this year was made into the starting point to discuss the enterprise for PAS in the MNHA.

3. FINDINGS: ENTERPRISES IN THE MNHA FOR PAS

The MNHA issued the report of "Evolution of the MNHA" in 2000 and showed a basic concept to undertake reform of business deployment and organization management (Kawai, 2002). In the report, support of lifelong learning for the public and fulfill of the think tank function about nature and environment were shown as important enterprises in the museum evolution. In fact, it was aimed to train the public to be a promoter of lifelong learning. This is noted as "By providing the high quality service using material resources and human resources of the museum, the MNHA will encourage advanced study needs of the public from children to senior citizens staff (Museum of Nature and Human Activities, Hyogo *et al.*, 2004)."

Soon after publishing the report of "Evolution of the MNHA", a museum staff member, who is a specialist of insect ecology, started a course for the public. The course is called " Instructor Training Course for Chirping Insects". In the instructor training course for chirping insects, the beginners' class from June to August and the experienced class from August to October are prepared (Museum of Nature and Human Activities, Hyogo, 2007). Among these classes, only the person who finished the beginners' class can take a course for the experienced class. Thus, approximately the half number of people, who finished the beginners' class until 2007, took the experienced class (Miyatake, 2008). In the beginners' class and the experienced class, participants have to take a day course per month in the museum and have to continue the course for three months. Through the course, they are expected to acquire identification skill of 15 kinds of chirping insects. Moreover, the participants in the experienced class are required to carry out a practical experience to work as an instructor on the fourth day, that is the final day of the course (Museum of Nature and Human Activities, Hyogo, 2007).

In the instructor training course introduced above, people who finished the experienced class have formed an independent learning group since 2004. They support participants in the beginners' class of the instructor training course for chirping insects, and manage some museum events. Some members of the group also investigate chirping insects around Hyogo area (Komoda, 2006). In these activities of the public group, museum staff does not lead them, but members of the public group perform by themselves from a plan to practice. A staff member of the museum has relation only as an adviser to choose an appropriate method for the field investigation and data collection. That is, the public group members independently carry out their activity.

The MNHA has started to organize a presentation space for the independent learning groups since 2006. In the event, several independent learning groups working at the museum report a summary of their research activities in a year. In the first time of the symposium, held on 11 February in 2006, 35 groups made their presentations by oral and poster. This event gave an opportunity for the groups to exchange ideas of group activities and outcomes as well as a place of presentation.

Since 2007, the museum has begun to provide activities for the public held by the independent learning groups as official events of the museum. 13 kinds of activities were planed in 2007. The independent learning group members, who originally took part in a museum activity as individual learners, changed to a sort of instructor in the museum in this phase.

4. DISCUSSION

As we have seen above, there are several enterprises in the MNHA to promote PAS. For example, the MNHA issued the basic concept to provide research activities for the public in 2000. Since then, the museum made steady progress to build the setting in which the public people take action spontaneously and continuously.

4.1. The Progress of the Settings and the Leadership in the Museum Enterprises

Here, the setting and the leadership expressing the progress to promote PAS will be considered from the enterprises in the MNHA. The enterprises in the MNHA for PAS from 2000 to 2007 will be summarized as five issues below.

Museum enterprises in the MNHA;

- The museum published a clear policy to provide activities for the public in 2000.
- A museum staff member developed a course for the public which promote individual learning for the public in 2000 and 2001.
- An independent learning group by the public who finished the museum course was created in 2003
- The museum organized a symposium for the public in 2006
- The public learning group held a museum learning activity for the public in 2007

When we look at these five example enterprises in the MNHA for the public, the following settings can be shown in terms of the progress of PAS.

Settings showing PAS progress in a museum;

i. The museum shows their PAS concept in policy statement.
ii. The museum attracted individual learners and involved in museum activities organized by museum staff.
iii. Independent learning groups are created in the museum and the museum leads individual learners into the groups.
iv. Independent learning groups communicate with other groups.
v. Independent learning groups host an official museum activity for the public.

As for these issues, the settings in each from " i " to " v " is summarized in Table1-(a).

Then we turn to discuss which subject shows the leadership in each settings. In "i. The museum shows their PAS concept in policy statement. " and "ii. The museum

attracted individual learners and involved in museum activities organized by museum staff.", the subject is a museum. It is because a museum publishes a policy statement and provides activities to attract the public. Then, in "iii. Independent learning groups are created in the museum and the museum leads individual learners into the groups." and "iv. Independent learning groups communicate with other groups.", the public people join as the subject as well as a museum. They form independent learning groups among the public by working together. The independent groups also can exchange their ideas of group learning activity in this phase. Furthermore, in "v. independent learning groups host an official museum activity for the public.", the public people become the subject instead of a museum. In this final phase, the public people take charge of some museum learning activities.

To sum up these, if we focus on the leadership in the PAS progress, it turned out there are three categories to promote PAS (Table1-(b)). The subject changes from a museum to the public.

Table 1 Setting and Leadership in the PAS progress

a. Progress in the settings	b. Progress in the leadership
Publishing policy statement	Museum
Attracting the individuals among the public	
Creating independent groups	Museum and the public people
Communicating with independent groups	
Hosting the museum activities	The public people

4.2. Phases as index for PAS Progress

In the above section, five issues in the settings and three categories in the leadership are found in the progress of museum enterprises for PAS. Regarding to these findings, it will be described a PAS progress model based on the changes in the leadership.

The model is shown in Figure1. When a museum shows the leadership in the PAS enterprise, that is the first phase in the PAS progress. In this phase, the states is that the museum provides outreach activity for the public (Fig1-a). Then if the public independent groups are formed based on museum learning activities, the leadership is taken on by both a museum and the public. This phase can be placed in the second (Fig1-b).

Finally, in the third phase, the public people have the leadership. The status in this phase is that utilizing a museum and museum activity are the part of people's ordinary life. In other word, existence and learning activity of a museum infiltrate into the public life (Fig1-c).

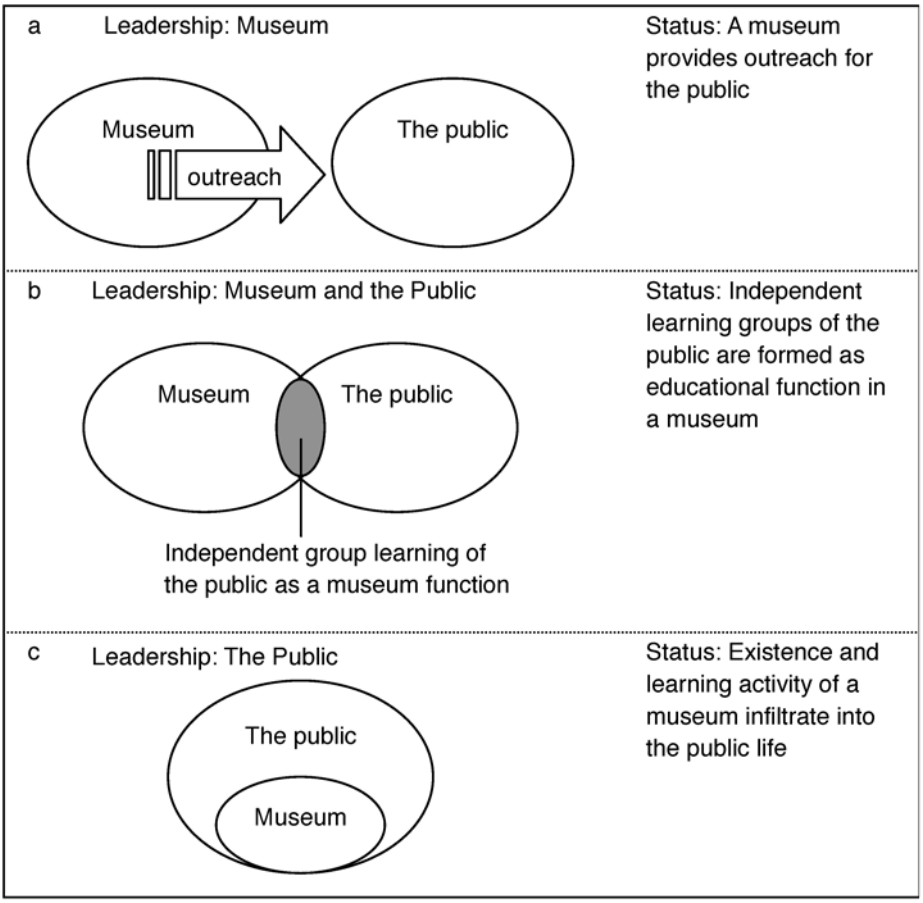


Figure 1 A PAS Progress Model based on the Leadership

5. CONCLUSION

To sum up these, as through this progress, the museum successfully changed the public's motivation from guest to host. From the case study of the MNHA, it is found out that there are five issues in the progress of the settings for PAS. Besides, when we focus on the subject in each settings, three phases are clarified. In short, it would be said that these issues might be considered as an achievement indicator of PAS.

Of course, all museums do not necessary to achieve the fifth phase, because infrastructure such as human resources and policy statement to provide activities for the public may different. However, if we have a certain index of the achievement phases to

evaluate how museum activities contribute to PAS, providing activities for the public will be more manageable. Hence, it will lead to promote PAS furthermore in the society.

As enterprise in the MNHA is quite unique in Japanese museums, we continuously carry on our research on the museum.

6. REFERENCES

Falk, J. H. & Dirking, L. D. (2000). *Learning from Museums*, Altamira Press.

Kawai, M. (2002). Foreword, *Annual Report 2001 (Kanpo 2001)*, the Museum of Nature and Human Activities, Hyogo, 1, 2002 (in Japanese).

Komoda, Y (2006). Map of Chirping Insect's in Fukada Playground, *Public Square for Symbiosis (Kyosei-no-Hiroba)*, 1, 1-3, Museum of Nature and Human Activities, Hyogo (in Japanese).

Lucas, K. (2000). One Teacher's Agenda for a Class Visit to an Interactive Science Center, *Science Education*, 84(4) 524-544.

Ministry of Education, Culture, Sports, Science and Technology (2005). Cooperation among Schools, Communities and Families, *FY2005 White Paper on Education, Culture, Sports, Science and Technology,* http:// www.mext.go.jp/ b_menu/ hakusho/ html/ 06101913.htm.

Miyatake, M (2008). Map of Chirping Insects 2007, *Public Square for Symbiosis (Kyosei-no-Hiroba)*, 3, 88-92, Museum of Nature and Human Activities, Hyogo (in Japanese).

Museum of Nature and Human Activities, Hyogo & Hyogo Prefectural Board of Education (2004). New Development of Museum of Nature and Human Activities, Hyogo, Humans and Nature, Special Edition, 4-38 (in Japanese).

Museum of Nature and Human Activities, Hyogo (2007). *Seminar Guide*, 2007 (in Japanese).

Nakayama, H., Yamaguchi, E. & Satoka, A. (2003). Case Study of Cooperation between a Lower Secondary School and a Museum through Field Study: The Case of MiyazakiPrefectural Museum of Nature and History*, Journal of Science Education in Japan*, 27(1), 71-81. (in Japanese)

Rennie, L. (2001). Communicating Science Through Interactive Science Research Centres:A Research Perspective*, Science Communication in Theory and Practice*, (Eds.) S. M. Stocklemayer, M. M. Gore and C. Bryant, 107-122, Kluwer Academic Publishers.

Stocklemayer, S.M., Gore, M.M., and Bryant, C (2001). *Science Communication in Theory and Practice*, (Eds.) S. M. Stocklemayer, M. M. Gore and C. Bryant, Kluer Academic Publishers.

7. ACKNOWLEDGEMENTS

I thank to Dr. Otani, a museum staff member of the MNHA and members of the learning groups in the Museum of Nature and Human Activities, Hyogo, who gave a great support to this research. This research is supported by the Grant-in-Aid for Young Scientists (B) No. 19700617 from 2007 to 2008 and Research Exchanging Program between JSPS and RCN in 2008 to Shiho Miyake from the Ministry of Education, Culture, Sports and Technology in Japan.

DEEP ETHICS: RESEARCH AND RESPONSIBILITY

Moyra Keane
University of the Witwatersrand, Johannesburg
moyra.keane@wits.ac.za

▼ Abstract

Research that seeks to engage participants and transform practice and people requires a deepening of relationships. Close participant relationships increase the complexity of engagement, as well as creating a possible proliferation of expectations. In a participative framework, especially across cultures, the question is: are conventional contractual ethics agreements appropriate in science education? In this paper I explore the moral, legal and epistemological obligations of researchers in a prolonged participative research project. Can the conflicts that arise across *truth, justice* and *care* be resolved in the complexity of research and project dilemmas? I discuss the preservation of individual rights, confidentiality and versions of truth, along with cultural concerns and community harmony. In working in a rural area of KwaZulu-Natal, South Africa, the framework of *ubuntu* is used as a guide to ethics. I argue that ethical obligations cannot be sufficiently met through conventional contractual agreements.

Key Words ethics; culture; research responsibility

1. INTRODUCTION

How do standard ethical requirements fit with participative research and engagement in rural communities and a framework of *ubuntu*? How does the quest for truth and justice balance with ethics of care? When is it appropriate to respond to calls for help outside the research plan? How does one resolve issues of disquieting findings and where are the boundaries of responsibility?

2. THE FICTION OF STANDARD ETHICAL REQUIREMENTS

> *"You will remain anonymous, what you say is confidential, your participation is voluntary and you may withdraw at any time."*

This standard phrase of research ethics, although designed to protect participants, has a connotation of the 'researched as specimen'. It is hardly the basis for building a trusting relationship within a shared and egalitarian research partnership. It is also laden with assumptions about power, culture, and a simplistic research process. In our research project with a rural community, such a contractual approach was baffling – if not offensive to participants. We nonetheless felt obliged to moot the possibility of complying with these standards according to the ethics requirements of the universities. Some of the contentious points were: anonymity, voluntary participation, lack of

commitment (option to withdraw at anytime), and confidentiality. In addition were the more subtle ethical issues of creating expectations, being drawn into project and resource management, and finding ways to withdraw *ourselves*.

From the start of the research project, the notion of anonymity was viewed as insulting and condescending. No-one wished to be anonymous. The concept is largely fictitious anyway: when the research derives from an actual setting and events, with determined efforts, the codes of anonymity can be broken. (There is a well-known South African novel based on a murder in this area, in which names and places have been greatly fictionalised, but people in the area "know" who is who in the novel.) Steinberg (2003) observes that hiding names is a ruse. Also, the person (in the story or research report) *herself* knows. It is not only public exposure that may be damaging: what are the ethics of finding out about ourselves through another's public analysis?

The HSRC (2005) report on rural education in South Africa, "Emerging Voices", uses names of actual schools even though this could be damming for many principals, teachers and schools. For example, the report cites, as in our project, students' complaints of teachers not teaching, of corporal punishment and (illegal) compulsory school fees. Perhaps because these are widespread problems they are not read as an expose of a particular school (for ethics is a responsibility of readers as well as writers).

Another issue is that anonymity is unevenly applied. The researchers enjoy publicity while the 'researched' are 'unidentified'. This practice assumes that the 'researched' have needs to be protected from embarrassing actions while the researchers have cause to be proud of *their* actions! Or it assumes the researched have no rights to acknowledgement for their ideas and achievements.

The assurance of 'confidentiality', 'voluntary withdrawal' and 'informed consent' are also too glibly promised. Our research centred on work as a community, in which the opening meetings established a sense of direction, feelings of hope, as well as long-term commitment, rather than precise goals and activities. 'Informed consent' was limited while no-one quite knew what was being consented to. The broad area was science education – but what shape this would take was still unknown. Confidentiality also made no sense in a community project. It could more likely cause division and suspicion than community development. And while voluntary withdrawal – from a particular activity, or the project overall – was always possible (and occurred), it had to be seen in the light of responsibilities to the community. (In fact the community was as likely to be critical of us for not coming often enough to the research site, or not following through an idea, as we were of them.) Of course there is the added pressure from funders who assume that, in fact, participant withdrawal amounts to research failure.

Solutions to these issues emerged only partially through processes of participation – and took time. At one level, the overall participatory framework for the study was openly shared, shaped and understood by the participants. 'Participation' is much more than a process. At a second level, detailed planning and involvements were always open to negotiation. Rather than a legal contract, 'informed consent' was a matter of day-to-day agreement, as a natural part of planning and action. While these solutions did not fit the standard 'rules' laid out by university ethics committees, they were true to the spirit of such rules.

Formal ethics requirements of universities are culturally biased and more strongly located in medical and quantitative paradigms. These are not necessarily appropriate to participative, socio-cultural studies in rural South Africa. There are alternative ethical paradigms. For example, ethics based on *communitarianism* "locates morality within a given community and its shared norms and 'practices'." (MacIntyre, 1981, in Howe and Moses, 1999:33). This has some application for our research, but we have drawn more closely on *Care Theory* which maintains that "caring is the ethical universal" (Noddings, 1984, in Howe and Moses, 1999:34). This applies well to my presentation of 'truths' about the schools, as it emphasises "the view from here" rather than the ideal circumstances, abstract principles, and privileged positions in "the view from nowhere" (Nagel, 1986, in Howe and Moses, 1999:34).

The focus on individual rights is just one example of potentially culturally-biased ethical norms. In some communities individuals are not seen as having the autonomy to decide whether to participate. Further, one participants' contribution can affect everyone. In our project the *Induna* and principal said it was fine for students to participate. When I produced forms for parents to sign the *Induna* and principal's response was one of tolerant bemusement (from a philosophical perspective as well as a practical one). (When I came to collect the forms I watched the principal sign on behalf on parents! And the *Induna* seemed not altogether pleased that I had not simply taken his word on the matter: he sees the village children as *his* children.

In standard research approaches, the researcher has almost entire control – from design to dissemination. Ethics are presumed to be satisfied through the community's consent, and promises of anonymity. However, the research is a perturbation of the community and bound to have consequences for it. This raises ethical dilemmas (Adler and Lerman, 2003): 'Who sets the goals?' 'To whom is the researcher accountable?' 'Who owns the research?' And even: 'Do participants also have ethical obligations?' Most ethics committees focus on the researcher's obligations to subjects of research. There are also responsibilities to funders, fellow researchers, students and research itself.

3. DILEMMAS

> "*…many of the dilemmas that I had to resolve sprang not from problems of the research activity itself, but from difficulties encountered in trying to follow prescribed…models…*"
>
> *(Louisy, 1997:205)*

The aspiration for openness, like the aspiration for democratic processes, is fraught when applied in a particular setting. Should we be reporting students' illegal absenteeism from school? What if worse things came to light such as fraud? What would we do with rumours, confidences and claims that individuals might offer, informally and formally? Who would decide which ones were 'relevant' and, if so, how they might be aired in public presentations, or even as part of 'triangulation'? Research reporting – as part of the planning process, and in final reports – is inevitably selective: if research reports focussed on questionnaire answers (which were collected), many

sensitive findings about the research site and the people could be avoided. Would that be the 'right' choice? Indeed, if research reports chose to skirt knowledge that 'everyone' at the meeting had, whose needs were being served? The consequences of research and what it chooses to report cannot be anticipated. This in itself is an ethical dilemma (Adler and Lerman, 2003).

It is also a validity dilemma – which may be considered a dimension (perhaps a more subtle one) of ethics. Reported goals and actions are criteria for participative and consequential validity (Lather, 2001). The secondary school's choice (which they openly negotiated with us, offering us access to the students and facilities and broad support, as long as they were not involved in the 'teaching') was consistent with 'participative validity', but counted against the science education project in terms of consequential validity. As another example, in the case of corporal punishment, epistemological validity was an issue we discussed openly with the principals. Our ideologies of no corporal punishment were generally at odds with those of elders and principals (although not the students). This raises two further ethical issues: the personal stance of the researcher, and the distinction between research and evaluation. In positivist, detached research, researchers might be able to collect data without disclosing their personal positions on the issues being discussed. This is both inappropriate and impossible in an on-going participative project. We were in the project largely to learn, and that required openness on our part: burying our own sympathies too deeply, or pretending alignment with respondents would have been both unethical and unproductive (Patton, 2002). So too, the distinction between research and evaluation had ethical dimensions. I determined from the outset – and assured the schools and communities – that I was not there to evaluate. Compiling and presenting evaluations I knew would interfere with the openness of the project, and could result in imposed and misleading analyses (from the community's perspective) (Malcolm & Alant, 2004). However, within the context of the project itself, evaluation was a necessary and integral part of planning. Our solution was to restrict our evaluations to actions and conditions that were clearly relevant to the project, but such a distinction was sometimes impossible, such as, for example, when the secondary school repeatedly withdrew.

I am not suggesting that conventional ethics protocols should be ignored. I am suggesting that they need critical scrutiny and revision for the South African context. In our project we did hand out participation consent forms after explaining implications. We later also gave students forms asking permission to use photos, drawings, stories and recordings. Even while doing this we knew that most of the adults are illiterate in written English and Zulu. Also, many parents were not at the meetings or not even in the village. Students later signed on behalf of parents (forged signatures?) or the principal signed for them. These types of forms assume a contractual relationship and I suspect assuage the conscience of the researchers more than they protect participants. I suspect also that, if it came to a courtroom, their legality would be questionable, because of the difficulties of 'informed' consent and the competence to give consent. Ultimately, ethics is about honesty, truth and justice or, in terms of *ubuntu,* relationships and human dignity. These are more matters of principle than rules.

The cultural orientation towards voluntary participation is also pertinent. In what way can 'voluntary participation' be an authentic offer? Destitute communities may offer to participate in the hope of some material benefit, or they may, out of politeness, not wish to say 'no'. Subjects are naïve about research – they become involved for different reasons. On the other hand, it is ungenerous – even unethical – of participants to 'pull out' without serious attempts at negotiation. Participative research and development requires enormous time, money and emotional investment for researchers and participants. As in all relationships patience and mutual care are needed. Working in a community where *ubuntu* is a well established framework made this easier.

4. ETHICS AND RESEARCH CONSEQUENCES

Moral behaviour is judged by both intention and consequences, in relation to ethics of justice, truth and care. It is often not possible to balance these incommensurables and "intrinsically sanctimonious to choose." (Steinberg, 2003.) It is likely that research *will* cause some harm somewhere, alongside any 'good' it causes. This is sobering and needs vigilance, trust and mutual concern – which are central in the ethical paradigm of care theory (Howe & Moses, 1999) and *ubuntu*.

Consequences of research (as opposed to intentions), are more removed from the researchers' control. They arise not only from the knowledge generated, but directly for individuals and groups as part of the research process. They cannot be accurately foreseen. More control is lost in the reporting as information is disseminated to policy makers, academics and communities, and 'picked up' in a somewhat serendipitous fashion. As part of the research process too, the knowledge created along the way, and personal reflections and interactions can have varied and unpredictable consequences. For example, some female students who became more aware of gender issues in relation to HIV/AIDS may find themselves at odds with cultural expectations. A teacher who gained personal confidence and awareness of community issues resigned to work for an NGO. A research leader took on the care and virtual adoption of a community researcher. Participative research makes everyone culpable and vulnerable beyond prescribed formulas. Merriam (1998) moves the concern for consequences to a new domain when she argues that all researchers need to be skilled in 'risk assessment' and where possible risks include psychological stress, ostracism and political strife (Patton, 2002).

It is likely that the consequences of the research for researchers are clearer than for other participants: researchers build their knowledge, and use it in teaching, publications and career advancement. This is so for all research paradigms. For other participants, the research paradigm makes a difference. In the positivist tradition, other participants provide knowledge, perhaps from some commitment to 'science' as a public duty, a connection with the researcher or a hope for some benefit. The researcher seeks to perturb minimally the situation studied, and in that sense minimize the consequences for participants. In our research, however, in collaboration with the community, we hoped for significant changes in the situation being studied, and major consequences for the participants, especially in relation to relevant science education. We depended on processes of participation and a framework of mindful

inquiry, care and *ubuntu* to take care of the 'risk assessments' and to anticipate and plan for consequences.

Taking care not to cause harm is only one side of research responsibility. A possibly more challenging aspect is the moral imperative to activism. Kyle (1999) makes a case for science educators' ethical responsibility to become engaged in promoting equitable education in developing countries. Is research unethical if it ignores pressing humanitarian issues that are in need of redress? This brings to mind the words of Molier: "It is not only what we do but what we do not do for which we are accountable."

5. ETHICS OF DEMANDS

Participative research and engagement is demanding. Through participation and action in a specific situation, it seeks to reduce the separations of researcher and researched, knowledge and action, action and consequences. Responsibilities to and of the participants, possible consequences of the research, and concerns for justice (as well as knowledge and care) are raised for discussion, and more openly addressed. Risks, demands and commitments are all higher. This raises an ethical dilemma of how much can be reasonably expected from participants - including researchers.

"Rigour …challenges the other to take part." (Shor & Freire, 1987:4). At all stages of this research, participants were 'challenged to take part' – to commit time and energy and take risks. The community project management committee was formed from villagers who had no experience in managing a cooperative, chicken farming, or accounting. The farmers built chicken cages, and were suddenly confronted with 20 chickens and a bag of grain. The secondary school hosted university researchers and agreed to a project that would seriously challenge school routines and practices. The students conducted interviews, wrote stories, designed posters and prepared a play on HIV/AIDS to put on before 500 people, including the traditional leaders. And, at every turn, we were challenged on one hand to hear in new ways, do new things. All of these demands have ethical dimensions, where commitment and adventure are entwined with risk, duty and guilt. Who then makes the choices?

6. TRUTHS

I have so far emphasised the aspect of care as a way through the dilemmas of research ethics. In the pursuit of knowledge creation, 'truth' in relation to ethics needs analysis. The Truth and Reconciliation Committee outlined four kinds of Truths (TRC, 1998). I illustrate these through my research journal entries.

1. Factual Truth: this is forensic – legal, scientific, empirical and observable. An example of this in our project is:

   'I arrived at Sinevuso, Mr Mkhize was not there. Nor Mr Makhanya and Mrs Makhubela.' (Journal 1, 7th March))
   'In the afternoon I went to Lusiba. Mr Hadebe was not there.'
   (Journal 1, 4th March)
   'Meeting Wed at Lusiba with teachers (Hadebe not there)'
   (Journal 1 23rd April)
   'Arrived at Sinevuso about 10 am – Mkhize not there.' (Journal 1 23rd April)

2. Personal Truth: this includes feelings, impact, perception and is usually censored out of research reports.

   'Nothing is happening!' (Email to Project Leader.)
   'I'm being let down!' (Phone call to Project Leader.)
   'The problem is with the school.' (Neighbouring principal.)

Perspectives become exaggerated through the internal-personal accumulation which becomes part of the individual reality. One event has many truths.

3. Dialogical / social – hermeneutic Truth: this is, in a participative paradigm, the most reliable, and has goals of being transformative.

   '"We support this project but there is not enough time." – Mr Mkhize.'
   'Mr Mkhize: "There is a third reason I forgot to mention, there is no good understanding among the teachers about what is taking place here, I mean they are just wondering as to what [way] is this community-based education going to help the school."'

4. Healing (Restorative) Truth: – this is the telling of story; restoring dignity; acknowledging human context; indirect; critical. This has been attempted through Science Festivals and through a Community Research Booklet, although achievement is likely to be limited. Hopefully this is where research reporting contributes. Reason & Bradbury (2002:10) stress the importance of this healing:

   > *"Given the condition of our times, a primary purpose of human inquiry is not so much to search for truth but to* heal, *and above all to heal the alienation, the split that characterises modern experience."*

7. CONCLUSION

In Transformative Action Research in science education, ethics need to be part of participation and not an imposed legal contract - the terms of which are decided by researchers or university committees. As participation and engagement need to be negotiated, discussed and critiqued, so too do ethics. Ethics are dynamic and not separate from processes and relationships.

I am making a case for a more integrated and comprehensive concern with ethics. Ethics comes into play in the choice of research, purposes, broad methodology, data generation, analysis and reporting. Research can be used to deliberately foster ethics. Within the complexity of life-research, the researchers particularly, but also participants, need to rely on and develop their own sense of empathy and right action. There needs to be discretion based on care in all the aspects of research.

In the balance between truth, justice and care, the well-being of participants is of primary concern. Participative research is not an inquisition. It is also largely subjective. The real world of wresting with truth is not easily sanitised through a set of prescribed protocols. Ultimately it comes down to caring awareness in the pursuit of knowledge.

8. REFERENCES

Adler, J., and Lerman, S. (2003). Getting the description right and making it count: Ethical practice in mathematics education research. In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick, & F. K. S. Leung (Eds.), *Second International Handbook of Mathematics Education* (pp. 441 – 470). Dordrecht: Kluwer.

Howe, K.R. and Moses, M.S. (1999). Ethics in Educational Research, in Review of Research in Education, Iran-Nejad, A. and Pearson, P.D. (Eds.), Vol.24 AERA.

HSRC (2005). Emerging Voices: a report on education in South African Rural communities. Nelson Mandela Foundation, Houghton, South Africa.

Kyle, W.C. (1999). Science education in developing countries: Access, Equity, and Ethical responsibility, Journal of Southern African Association of Research in Mathematics and Science Education, 3(1) pp.1-13.

Lather, P. (2001). Postpositivist New Paradigm Enquiry. Unpublished lecture at University of Durban-Westville, August, 2001.

Louisy, P. (1997). Dilemmas of Insider Research in a Small-Country Setting, Tertiary Education in St Lucia, in Qualitative Education Research in Developing Countries. Crossley, M. and Vulliamy, G. (Eds.) New York: Garland Publishing, Inc. pp. 199-220.

Malcolm, C. and Alant, B. (2004). Finding Direction When the Ground is Moving: Science Education Research in South Africa. *Studies in Science Education, 40, pp. 49-104.*

Merriam, S.B. (1998). *Qualitative Research and Case Study Applications in Education*. San Fransisco, California: Jossey-Bass Inc., Publishers.

Patton, M.Q. (2002). Qualitative Research and Evaluation Methods. California: Sage Publications.

Reason, P. and Bradbury, H. (2002). Introduction: Inquiry and Participation in Search of a World Worthy of Human Aspiration. In P. Reason and H. Bradbury (Eds), Handbook of Action Research: Participative inquiry and practice. London: Sage Publications. pp.1-14.

Shor, I., and Freire, P. (1987). *A Pedagogy for Liberation: Dialogues on transforming education*. Granby, MA: Bergin & Garvey.

Steinberg, J. (2003). "Midlands": A public talk. Houghton, Johannesburg. 17th August 2003.

TRC, (1998). *Truth and Reconciliation Commission Report on South Africa.* Cape Town: Juta.

9. ACKNOWLEDGEMENTS

I wish to acknowledge the leadership of Prof. Cliff Malcolm in this project, as well as all the participants in the research study, especially Mrs N. Sikhakhana, Mr S. Mchunu, and Chief Ndlovu.

SCIENCE-LIVE: A CONCEPT TO INTEGRATE STUDENT LEARNING, PRE-SERVICE TEACHER EDUCATION AND SCIENCE RESEARCH

Michael Schallies, Tobias Leonhard
University of Education,
Im Neuenheimer Feld 561, Heidelberg / Germany
E-mail: schallies@ph-heidelberg.de

▼ Abstract

At the chemistry department of the University of Education Heidelberg we have established a laboratory called science-live! It is devoted to student learning and pre-service teacher education at the same time. The laboratory is devoted it to the general topic "climate and energy". It offers experimental equipment to investigate the underlying scientific facts with respect to carbon dioxide in the atmosphere, climate change and alternative energy production. It is open to all lower secondary and higher secondary schools of the region.

Pre-service teachers from our university are engaged to work as tutors in this laboratory. Their job is to support students´ self-directed learning in the laboratory, being a mentor who is able to identify students´ needs, help them find a "research questions", support their experimental set-ups, and finally also help interpret the experimental results. Pre-service teachers are prepared for these task through regular prescribed seminars in the curriculum devoted to the theory of self-directed learning.

We are assessing the appropriateness of the learning environment for student learning and pre-service teacher professional development at the same time by qualitative and quantitative means.

Key Words self-directed learning, science learning, labwork

1. INTRODUCTION

At the chemistry department of our University of Education we have established a laboratory called *science-live!* in the year 2003 (http://www.science-live-heidelberg.de/). It offers a learning environment to students grade 5 through grade 8 and their teachers to all schools in the region around Heidelberg (N = 268). Laboratory activities are offered to the general topic "climate and energy". Experimental equipment is available for the investigation of underlying scientific facts, e.g. with respect to carbon dioxide in the atmosphere, climate change and alternative energy production. The topic climate and energy fits well into the curricula of lower secondary and higher secondary schools in Germany.

The pedagogic concept is based on self-directed learning (Knowles, 1975). Experimental stations devoted to the investigation of wind energy, photovoltaic, water energy, conversions of mechanical energy into electrical energy, properties of carbon dioxide and greenhouse effect are present in the laboratory environment. There are no prescribed experimental procedures to follow. Instead, students are required to find a "research question" for themselves first, then find an experimental setup to work on, get results, discuss their findings and finally present them to the whole group present. Students work in small groups of four to five students, each group being supported by a tutor who's task it is to support their activities in a non-directive way. Tutors are prepared for the task of supporting self-directed learning activities of the students in special courses at university. This is accomplished in regular seminars prescribed in the curriculum of the teacher education programme of the faculty. The activities of tutors are supervised by the person in charge of the student's laboratory (Tobias Leonhard), who is using a coaching concept to prepare students for their activities in the laboratory (Leonhard & Schallies, 2006). The whole concept is a systemic approach for student learning, teacher pre-service education and teacher further education which is evaluated by qualitative and quantitative means (Schallies, Storrer, & Welzel, 2007).

The activities at the University of Education fit well into a study programme prescribed to all students from the faculty of natural sciences and social sciences for interdisciplinary work, which is suppose to be a main task in their future career as a professional at school.

2. ASPECTS FOR EVALUATION

In order to evaluate the concept of the students laboratory science-live! we were interested to obtain students views about their laboratory activities, teachers views about the learning outcomes and pre-service teachers views about their work as a tutor in the laboratory. Student's views and teachers views were obtained by a questionnaire. The questionnaire was a modified version originally used in a precursor project for the Academy of Technology Assessment of the State of Baden-Württemberg (Schallies & Eysel, 2004). The questionnaire was tested with the first three groups of students coming to the laboratory in order to identify those questions that were difficult to understand or liable to be misunderstood. For a internal validation of the scales (Lickert type, five grades from "excellent" to "very bad") the order was reversed (from "very bad" to "excellent") after having obtained the first 500 questionnaires. As a consequence from the outcomes of the internal validation we also changed the scaling from "very difficult" to "very easy") into "too difficult" to "too easy".

Similarily the questionnaire for teachers was tested with the first five school teachers coming to the laboratory in order to find out if the items were understandable or amendments were necessary.

Questionnaires had to be filled in by students and teachers during the last part of their activities at the students´ laboratory. A standardized introduction was given to students and teachers before filling in the questionnaires.

3. RESULTS

The evaluation of the questionnaires is based on 62 groups of students (N = 1489

students). 212 students were counted to twice because they had two visits to the laboratory in the course of time. A total of 1019 data sets was obtained. For the analysis of data the programme SPSS 12.01 was used.

With respect to age two maxima were noticeable corresponding to students from grade 5 and 6 and grades 9 and 10 respectively. This can be explained from the best fit of the topic climate and energy to the curricula of schools. For the more detailed evaluation therefore two cohorts were formed: aged group13 and younger and age group 14 and older respectively. With respect to gender the ratio was nearly even (49% female, 51% male). The distribution of topics that were sought after during the laboratory work there is a nearly even distribution except for hydrogen cell and conversion of mechanical energy into electrical energy.

With respect to pre-knowledge 84% of the students give a positive answer. However, there is a gender specific difference since in the group of the 13 years old and younger male students are significantly more positive about their pre-knowledge than female students. Sources of pre-knowledge are mainly classroom activities at school or information from TV, radio, internet (54%) and print media (28%).

With respect to interest there is also a significant gender specific difference with younger students: a larger number of males declare their interest than females of the same age group. However, this difference fades with growing age. Analysis of the data in the group aged 14 years plus shows, that there is a correlation between pre-knowledge and interest, especially with females ($p<0.01$). With respect to experimental activities in the laboratory there were eight items in the questionnaire:

1. How do you rate the opportunities to gain new experiences? 2. How do you rate the opportunities to gain new knowledge? 3. How do you gain the opportunities to research on your own? 4. How do you rate the support of your tutor? 5. How do you rate the knowledge of your tutor? 6. How do you rate the way tutors put questions to you? 7. How do you rate experimental difficulties? 8. How do you rate the handling of equipment?

The main results are shown in the following graphs. There are no gender specific differences except for the rating of the knowledge of tutors: this is significantly rated better by female students.

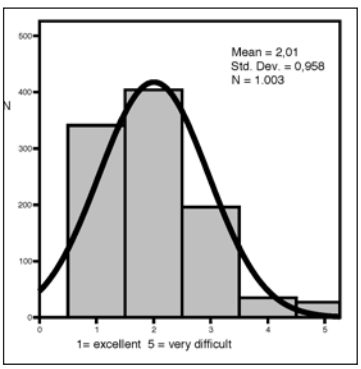


Figure 1 rating tutors´ questions

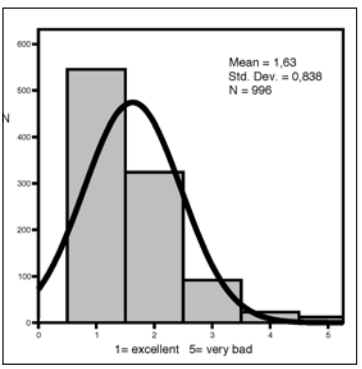


Figure 2 rating tutors´ knowledge

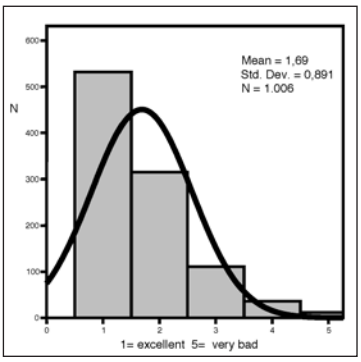


Figure 3 rating individual research

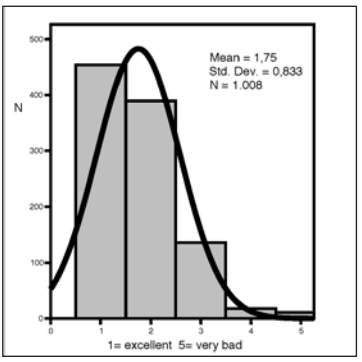


Figure 4 rating new experiences

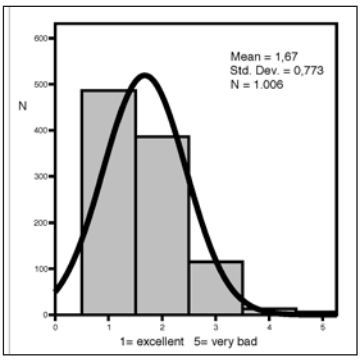


Figure 5 rating gain of knowledge

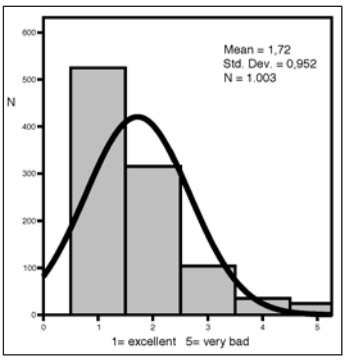


Figure 6 rating tutors´support

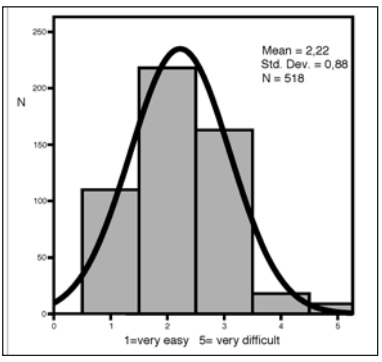


Figure 7 experimental difficulties (I)

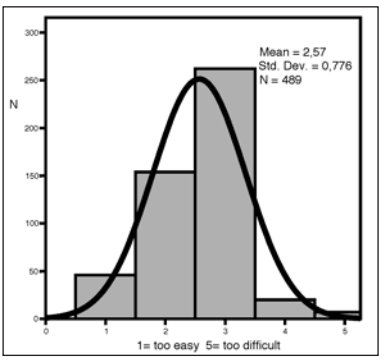


Figure 8 experimental difficulties (II)

In the questionnaire there was also an open question asking students for suggestions about improvements in the students´ laboratory. A majority of 57% stated that everything was fine and there was no need to change anything. The rest of answers was categorized and made mention to "more time needed, more support needed, more action" and others. The largest percentage in these categories was 5.6% ("more time"). "More support" was mainly mentioned by female students, whereas male students ask for "more action".

4. GETTING INSIGHT IN THE ACQUISITION OF KNOWLEDGE

For a measurements of gain of knowledge in a classical design of research one can use a pre-test, a post-test and a follow-up test. This classical design did not appear appropriate since the learning environment is devoted to self-directed learning, and specific learning aims have not been defined. Also, we did not want to have a test situation in a non-conventional laboratory environment that is designed to develop students´ creativity. We decided to work on this question with a group of classes that came to the science-live! laboratory twice on a regular basis. Between the first visit and the second visit there was a difference in time of up to seven months. In the context of the second visit of every class we decided to use a method called "stimulated recall" in the course of the students´ task to find another "research question" for their labwork.

The investigation was started by giving a poster to the students showing some key components of their experiment on their first visit. Students were then asked to add details or give explanations to the poster, either by drawings or as a text. The students could work in groups of 4 to 5, so the results cannot be assigned to individuals. Data obtained from four complete classes were analyzed. Aspects for evaluation were:

1. What can be seen? (descriptive approach)
2. Analysis of the added content.
3. Correctness of the added contents.
4. Is there a correlation with the period of time having elapsed between the two visits?
5. How can the different aspects be valued?

The evaluation showed in general that students are able to reproduce the main aspects of their first experiments in the laboratory. They can reproduce the correct scientific terms, but also the process of experimentation. Since there is a logical connection between text and picture in the presentations one can deduce that an understanding of the experiment has evolved. A basic understanding of scientific methodology can be deduce which shows that the activities in the laboratory science-live! is not just fun and action but a serious activity for the students with relevance to their living environment.

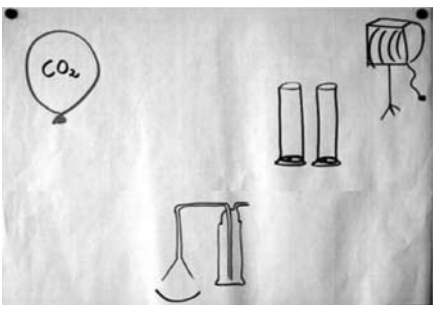


Figure 9 poster given as start

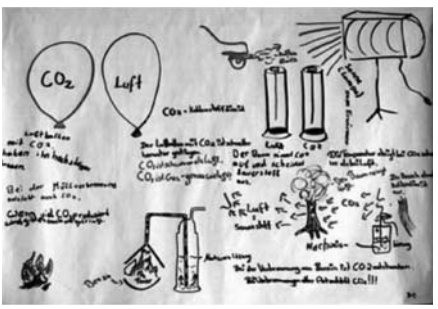


Figure 10 poster completed in detail

5. INTEGRATION OF TUTOR'S ACTIVITIES INTO THE PRE-SERVICE TEACHER EDUCATION PROGRAMME

From the evaluation of tutors´ individual portfolios one can deduce that the tutorial tasks are very appropriate as a first step in preparing the professionalisation of tutors. Especially positive mentioned is tutors´ experience of having to adapt to a totally new and different learning group every day they work in the laboratory. It seems to be a very authentic training situation for pre-service teacher education since they have to adapt to very different groups of age, from different type of schools and different pre-knowledge not known to the tutors until they face their group of students in the lab the first time. They rate these experiences much better than the standard pre-service teacher education programmes where they have to teach a regular class at one of the schools in the vicinities once a week for one our. The advantage of working as a tutor in the student's laboratory is that they can concentrate on one topic like photovoltaic or carbon dioxide in the atmosphere for one semester and gain experience in supporting learning activities of students of different age, pre-knowledge, experimental experience for continuously. Progress is then made in transforming teaching activities into learning activities of the students and being able to support student's activities in a non-directive way. Of course there are differences in the way school children rate the support of individual tutors. But the analysis of questionnaires with respect to individual tutors shows that the group as a whole is given rather homogenous ratings by the school children.

Table 1 ratings for individual tutors

tutor	Nos of questionnaires	mean	Standard deviation
1	66	1,76	0,77
2	84	1,85	0,78
3	62	2,10	1,07
5	213	2,03	0,96
6	89	2,18	0,98
7	66	2,14	1,14
8	60	2,17	0,99
10	46	2,07	1,00
13	41	1,98	0,85

6. CONCLUSIONS

The learning environment of the students´ laboratory *science-live* is rated positive by students from schools and by pre-service-students in teacher education programmes as well. The central aspect of self-directed learning is perceived by students and recognised in a positive way. Integration into the education programmes of the faculty has been accomplished. Students´ learning outcomes have not been followed yet system-

atically over longer periods of time. But since some schools in the vicinity have started to send all their classes to the laboratory *science-live* on a regular basis, we shall have a chance for a follow-up research.

7. REFERENCES

Knowles, M. S. (1975). Self-Directed Learning: A Guide for Learners and Teachers. New York: Association Press.

Leonhard, T. & Schallies, M. (2006). Coaching als Ansatz für eine wissenschaftliche Lehrerbildung? Grundfragen, Forschungsvorhaben und Zwischenergebnisse. Pitton, Anja. Lehren und Lernen mit neuen Medien. [26], 192-194. Berlin: LIT Verlag.

Schallies, M. & Eysel, C. (2004). Learning beyond School: Establishing a Laboratory for Sustainable Education. Chemistry Education: Research and Practice 5[2], 111-116.

Schallies, M., Storrer, J., & Welzel, M. (2007). Innovative Lehr-Lern-Konzepte in der Lehrerbildung. Erfahrungen mit Schul- und Hochschulprojekten. In L.Jäkel, S. Rohrmann, M. Schallies, & M. Welzel (Eds.), *Der Wert der naturwissenschaftlichen Bildung* (pp. 149-164). Heidelberg: Mattes Verlag.

8. ACKNOWLEDGEMENTS

We are grateful to the Robert Bosch foundation (Stuttgart), the "Fonds der Chemischen Industrie" (Frankfurt) and the university of education Heidelberg for their donations, which have made it possible to establish the laboratory and carry out the educational and research programmes.

STUDENT TEACHERS' PROBLEM SOLVING STRATEGY USAGE IN A PHYSICS COURSE: RELATIONSHIP WITH ACHIEVEMENT LEVELS

Serap ÇALIŞKAN*, Gamze Sezgin SELÇUK and Mustafa EROL
Department of Secondary Science and Mathematics Education,
Dokuz Eylül University, Buca, 35160, Izmir, TURKEY
**E-mail: <serap.caliskan@deu.edu.tr>*

▼ Abstract

This study has examined the relationship between problem solving strategy use of student teachers and achievement level in a physics course. In this study, pretest-posttest quasi-experimental design with equivalent control group was used. Two groups of student teachers (*n*=73) who took Physics I course participated in this study. In the strategy group, problem solving strategies were taught. No strategies were taught to the control group. Data of the study were collected by the Physics Achievement Test and the Physics Problem Solving Strategies Scale. Findings of the study indicate that there were meaningful differences between the student teachers' achievement levels and their strategy usages in certain dimensions. The implications of these results for physics instruction are discussed.

Key Words physics education, problem solving strategies, achievement, strategy usage.

1. INTRODUCTION

Problem solving is usually defined as formulating new answers, going beyond the simple application of previously learned rules to create a solution (Woolfolk, 1993). The basic problem solving process is a linear, hierarchical process. Each step is a result of the previous step and a precursor to the next step. Whereas each of these steps is considered as separate skills, each step is categorized into sub skills. These skills can be considered as the analytical parts (heuristics) of the problem solving process which requires defining, investigating, reviewing and processing of the information regarding the problem. Somewhat synonymous term is "strategies". According to Mayer, a problem-solving strategy is a technique that may not guarantee solution, but serves as a guide in the problem solving process (Gick, 1986). Literature shows that individuals who use the problem solving strategies effectively were called as "expert problem solvers" and who can not use it sufficiently were called as "novice problem solvers". The research related to the problem solving in physics are focused on two main titles. First one of these is the research regarding the comparison of the problem solving behavior differences among expert and novice problem solvers (for instance:

Chi, Feltovich, & Glaser, 1981; Larkin, McDermott, Simon, & Simon, 1980). And the research existing in the second group is directed towards teaching problem solving strategies in order to make the novices become expert problem solvers (for instance: Huffman, 1997; Larkin & Reif, 1979; Mestre, Dufresne, Gerace, Hardiman, & Touger, 1993). In this context, in field literature review, it was seen that lots of researches had been done related to the physics and problem solving strategies abroad. However in Turkey this subject is neglected. When literature in our country related with the subject is examined, unfortunately, there are few studies on determination and usage of the problem solving strategies in science and physics (Çalışkan, Selçuk, & Erol, 2006; Selçuk, Çalışkan, & Erol, 2006; Selçuk, Çalışkan, & Erol, 2007); and there is only one study on instruction of problem solving strategies (Gök, 2006). Unfortunately, this subject has not been given importance sufficiently in our training system. Teachers neglect this subject with reasons such as that period of training is limited, that course programs are loaded or that they themselves have sufficient knowledge on that field. At this point, carrying out this research with the student teachers has special importance, and it is believed that for the student teachers being familiarized with the problem solving strategies, comprehending the importance of usage of these strategies would affect them towards encouraging to teach and use these strategies at their teaching profession in the future, and to teach them to their students. In the light of these information, in this research, the correlation between the achievement levels and strategy usage of the student teachers who were classified as "high achiever" and "low achiever" according to their achievement levels at strategy group and control group (i.e., whether their usage of problem solving strategies differs according to their achievement levels or not) were investigated. In this context the following research question was posed: "Is there any significant difference between the usage of problem solving strategies of the student teachers at strategy and control groups according to their achievement levels?"

2. METHOD

2.1. Participants

The participants of this study consisted of 73 second-grade student teachers (Strategy Group, n=37, 21 male and 16 female; Control Group, n=36, 11 male and 25 female) who are students of Department of Elementary Mathematics Education of Faculty of Education in at Dokuz Eylül University in Izmir (Turkey). Department of Elementary Mathematics Education students are randomly separated to sections as section A and B. All the participants who enrolled Physics I course (a fall semester course) were included in this study.

2.2. Research Design

In this study, pretest-posttest quasi-experimental design with equivalent control group was used. There were one control and one experimental group, namely, the strategy group. Since the classes were equivalent, they were assigned by lottery to the strategy and the control groups. The strategy group received strategy plus traditional

instruction and the control group received only traditional instruction (i.e., without the strategy instruction emphasis). Both groups were tested before and after the intervention to measure their physics achievement, and problem solving strategy use.

2.3. Data Collection

The data of the research was collected by Physics Achievement Test (PAT) and Physics Problem Solving Strategies Scale (PPSSS). These measuring instruments were explained in detail below.

Physics Achievement Test (PAT): In the study, in order to determine the students' physics achievement, PAT developed by the researchers was used. The PAT contains 37 five-option, multiple-choice questions. The test was intended to determine the knowledge of the students related to the fundamental concepts, and their skills on recalling the relationships between the concepts, and applying them to the problems. The Kuder-Richardson reliability of the test was found as 0.77.

Physics Problem Solving Strategies Scale (PPSSS): This scale was developed for determining problem solving strategies of student teachers used in physics courses during solving physics problems. Scale contains 5 options of "Always", "Often", "Sometimes", "Rarely" and "Never" with Likert-type items. Items in the scale are grouped in 10 dimensions and can explain 53 % of total variance. The names, number of items and Cronbach's Alpha (α) of the dimensions are as follows: Forward Strategy, 10 items, α: 0.81; Organizing Problem, 4 items, α:0.67; Attention Strategy, 5 items, α:0.73; Planning, 5 items, α:0.66; Visualization, 4 items, α:0.63; Estimating, 5 items, α:0.67; Analogy, 4 items, α:0.70; Self Monitoring, 4 items, α:0.72; Checking, 4 items, α:0.78; and Self Evaluation, 6 items, α:0.83. The items of the scale were numbered as 5, 4, 3, 2, and 1 starting from Always to Never (maximum score=255, and minimum score=51). The Cronbach's Alpha reliability coefficient belonging to general PPSSS scale is 0.94.

2.4. Procedure

The study was conducted during the fall semester in fundamental Physics I course. The duration of the study was six weeks from September to November. Pretest measures of physics achievement, and strategy use were collected in the first week of the fall semester. During the intervention, the strategy group received explicit problem solving strategy plus traditional instruction in whole-class format for four lesson hours (45-minute) a week. Before starting treatment of the subjects planned for education, training was given on problem solving strategy which is acronym UQAPAC+SE (Understanding the Problem, Qualitative Analyzing of the Problem, Solution Plan for the Problem, Applying the Solution Plan, Controlling + Self Evaluation) in the process of research. This strategy presents the implicit problem solving strategies used by the experts in a stepped structure explicitly in order to provide the novices' problem solving approaches to become as good as the approaches of more expert problem solvers. During instruction of this problem solving strategy, instructions were distributed for giving information on the stated strategies and usage/usages of them including the special problem solving strategies. During the experiment, the same problems were solved with the subjects in both groups, however, the subjects in the strategy group

studied on *Problem Solving Sheets* which support the strategy usage at problem solving. The strategy and traditional instruction implemented by the first researcher who is expert in the field of physics education.

2.5. Analysis of Data

The collected data from the PAT and PPSSS were analyzed by SPSS, 13.0 versions. Kruskal Wallis H-Test and Mann Whitney U-Test for Independent Samples were employed. All statistical tests reported in this paper were conducted with a significance level of $\alpha = 0.05$.

3. RESULTS

In order to examine the relations between achievement level and strategy use of student teachers, as a first step, Physics Achievement Test (PAT) points were classified. Minimum point taken from (PAT) used in the study was 0 and the maximum point was 37. Regarding this point range, the following criterion was applied while grouping the student teachers according to their achievement levels: The student teachers who got "0-18 points" from PAT were defined as "low achievers", while the student teachers who got "19-37 points" were defined as "high achievers". As a second step, when the frequency distributions were examined according to the pre-test scores which the student teachers in strategy and control groups got from PAT, it was seen that all of the student teachers were "low achievers", and since these groups were not convenient according to the criterion, then, the correlation between the achievement level and strategy usage according to the pre-test results was not investigated. Then, frequency distribution was done with respect to points of the student teachers in strategy and control groups from PAT post measurements. Since convenient groups according to the criteria specified before at the beginning were obtained according to the post test scores (see Table 1), the comparisons were done according to the post measurements.

Table 1 The Distribution of Participants According to Achievement Level and Groups

Achievement	Strategy Group		Control Group		
Groups	n	%	n	%	Total
Low	9	24	24	67	33
High	28	76	12	33	40
Total	37	51	36	49	73

Note: *n:* number of participants in groups; *%:* percentage of participants in groups

The results of Kruskal Wallis H Test applied to test whether there was a significant difference or not between the score averages which student teachers existing in strategy and control groups obtained from the general PPSSS scale according to the high and low achievement levels were presented at Table 2.

Table 2 Kruskal Wallis H Test Results According to PPSSS Scores of High and Low Achiever Student Teachers in Strategy and Control Group

	Groups	n	Mean Rank	df	X^2	p value	Significant Difference
PPSSS	SGL	9	26.39	3	13.60	0.00*	SGH-SGL SGH-CGL, CGH-CGL
	SGH	28	45.41				
	CGL	24	27.13				
	CGH	12	45.08				

Note: *$p<0.05$; SGL: Strategy Group Low; SGH: Strategy Group High; CGL: Control Group Low; CGH: Control Group High

In Table 2, from results of Kruskal Wallis H Test, it was found that there is a significant difference among achievement levels of the student teachers statistically [$\chi^2(3)=13.44$, $p<0.05$]. When the mean ranks of the groups were taken into consideration, it was determined that the highest mean rank was in SGH (45.41) and CGH groups (45.08), and the lowest mean rank was in CGL (27.13) and SGL (26.39) groups. As a result of the Mann Whitney U-Tests done within pair combinations of the group to determine the cause of the significant difference observed between the groups, it was found that the difference between the problem solving strategies usages was significantly different for the student teachers in SGH group than the student teachers in SGL and CGL groups, and for the student teachers in CGH group than the student teachers in CGL group ($p<0.05$).

The results of Kruskal Wallis H Test applied to test whether there was a significant difference or not between the score averages which student teachers existing in strategy and control groups obtained from each sub-dimension of PPSSS scale according to the high and low achievement levels were presented at Table 3.

Table 3 Kruskal Wallis H Test Results According to PPSSS Sub Scale Scores of High and Low Achiever Student Teachers in Strategy and Control Group

Sub Scales of PPSSS	Groups	n	Mean Rank	df	X^2	p value	Significant Difference
Forward Strategy	SGL	9	28.56	3	7.99	0.04*	SGH-CGL
	SGH	28	43.82				
	CGL	24	29.63				
	CGH	12	42.17				
Organizing Problem	SGL	9	34.11	3	12.33	0.00*	SGH-CGL, CGH-CGL
	SGH	28	43.52				
	CGL	24	25.69				
	CGH	12	46.58				

Attention Strategy	SGL	9	34.44	3	5.98	0.11	No Sign. Diff.
	SGH	28	44.25				
	CGL	24	30.21				
	CGH	12	35.58				
Planning	SGL	9	24.83	3	10.20	0.02*	SGH-SGL, SGH-CGL
	SGH	28	45.16				
	CGL	24	30.06				
	CGH	12	40.96				
Visualization	SGL	9	26.44	3	9.58	0.02*	SGH-SGL, SGH-CGL
	SGH	28	44.55				
	CGL	24	29.65				
	CGH	12	42.00				
Estimating	SGL	9	33.67	3	6.40	0.09	No Sign. Diff.
	SGH	28	43.25				
	CGL	24	29.15				
	CGH	12	40.63				
Analogy	SGL	9	30.78	3	4.43	0.22	No Sign. Diff.
	SGH	28	40.21				
	CGL	24	31.83				
	CGH	12	44.50				
Self Monitoring	SGL	9	31.06	3	2.55	0.46	No Sign. Diff.
	SGH	28	39.61				
	CGL	24	33.58				
	CGH	12	42.21				
Checking	SGL	9	23.61	3	4.61	0.20	No Sign. Diff.
	SGH	28	39.64				
	CGL	24	36.79				
	CGH	12	41.29				
Self Evaluation	SGL	9	23.83	3	11.65	0.01*	SGH-SGL, CGH-SGL, SGH-CGL, CGH-CGL
	SGH	28	44.00				
	CGL	24	29.44				
	CGH	12	45.67				

Note: *$p<0.05$; SGL: Strategy Group Low; SGH: Strategy Group High; CGL: Control Group Low; CGH: Control Group High

As the findings obtained at Table 3 were examined, it was found that there was no significant difference in the problem solving strategies usages of high and low achiever student teachers in strategy and control groups in dimensions of Attention Strategy (X^2=5.98, p>0.05), Estimating (X^2=6.40, p>0.05), Analogy (X^2=4.43, p>0.05), Self Monitoring (X^2=2.55, p>0.05) and Checking (X^2=4.61, p>0.05); how-

ever, they had significant difference in dimensions of Forward Strategy (X^2=7.99, p<0.05), Organizing Problem (X^2=12.33, p<0.05), Planning (X^2=10.20, p<0.05), Visualization (X^2=9.58, p<0.05) and Self Evaluation (X^2=11.65, p<0.05). When the mean ranks of the dimensions where significant difference exist were taken into consideration, it was seen that in Forward Strategy, Planning and Visualization dimensions, similarly the highest mean rank was in SGH group (respectively 43.82; 45.16; 44.55), and the lowest mean rank was in SGL (respectively 28.56; 24.83; 26.44) group; in Organizing Problem dimension, the highest mean rank was in CGH group (46.58), and the lowest mean rank was in CGL group (25.69); and in Self Evaluation dimension, the highest mean rank was in CGH group (45.67), and the lowest mean rank was in SGL group (23.83). As a result of the Mann Whitney U-Tests done within pair combinations of each sub-dimension to determine the cause of the significant difference in Forward Strategy, Organizing Problem, Planning, Visualization and Self Evaluation dimensions, it was found that the student teachers in SGH group used Forward Strategy significantly more often than the student teachers in CGL groups, and the student teachers in SGH and CGH groups used the Organizing Problem strategy significantly more often than the student teachers in CGL group, and similarly the student teachers in SGH group used Planning and Visualization strategies significantly more often than the student teachers in SGL and CGL groups, and finally the student teachers in SGH and CGH groups used the Self Evaluation strategy significantly more often than the student teachers in both SGL and CGL groups.

4. DISCUSSION

From the findings of this research, it can be concluded that there were significant differences between the problem solving strategies usages of high and low achiever student teachers in strategy and control groups. This result is consistent with the results of the research done in our country and abroad showing that there was a correlation between the strategy usages of the students and their academic achievements, and that the strategy usage affected the achievement level (Camahalan, 2006; Gök, 2006; Johnson & Stewart, 2002; Lang, Mastropieri, Scruggs, & Porter, 2004; Patrick, Ryan, & Pintrich, 1999; Sarıtaş, 2002; Selçuk, et al., 2006). According to the results of the analysis, it was determined that the problem solving strategies usages of high and low achiever student teachers in strategy and control groups differed significantly according to the general PPSSS scale. It can be concluded that the highest mean ranks were in SGH and CGH groups, and there were significant differences between these groups and unsuccessful groups; however when we take into consideration that the SGH group had the highest mean rank, it can be concluded that the most strategy usage belongs to the high achiever group who had the strategy instruction, and both high achiever groups used significantly more strategies than the low achiever groups. The reason of being closer of the strategy usage in CGH group to the SGH group can be explained as often usage of the problem solving strategies naturally by a few number of high achiever student teachers in this group. In this context, the significant difference between the strategy usages of CGH group

who were not instructed any strategy instruction and the CGL group can be interpreted as the natural result of being a high achiever group for CGH group. It was determined that the problem solving strategies usages of high and low achiever student teachers in strategy and control groups did not differ significantly in Attention Strategy, Estimating, Analogy, Self Monitoring and Checking sub-scales of PPSSS scale; but differed significantly in Forward Strategy, Organizing Problem, Planning, Visualization and Self Evaluation sub-scales. These strategies where difference exists are presented as the strategies used by the expert (well) problem solvers in many researches in field literature (for instance: Chi et al., 1981; Larkin et al., 1980; Reif & Heller, 1982). When the groups which constitute significant differences in all subscales where difference exists were taken into consideration, it was determined that the student teachers in SGH and CGH groups used the problem solving strategies significantly more than the student teachers in SGL and CGL groups. From these findings, it can be said that the high achiever student teachers used the strategies used by the expert problem solvers more than the low achievers, and there was a significant correlation between the achievement level and the strategy usage in these dimensions. However, when the mean ranks in the dimensions where the difference does not exist were taken into consideration, then it was determined again that usage of these strategies were more in high achiever SGH (in Attention Strategy and Estimating strategies) and CGH (in Analogy, Self Monitoring and Checking strategies) groups. The most fundamental way to achieve in physics which is one of the areas where the problem solving is densest is being a well problem solver. And the most important factor in being a well problem solver is to use the efficient problem solving strategies (Selçuk et al., 2006). From this point, it can be said that being the strategy usages of the high achiever student teachers more than the low achievers in all sub-scales was an expected result of the research. It was determined that the highest mean ranks in Organizing Problem and Self Evaluation sub-scales were in CGH group, and SGH group followed this with the close mean ranks. Being used of these strategies less in SGH group even with a small difference can be explained as the high achiever student teachers in strategy instruction group could not internalize these strategies so much within a six week period, and the instruction could not be effective in these two dimensions in desired level within this period. When it was considered that the SGH group had the highest mean rank in Forward Strategy, Planning and Visualization sub-dimensions, it can be concluded that the high achiever group where the strategy instruction was done used these strategies especially used by the expert, in other words successful problem solvers very often significantly more than SGL and CGL groups, and not significantly, but slightly more than CGH group. And from this point, it is thought that applying such kinds of strategy programs could be useful for the student teachers to use the efficient problem solving strategies.

5. RECOMMENDATIONS

Following recommendations may be suggested with respect to results obtained from the study:

1. More studies should be done in different fields on relations between usage of problem solving strategies and different variables of strategy usage (i.e. age, sex, achievement, class level, socio-economic and socio-cultural level, graduated school).
2. Relations of strategy usage with achievement should be conducted with different groups and in different subject areas.
3. It is strongly recommended that physics instructors should use explicit learning strategy instruction in their lessons to develop students' problem solving skills and the related outcomes such as course achievement.
4. Research is needed in different educational settings to determine the effects of strategy instruction on different learning outcomes (e.g. self-efficacy beliefs, learning satisfaction and motivation to learning).

6. REFERENCES

Camahalan, F. M. G. (2006). Effects of self-regulated learning on mathematics achievement of selected Southeast Asian children. *Journal of Instructional Psychology*. *33* (3).

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and Representation of physics problems by experts and novices. *Cognitive Science, 5*, 121-152.

Çalışkan, S., Selçuk, G. S., & Erol M. (2006). Evaluation of problem solving behaviors of physics teacher candidates. *Hacettepe University Journal of Education*, *30*, 73-81

Gick, M. L. (1986). Problem-solving strategies. *Educational Psychologist, 21* (1&2), 99-120.

Gök, T. (2006). The effects of problem-solving strategies on students' achievement, achievement motivation and attitude in the cooperative learning groups in physics teaching. Dissertation, Dokuz Eylül University, Turkey.

Huffman, D. (1997). Effect of explicit problem solving instruction on high school students' problem solving performance and conceptual understanding of physics. *Journal of Research in Science Teaching, 34*, 551-570.

Johnson, S.K., & Stewart, J. (2002). Revising and assessing explanatory models in a high school genetics class: a comparison of unsuccessful and successful performance. *Science Education,* 86, 4, 463-480.

Lang C. R., Mastropieri, M. A., Scruggs T. E., & Porter, M. (2004). The effects of self-ınstructional strategies on problem solving in algebra for students with special needs. *Advances in Learning and Behavioral Disabilities, 17*, 29-54.

Larkin, J. H., McDermott, J., Simon, D. P., & Simon, H. A. (1980). Expert and novice performance in solving physics problems. *Science, 208*, 1335-1342.

Larkin, J. H., & Reif, F. (1979). Understanding and teaching problem solving in physics. *European Journal of Science Education, 1*, 191-203.

Mestre, J. P., Dufresne, R. J., Gerace, W. J., Hardiman, P. T., & Touger, J. S. (1993). Promoting skilled problem-solving behavior among beginning physics students. *Journal of Research in Science Teaching*, *30* (3), 303-317.

Patrick, H., Ryan, A. M., & Pintrich, P. (1999). The differential impact of extrinsic and mastery goal orientations on males' and females' self regulated learning. *Learning and Individual Differences*, *11* (2), 153-171.

Sarıtaş, E. (2002). The learning strategies, attitudes and performance levels of succesfull and unsuccesfull problem solvers in cooperative and traditional classes. Dissertation, Dokuz Eylül University, Turkey.

Selçuk, G. S., Çalışkan, S., & Erol, M. (2006). Use of problem solving strategies and physics success. *Çağdaş Eğitim Dergisi*, *334*, 15-23.

Selçuk, G. S., Çalışkan, S., & Erol, M. (2007). The effects of gender and grade levels on Turkish physics teacher candidates' problem solving strategies. *Journal of Turkish Science Education (TUSED)*, *4* (1), 92-100.

Woolfolk, A. (1993). *Educational psychology*. (5th Edition). USA: Allyn and Bacon.

EXAMPLES OF ACTIVITIES PREPARED BY THE TECHNOLOGICALY-SUPPORTED MIND MAPPING AND CONCEPT MAPPING TECHNIQUES, WHICH ARE BASED ON THE CONSTRUCTIVIST APPROACH*

Ali Günay BALIM**, Sabriye Nihan TAŞKOYAN**, Esra ÖZGÜDER**,
Güliz AYDIN**, Suat TÜRKOĞUZ**, Didem İNEL**,
Ertuğ EVREKLİ**, Sema BENLİ**

*This study is supported by 106K093 numbered TUBITAK Project.

**Dokuz Eylul University, Buca Faculty of Education,
Demartment of Science Education, Buca – Izmir / TURKEY
E-mail: <agunay.balim@deu.edu.tr>

▼ Abstract

Learning techniques, which are based on the constructivist approach, give an opportunity for students to construct their knowledge by enabling the active participation. Mind mapping and concept mapping are the examples about the so-called techniques. Concept mapping is considered as a technique utilizing students to construct concepts and their relations with each other. Through the use of the mind mapping technique, students can not only construct concepts but also use both lobs of the brain for a permanent learning.This study includes concept maps and mind maps, which are prepared in computer environment, for the unit of "Light and Sound" in the the 6th grade Science and Technology Curriculum. There are also suggestions on the objectives of using this technique in the lessons, as well as important tips on preparing the maps.

Key Words Constructivist approach, concept maps, mind maps

1. INTRODUCTION

The education system has to keep up with the rapid development of the technology and information age. The main objective of the education and teaching process is not directly giving information to the students anymore, but teaching them find ways to access information and construct it by themselves. Several learning approaches and models have been developed by researches to fulfill this goal so far. One of those is the constructivist approach.

Constructivist approach has been developed as an alternative method to the existing traditional theories (behavioral and cognitive) and to meet the needs of the technology and information age. This approach mainly focuses on the experiences that the student gains through life. When people face some sort of real life experience,

they construct knowledge in their minds, which means knowledge should be experienced in person and compared in daily life so that it can be learned (İşman et al., 2002, quoting from İşman, 1999).

As for the constructivist approach, the individual constructs knowledge through his/her own experience, observation, comment, and mental thinking processes. Learners actively construct new knowledge by making use of their existing knowledge and experiences (Windschilt, 2002).

Constructivism is an approach on how knowledge is acquired. It is also quite successfull in comprehending and commenting on the learning-teaching experiences. The principles put forward by the constructivist approach give important clues on what can be done to develop more effective teaching methods and techniques.

The objective of the Science and Technology course is the students' understanding of the concepts and correlating them with the natural events which surround themselves. Therefore, the mind and concept maps, on which the mental constructions and organizations are shown, are significant as being tools that support the constructivist approach.

1.1 Mind Maps

Mind maps schematize the knowledge with figures, pictures or symbols to enable the knowledge transfer among the brain cells. The schematization of the knowledge helps the relations among the thoughts be better comprehended. The purpose of the schematization of knowledge, in other words, formation of the visual learning is to clarify thoughts, empower comprehension, incorporate relations with the new knowledge, correct the misconceptions, accelerate recalling and make the student construct knowledge in a plot that supports the constructivist approach (Kalaycı, 2001).

Mind mapping is a free-thinking technique which renders the correlation of thoughts and information possible and it contributes to meaningful learning when used within the constructivist approach. Both the teacher and the learner can improve their learning skills and exploit their imagination more freely through mind mapping technique (Derelioğlu, 2005). It is considered that with the help of these maps, the right and left lobes of the brain are used concurrently, thus, the brain is used more effectively. These maps are tools which enable us to fulfill the naturally-large potential of the brain easily and use these elements at the same time (Yalın, 2004).

As it has been realised that the visual presentation of the knowledge is important, some software suitable for the learning and teaching techniques has recently been developed. One of them is the "Mind Manager" software which enables the implementation of the mind mapping technique. With the help of this software, the students can freely schematize their knowledge on a given subject and give meaning to it with the pictures, images or symbols from the program's library or internet. This program enables to form mind maps in the computer environment. The expressions, emoticons or interesting images in the software make it easier to recall the knowledge without difficulty.

1.2 Concept Maps

Constructing the new knowledge by incorporating it into what students already know and thus accessing the new knowledge is the basis of the Science and Technology Curriculum. Students should be provided the environments in which they can use their cognitive abilities and compare their previous knowledge with the new. One of the bi-dimensional learning and teaching techniques, the mind mapping, the learners have the opportunity to compare the new concepts they have learned to their present knowledge and correlate them with each other within the same environment. Concept mapping is a technique creating permanent learning in the students' visual comprehension of the subjects. The aim of the concept maps is both presenting the knowledge in an organized way and providing the knowledge to be organized in the mental processes of the individual (Aykanat, Doğru and Kalender, 2005, quoting Kinchin, 2002).

Concept mapping utilizes the students' seeing and comprehending relations among the concepts. On the concept map, the concepts are linked to each other by means of lines that represent the relation (Çavaş and Pekmez, 2001). From the aspect of utilizing the meaningful learning as it shows the students clearly which concept is related to which one, the concept map is an effective technique (Köseoğlu et al., 2003). Concept maps are tools used to realize the meaningful learning and help knowledge be kept in the long term memory because the storage of knowledge in a specifically organized way is a cognitive process which plays a part in recalling (Öztürk and Karayağız, 2006).

Applicability of the concept maps in learning and teaching science subjects, organisation of the curriculum and evaluation of information through construction are approved by many researchers. Despite this fact, researchers expressed that the concept maps prepared with pencil and paper have some limitations. Considering the functions of the computer, many instructors believe that the computer technology is the potential solution to the limitations of the concept maps prepared with pencil and paper (Aykanat, Doğru and Kalender, 2005, quoting from Tsai, Lin and Yuan, 2001).

Several software to transfer a concept map, a technique enabling the visual representation of knowledge, into the computer environment has been developed and presented to the users. The "Inspiration" is one of the most commonly used programs among these softwares. The "Inspiration" is a powerful learning tool which enables the students form their impressions and ideas visually / graphically on a subject. Concepts and ideas can be expressed with the help of various pictures, images or figures via the library of the "Inspiration" Program. It is thought that students will be able to keep the knowledge related to the concepts in their minds much longer (Çavaş and Pekmez, 2001).

The "Inspiration" Program is a convenient tool for brainstorming, planning, organizing, preparation, making drafts, drawing pictures, preparing concept maps and transition to the web environment. The "Inspiration" Program not only meets all the expectations in preparing a concept map, but also embodies a lot of facilities as in developing creativity both for the beginners and advanced users. Besides the image,

figure, picture, emoticon library of the program, the user can also create his/her library. One of the most useful features of the program is that it uses two kinds of presentation. The concepts on the concept map, which has been prepared in the form of a scheme, and the relations with each other, can also be viewed as a draft, which is in the form of an enumerated list, if needed and vice versa, the enumerated concepts can be transformed into a scheme. Another user-friendly feature of the program is that it enables adding explanatory notes for each figure or symbol on the scheme if necessary and later these can be viewed in the form a list.

2. METHOD

This is a descriptive study in that it embodies information regarding the constructivist approach and the mind and concept maps that are in compliance with the constructivist approach. Besides, the study includes mind maps prepared with the Mind Manager Program and concept maps with the Inspiration Program in the computer environment. These mind and concept maps have been prepared by focusing on the acquisitions of the unit "Light and Sound" in the 6th grade Science and Technology Curriculum. The mind and concept maps have been prepared by focusing on the inclusion of the basic concepts within the content of the subject, taking the students' constructing the concepts better as the basis. For this, the unit has been analyzed in two dimensions, thus two different mind and concept maps have been prepared in the frame of two main concepts, "Light" and "Sound".

Following are the examples of mind and concept maps as to the subjects "Light" and "Sound" respectively.

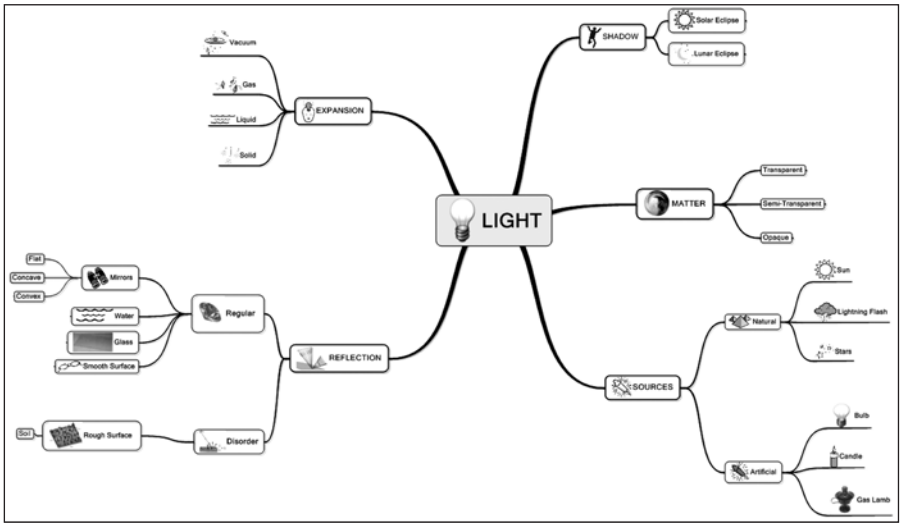


Figure 1 Mind Map Example Prepared as to the Concept "Light".

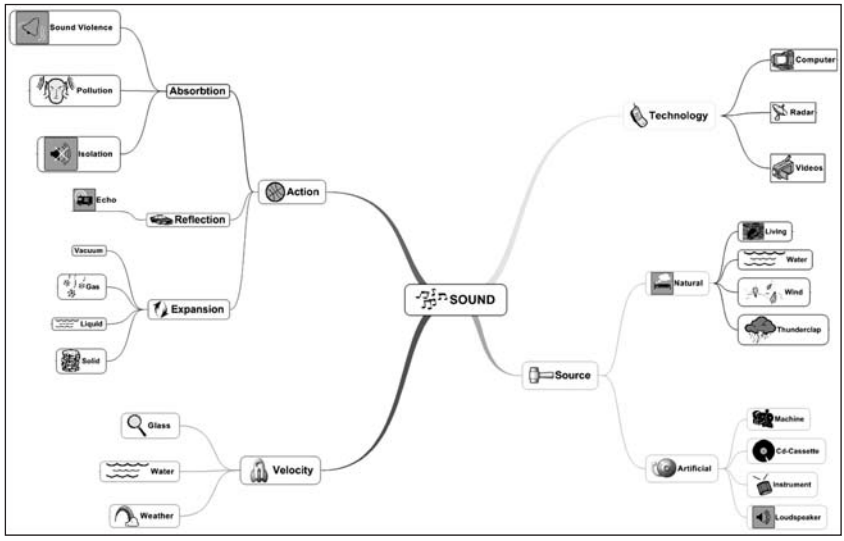


Figure 2 Mind Map Example Prepared as to the Concept "Sound".

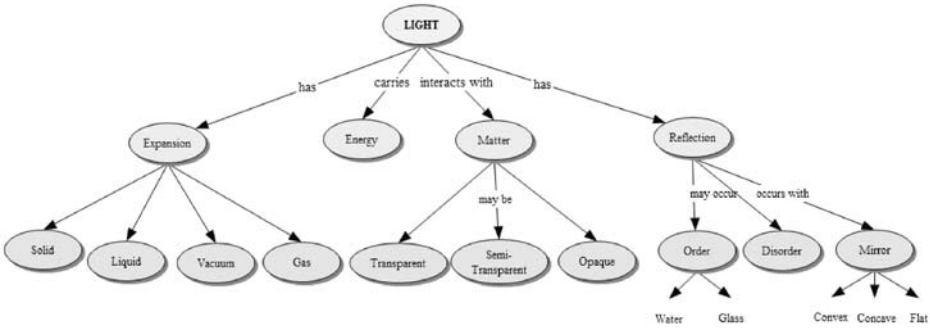


Figure 3 Concept Map Example Prepared as to the Concept "Light".

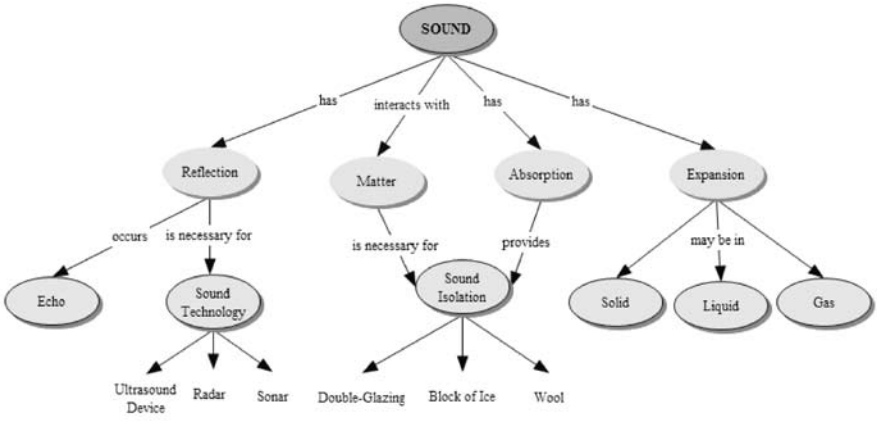


Figure 4 Concept Map Example Prepared as to the Concept "Sound".

3. CONCLUSION

It is thought that technologically-supported mind and concept maps about "Light and Sound" are useful in realizing the meaningful learning and elevating the student-engagement and motivation in the lessons. By making use of technologically-supported mind and concept mapping techniques in the lessons, the teachers can guide their students to construct their own knowledge while learnign the new concepts.

Following are the suggestions on the usage of the mind and concept maps for the teachers of Science and Technology course.

1. Mind and concept maps can be used at the beginning of the units with the purpose of examining the students' pre-knowledge on the subject and identifying any possible misconceptions.
2. The students can be asked to prepare mind and concept maps at home and unite them in groups in the class. Thus students can find the chance to study cooperatively in the frame of a constructivist learning and this will make it easier for teachers to diagnose any possible misconceptions or specify what knowledge the student's lack.
3. The students can be asked to add the concepts they have learned during the teaching process onto the mind and concept maps they have prepared by hand at the beginning, thus it can be easily checked out how they correlate the concepts and construct them.
4. The students' learning or not learning of the subject can be diagnosed by making them prepare mind and concept maps or asking them to fill in the blanks on the mind and concept maps with some certain concepts given.
5. The students can be helped to discover their creativity by asking them to reconstruct the mind and concept maps they have already prepared by hand in the computer environment again. Thus, they are given the chance to construct their own knowledge.

4. REFERENCES

Aykanat, F., Doğru, M. and Kalender, S. (2005). Bilgisayar Destekli Kavram Haritaları Yöntemiyle Fen Öğretiminin Öğrenci Başarısına Etkisi. **Journal of Kastamonu Education**, 13, 391-400.

Baki, A. and Şahin, M. S. (2003). Bilgisayar Destekli Kavram Haritası Yöntemiyle Öğretmen Adaylarının Matematiksel Öğrenmelerinin Değerlendirilmesi. **The Turkish Online Journal of Educational Technology**, 3 (2).

Çavaş, B and Pekmez, E. Ş. (2001). **Fen Eğitiminde Kavram Haritaları ve İnspiration Programı Uygulamaları**. Maltepe University, Science Education Symposium, İstanbul.

Derelioğlu, Y. (2005). **Hayat Bilgisi ve Sosyal Bilgiler Öğretimi Dersinde Akıl Haritasının Kullanımı.** Good Examples in Education Conference, İstanbul.

Kalaycı, N. (2001). **İki Boyutlu Görsel Öğrenme ve Öğretme Araçları.** 10th National Educational Science Congress. Abant İzzet Baysal University.

Köseoğlu, F., Atasoy, B., Kavak, N., Akkuş, H., Budak, E., Tümay, H., Kadayıfçı, H. and Taşdelen, U. (2003). **Yapılandırıcı Öğrenme Ortamı İçin Bir Fen Ders Kitabı Nasıl Olmalı?** Ankara: Asil Publishing.

İşman, A., Baytekin, Ç., Balkan, F., Horzum, M. B., Kıyıcı, M. (2002). Fen Bilgisi Eğitimi and Yapısalcı Yaklaşım. **Turkish Online Journal of Educational Technology – TOJET**, 1–1(7).

Öztürk, C. and Karayağız, G. (2006). Teori İle Uygulama Arasında Yeni Bir Köprü: Kavram Haritası. *C.Ü.* **Journal of Nursing College**, 10(1).

Windschitl, M. (2002). **Framing Constructivism in Practise as the Negotiation of Dilemmas: An Analysis of Conceptual, Pedagogical, Cultural and Political Challenges Facing Teachers**. Review of Educatıonal Research.

Yalın, H. İ. (2004)**. Öğretim Teknolojileri ve Materyal Geliştirme.** İstanbul: Nobel Publishing and Distribution. 73.

PROSPECTIVE SCIENCE TEACHERS' PERCEPTIONS ABOUT PHYSICS LABORATORY ENVIRONMENT

Halil Turgut, M. Kürsad Duru
Marmara University, Department of Science Education, Turkey
halil.turgut@marmara.edu.tr, kursad.duru@marmara.edu.tr

▼ Abstract

The science laboratory should be defined as a setting in which students work cooperatively in small groups, investigate phenomena and have the chance of enhancing constructive social relationships as well as positive attitudes, cognitive growth. So having a valid source of information regarding the interactions, manipulation opportunities and physical environment in laboratories and assessing students' perceptions of the laboratory learning environment is important. The purpose of the study was to examine prospective science teachers' perceptions of the laboratory learning environment at the beginning and end of a three years period in faculty. Quantitative research methodologies were use with a one group pretest-posttest design. Forty-six prospective science teachers of 20 female and 26 male were participated in this study during 2005-06 and 2007-2008 school years. To determine the prospective science teachers' conceptualizations about the learning environment in laboratories, the Science Laboratory Environment Inventory (SLEI) questionnaire was used. The results of this study show that prospective science teachers perceived physics laboratory environment generally positively except at dimension of "open endedness". They believe that they could work with their classmate cohesively in laboratory, the rules they must obey were defined and presented clearly and the experiments they performed were integrated successfully with the content of related lessons. In order to develop more positive perceptions about physics laboratory activities in laboratory should be designed to be more open ended by taking into consideration the limitations of time and equipments.

Key Words Physics Laboratory Environment, Prospective science teachers

1. INTRODUCTION

The science laboratory should be defined as a setting in which students work cooperatively in small groups and investigate phenomena (Hofstein, 2004) and in such a laboratory setting students would have the chance of enhancing constructive social relationships as well as positive attitudes, cognitive growth (Lazarowitz, Tamir, 1994). So laboratory activities have a central role in the science curriculum and science educators have suggested that students engaging science laboratory activities had many benefits (Hofstein & Lunetta, 2004).

Tobin (1990) suggested that when students had the opportunity to manipulate equipments and materials in such an environment which is suitable to construct their knowledge of phenomena and related scientific concepts, meaningful learning is possible but he also claimed that such opportunities were not offered in school science in general. That claim makes having a valid source of information regarding the interactions, manipulation opportunities, physical environment and etc. in laboratories and assessing students' perceptions of the laboratory learning environment important (Hofstein, 2004).

A group of science educators in Australia had firstly focused on that need of assessing students' perceptions in the science laboratory (Fraser, McRobbie, & Giddings, 1993) and developed an instrument called *Science Laboratory Environment Inventory* (SLEI). SLEI, was found to be sensitive to different approaches to laboratory work (Fisher, Harrison, Henderson, & Hofstein, 1999), had been used in several studies and also in this research.

This study was conducted to assess students' perceptions of the laboratory learning environment at the beginning and end of a three years period in faculty. The main questions of the investigation were:

1. Had the prospective science teachers' perceptions about physics laboratory environment changed during their three years of experience in faculty? If yes, in what ways?
2. Were there any significant differences between prospective science teachers' first perceptions about physics laboratory environment according to gender?
3. Were there any significant differences in the development of prospective science teachers' perceptions about physics laboratory environment during their three years of experience in faculty according to gender?

2. METHODOLOGY

The present study made use of a quantitative research methodology with a one group pretest-posttest design that it was attempted to examine the prospective science teachers' conceptions about physics laboratory environment at the beginning and end of a three years period in faculty.

2.1. Participants and Course Context

Forty-six prospective science teachers of 20 female and 26 male were participated in this study during 2005-06 and 2007-2008 school years. The participants were enrolled Physics I (mechanics) Lab, Physics II (electricity and magnetism) Lab and Science (optics and fluids) Lab and were taught by the same instructor, two hours a week for a period of twelve weeks in each semester. The content of Physics I and II Labs were directly related with Physics I and II courses and participants made use of theoretical knowledge presented to them in those courses whereas experiments in Science Lab were chosen from elementary science courses. At the beginning of each laboratory, participants were given a guiding paper including information about materials, theoretical background about experiments, how to conduct the experiments, gather data

and tables, graphics that must be prepared. Experiments were conducted by participants in groups of five according to those papers and they also had the opportunity of asking help from the instructor. After the experiments performed participants wrote reports individually in which they placed the data, calculations, graphics, tables, results and a conclusion they constructed on those.

2.2. Data Sources and Analysis

To determine the prospective science teachers' conceptualizations about the learning environment in laboratories, the Science Laboratory Environment Inventory (SLEI) questionnaire was used. SLEI which was developed and tested internationally by Fraser, Giddings and McRobbie (1993), had two forms of (1) actual and (2) preferred in which students views of their actual laboratory environment and preferences in a laboratory setting were examined respectively. In this study the actual form of SLEI with 35 items was used with five different dimensions of (1) participant cohesiveness, (2) open-endedness, (3) integration, (4) rule clarity, and (5) material environment. This questionnaire is a five-point Likert-type scale including responses from "almost never" to "very often." The scores obtained in each dimension constitute the participants' perceptions of science lab environment for that dimension and high scores mean stronger perception. For example, a high score at he dimension of "rule clarity" means participants perceive science lab environment as a setting in which rules are clearly defined and presented.

The SLEI was adopted to Turkish for General Chemistry Laboratory by Doğan, Doğan, Atılgan, Batçıoğlu and Demirci (2002) and found to be reliable and valid for Turkish culture. The researchers mentioned that they performed factor analyze with varimax rotation and found that the dimensions and distributions of items to those dimensions of Turkish version of SLEI was the same as in original form. The cronbach-alpha scores for those dimensions were determined to be changing from 0.59 to 0.87 while 0.85 for the whole instrument. In this study the items of Turkish version of SLEI was modified to Physics Laboratory and administered to participants at the third week of 2005-06 fall semester as a pre-test and at the end of the 2007-08 fall semester as a post-test. Before pre-test, participants had conducted two different experiments in Phycis I lab. Hence pre-test results were thought as the indicators of prospective science teachers first conceptualizations about laboratory environment in university. The data derived by SLEI was analyzed statistically for each dimension and participants' pre-test and post-test scores were compared with SPSS 10.0.

3. FINDINGS

In order to evaluate the possible changes in prospective science teachers' perceptions about physics laboratory environment after three years of experience in faculty, comparisons were made between participants' pre-test and post-test scores with the use of paired sample t-test. The results are summarized below in Table 1.

Table 1 Participants' Pre-Test and Post-Test Scores Comparisons

Dimension		N	Mean	sd	T	df	Sig.
Participant Cohesiveness	Pre	46	3,78	,62	-1,17	45	,25
	Post	46	3,89	,48			
Open Endedness	Pre	46	2,56	,60	-,67	45	.51
	Post	46	2,64	,52			
Integration	Pre	46	3,70	,58	,10	45	.92
	Post	46	3,69	,50			
Rule Clarity	Pre	46	3,48	,50	-2.14	45	.04
	Post	46	3,67	,48			
Material Environment	Pre	46	3,47	,67	2,09	45	.04
	Post	46	3,26	,72			

Table 1 shows the comparisons of participants' mean scores on the five scales of the SLEI before and after three years of experience. It was seen that there were significantly meaningful differences between pre and post test scores of participants only at the "rule clarity" and "material environment" scales. At the "rule clarity" scale participants' mean scores were determined to be increased after three years of experience whereas at the "material environment" scale decreased. Participants tended to perceive physics lab environment as a setting where the rules which must be obeyed defined and presented more clearly as they had more experience in lab over time.

In order to determine any possible differences between prospective science teachers' first perceptions about physics laboratory environment according to gender, comparisons were made between participants' pre-test scores with the use of Mann-Whitney U tests. The results are summarized below in Table 2.

Table 2 Participants' Pre-Test Scores

Dimension	Gender	N	Mean Rank	Sum of Rank	Mann-Whitney U	Sig.
Participant Cohesiveness	Males	26	24,23	630,00	241,00	,67
	Females	20	22,55	451,00		
Open Endedness	Males	26	27,87	724,50	146,50	,01
	Females	20	17,83	356,50		
Integration	Males	26	24,83	645,50	225,50	,44
	Females	20	21,77	435,50		
Rule Clarity	Males	26	23,88	621,00	250,00	,82
	Females	20	23,00	460,00		
Material Environment	Males	26	23,88	621,00	250,00	,82
	Females	20	23,00	460,00		

Table 2 shows the comparisons of participants' mean scores on the five scales of the SLEI for pre-test. It was seen that participants' perceptions about physics laboratory environment were not significantly different according to gender except at the dimension of "open endedness". At the dimension of "open endedness" male participants' perceptions about physics laboratory were determined to be stronger that they perceive science lab more open ended than females.

In order to evaluate any possible differences in the development of prospective science teachers' perceptions about physics laboratory environment during their three years of experience in faculty according to gender, comparisons were made between participants' pre-test and post-test scores with the use of analysis of covariance. The post test scores and corrected mean values of participants are given below in Table 3 and results are summarized in Table 4.

Table 3 Participants Post-Test Scores

Dimension	Gender	N	Mean	Corrected Mean
Participant Coherence	Male	26	3,86	3,857a
	Female	20	3,93	3,934a
Open Endedness	Male	26	2,72	2,722b
	Female	20	2,54	2,533b
Integration	Male	26	3,77	3,770c
	Female	20	3,58	3,588c
Rule Clarity	Male	26	3,64	3,642d
	Female	20	3,71	3,716d
Material Environment	Male	26	3,27	3,257e
	Female	20	3,26	3,274e

Table 4 ANCOVA Results According to Gender

Source	Type III Sum of Squares	Df	F	Sig.
Participant Coherence	1,23	1	5,95	,02
Gender	6,68	1	,32	,57
Open Endedness	1,17	1	,00	,95
Gender	,34	1	1,25	,27
Integration	,10	1	,39	,54
Gender	,37	1	1,44	,24
Rule Clarity	,46	1	1,99	,17
Gender	6,26	1	,28	,60
Material Environment	6,83	1	17,54	,00
Gender	3,26	1	,00	,93

Table 4 shows the ANCOVA results according to gender on the five scales of the SLEI for corrected post test mean scores which were given in Table 3. It was seen that changes

in participants' perceptions about physics laboratory environment during a three years of period were not significantly different according to gender at all five scales.

4. CONCLUSION AND IMPLICATIONS

The results of this study show that prospective science teachers perceived physics laboratory environment generally positively except at dimension of "open endedness". They believe that they could work with their classmate cohesively in laboratory, the rules they must obey were defined and presented clearly and the experiments they performed were integrated successfully with the content of related lessons. Although participants perceived the physical and material quality of physics laboratory environment acceptable, their post test scores were significantly lower than pre test scores. It was seen that participants had perceived the activities performed in physics laboratory more structured. The guiding papers given to them including information about materials, theoretical background about experiments, how to conduct the experiments, gather data and tables, graphics that must be prepared were thought to be the most important factor in that perception of participants. In order to develop more positive perceptions about physics laboratory activities in laboratory should be designed to be more open ended by taking into consideration the limitations of time and equipments. If required, the guiding papers should be prepared with less direction and participants should let be free to organize experiments themselves. They should be given opportunities to work freely in laboratory out of laboratory sessions.

REFERENCES

Fisher, D., Harrison, A., Henderson, D., & Hofstein, A. (1999). Laboratory Learning Environments and Practical Tasks in Senior Secondary Science Classes. Research in Science Education, 28, 353-363.

Fraser, B., McRobbie, C.J., & Giddings, G.J. (1993). Development and Cross-national Validation of a Laboratory Classroom Instrument for Senior High School Students. Science Education, 77, 1-24.

Hofstein, A. (2004). The Laboratory in Chemistry Education: Thirty Years of Experience with Developmets, Imlementation, and Research. Chemistry Education: Research and Practice, 5(3), 247-264.

Hofstein, A. & Lunetta, V, N. (2004). The Laboratory in Science Education: Foundation for the 21st Century. Science Education, 88, 28-54.

Lazarowitz, R. & Tamir, P. (1994). Research on Using Laboratory Instruction in Science, In D. L. Gabel (ed.), Handbook of Research on Science Teaching and Learning, pp. 94-130. New- York: Macmillan.

Tobin, K.G. (1990). Research on Science Laboratory Activities: In Pursuit of Better Questions and Answers to Improve Learning. School Science and Mathematics, 90, 403-418.

Doğan, D., Doğan, E., E., Atılgan, H., Batçıoğlu, K., & Demirci, B.(2002). Farklı Üniversitelerin Eğitim Fakültelerindeki Genel Kimya Laboratuvarı Sınıf Çevresinin Bazı Değişkenler Açısından Değerlendirilmesi, V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Ankara.

THE TEACHING OF SOCIOSCIENTIFIC ISSUES IN INTERDISCIPLINARITY BIOLOGY-PHILOSOPHY, AN ETHICAL STAKE AND CITIZENSHIP ISSUE

Saida Kacem, Laurence Simonneaux
Institution/Affiliation
44 Rue Sâad Ghrab, cite des journalistes 2083, La Gazelle, Tunisie
E-mail: <kamaresaida@yahoo.fr>

▼ Abstract

This research starts from a relatively optimistic thinking based on the fact that the teaching of the socioscientific issues through the practice of argued debates can contribute positively towards education in scientific citizenship.

The teaching of techno-sciences raises topical questions which interfere in the classroom and at the same time carry scientific and social controversies within which it is possible to anchor the construction of new knowledge and citizen's behaviours. These controversial issues raise more questions and motivate the pupils more. Setting these topics for debate in the classroom could " *restore, if only a little, what* Astolfi likes to call " *the taste of knowledge (savoirs)* " *since the two words [saveur and savoir] come from the same Greek root " sapere ", as* Astolfi, 2006, marvellously put it in the foreword to the recent book: *L'école à l'épreuve de l'actualité. Enseigner les questions socialement vives* (Legardez & Simonneaux 2006). The present contribution is research in progress. It questions a protocol of training of future teachers. The principal objective is to train the pre-service teachers to teach socioscientific issues (SSI). Like Funtowicz and Ravetz (1992, 1993), we think that the SSI belong to "Post-Normal-Science". Accordingly, we will study the contribution of the training in epistemic, social and ethical values in the analysis of socioscientific issues by biology and philosophy future teachers. We will analyze the evolution of teacher trainees' decision-making after training on 3 socioscientific issues (the oncomice, the baby drug, the therapeutic cloning) and the impact of this socioepistemologic and ethical training on their teaching practices.

Key Words SocioScientific Issues, "Post-Normal-Science ", Values, Citizenship

1. INTRODUCTION

The choices that our companies have and will have to make more and more, those to which the individuals are each day more closely confronted require that the education of the person and the citizen gives to each one the means of having its freedom. The democracy is at this price: without what the major decisions instead of being the business of all will be the privilege of some

How consequently teaching could conceal this task? How for example, the professor of biology which evokes with its pupils, within the framework of the program, the genetic diseases, the new capacity offered by the genetic engineering could it be unaware of the psychological impact and the moral stake of the training which it will give? Can it not indicate the individual and collective problems of choice and standards which are implied? On subjects where, very often, knowledge and the facts are the business of the only scientists, while the debate on the values is replaced by the juxtaposition of judgements of "religious or moral authorities" isn't there an invaluable lighting to bring?

But biology is not the only discipline where difficulties arise bioethic. The teacher of philosophy for example, which in its class would like to speak with its pupils about what to humanity can means to belong overlook the concepts of genetic inheritance, genetic practices of engineering? This brings us to the importance of this interdisciplinarity specific to the socioscientific questions in the ethical and citizen formation of learning.

2. METHODOLOGY

2.1. The preliminary study

A preliminary study with high school pupils in their final year enabled me to identify the opinions of the pupils on these technosciences and to see whether they base their positions on the scientific aspects or on values. The questionnaire used comprises a short presentation of the technosciences under study. The questions relate to:

- The legitimacy of research to produce oncomice.
- The animal on which they prefer that this experiment is made.
- The place of man in nature.
- The right to make a sorting among the embryos obtained by an IVF to choose a drug baby to cure a sick brother or sister.
- The research on therapeutic cloning.
- Life, its definition and the age when it starts in the human being.
- Who decides? Laws, or "organizations independent of the law: families, doctors, researchers, politicians, philosophers, economists, patients, religious authorities

2.2. The principal study

It related to pre-service teachers in biology (17) and philosophy (18) and comprises several collections of data. The following protocol was set up.

- Pretest on the technosciences: documents explaining the 3 selected technosciences were distributed to future teachers. After consultation and comments on these documents, the questionnaires were filled. These questionnaires aimed at knowing the opinions of future teachers concerning the selected technosciences, and at seeing whether they detected epistemic values and especially social and ethical values related to these knowledge under construction.

- Didactic Intervention: future teachers of philosophy and biology took part in a socioepistemologic and ethical training, followed by a debate on the 3 technosciences.
- Post test: To measure the impact of the socioepistemologic and ethical training, as well as the interaction between future teachers of philosophy and biology, on the quality of their ethical reasoning and citizenship.

3. RESULTS

The analysis of these questionnaires showed that: the opinions with respect to selected biotechnologies are not homogeneous. Both, the future teachers of philosophy and those of biology are very favourable to obtaining oncomice: 16/17 (94, 11%) for biology teachers and 17/18 (94, 44%) for philosophy teachers. They were a little less favourable to the drug baby (88 % for biology teachers and 61% for philosophy teachers were for it).

However, therapeutic cloning was the least accepted by these teachers (more teachers of biology accepted this technoscience with 76% against 61% (11/18) of futures teachers of philosophy). The future teachers of philosophy were more inclined to think that man is the Master of nature (44 or 44% against 23 or 53%). The future teachers of biology were more favourable to the laws than those of philosophy (89% against 77%). They were also in favour of stopping scientific research in certain fields for fear of misused discoveries (94, 12% against 61, 11%).

Areas of reference for arguments: We distinguished 4 categories of responses according to frames of reference of arguments, which are primarily of **ethical**, or **religious** nature, or connected to **risks** or **the status of science.**

For the ethical argumentation, this research used the method of ethical analysis used by Bayrhuber (1999). The analysis follows the two systems of fundamental justification of Western ethics, the naturalits reasoning (related to wellbeing) and the personalist reasoning (related to human dignity), which determine, according to Bayrhuber (1999), the public discussion on genetic engineering. Ethical analysis envisages various solutions to a moral problem. Bayrhuber, used it for the ethical analysis of the genetic therapy; we used it for other SSIs. What about justification systems in Tunisia?

Oncomice were accepted by the majority. Man is regarded as superior to all animals: " *Agreeing with any practice on animals for the good of humanity* ", " *man has much higher position compared to the other animals, one should never compare a man with an animal, which prevents finding solutions (drugs) to human diseases through experiments on the animal* " (B8), " *research on animals are necessary for obtaining anti-cancer treatments* " (B11)... Even when man is regarded as an element of nature, he is regarded as the most significant element, which explains the results concerning the oncomice. The future teachers who accepted the conception of the baby drug seemed to adhere to a naturalist ethical reasoning, related to the general wellbeing of those concerned, and with health: " *because it (the drug baby) will cure his/her brother* ". The future teachers who refused this practice adhered to a personalist reasoning

related to human dignity: «*Each of us is entitled to originality "the child must be conceived and wanted for itself and not like a drug* ".

Religious arguments were also brought in: *because we will not be Muslims, it is God who controls creation* ". Concerning **research on the therapeutic cloning,** future teachers who did not accept this practice argued that it affects human dignity. Those favourable to therapeutic cloning accepted it "*provided that the therapeutic cloning represents the only way for possible cure*". But, future teachers also used religious arguments. They opposed, in a dialectical way, various ethical and religious arguments which raise the question of the status of the embryo and the conception of life.

Life is defined primarily as of divine origin: *a gift from God,* a *Divine present, to be satisfied with what God gives us, a stage* (which presupposes another stage or life after death in reference to religion), but also like: "*a right*", "the *blooming of the individual*" (*happiness, the wellbeing of the man, health, or laws which makes it possible to live* or *a dogma to be deciphered).* Life starts essentially "*at the stage egg cell*". The human egg holds the absolute value of a person, an individual in power. This could be at the origin of the personalist moral reasoning. But life also starts *at 40 days when the individual receives his soul* (an animist conception but connected with the Islamic religion, the soul is given by God), or it starts with *the first beats of the heart*" (mechanism, cardiocentrism), or "*with breathing*" or "*as soon as his/her parents want to have the baby*". In this case, it is a project. But there is a real difficulty in defining this concept.

A certain perception of the risks but also **a scientist representation** of science **appeared** in the answers to the question: Who has to decide? For 82, 86 % of the future teachers, the laws must intervene in sharp questions: "*these subjects are really in vogue nowadays, we need laws to not mistreat the human being*". The laws should not intervene for 11, 43 % «*but in certain cases, they can be an obstacle for the evolution of science*» (B1); «*because it is necessary to leave the matter to people who deserve it, science is the field of the researchers.* The majority of pre-service teachers are in favour of organizations independent of the law pronouncing opinions (80%), which involves the necessary "extended community of peers" required by Post-Normal-Science. However the economic and political fields are ignored. All pre-service teachers and the pupils wished to continue activities of information and reflexion on the technosciences and found these subjects new and particularly interesting.

4. CONCLUSION

The first results show that these pupils and these pre-service teachers are very favourable to the oncomice considering the very significant and superior status they accord to the human being, but also because of cancer, which has been causing enormous devastation. The other technosciences are sometimes disputed but generally better accepted by the biologists. When they are accepted, it is because they are judged to be for the good of humanity, the general wellbeing and as a cure, which enters within the framework of the naturalist ethical reasoning. When these practices are rejected, it is for religious reasons or the need for the respect of human dignity, and thus on the grounds of personalist ethical reasoning. The majority is in favour of laws controlling these practices, they are anxious and especially fear the consequences in particular

in the case of the therapeutic cloning; but they are enthusiastic about the oncomice which on the one hand do not involve man and on the other promise to cure cancer. But the most anxious are the pre-service teachers of philosophy. Simonneaux & *al.* (2005) already showed that the pupils following a humanity course are more anxious with respect to these practices than those following a scientific course.

Pre-service teachers are anxious about therapeutic cloning and fear the derivations of researchers. Their fears are in connection with moral values and religion and seldom with the social values of science. Among the latter, it is primarily the value of applicability to human needs which was mobilized. These teachers do not understand the complexity in the decision-making on the SSI and the various factors which come into play like the various stakeholders and those with economic and social interests, like the funding bodies of research institutions and the politicians whom they never wish to see intervene in laws concerning these Socio-Scientific Questions. We trained pre-service teachers (future teachers of philosophy and biology took part in a socioepistemologic and ethical training, followed by a debate on the 3 technosciences) who then implemented a sequence of teaching in interdisciplinarity with the pupils. Although the transcription and the analysis are not completed yet, we could note after having attended a first sequence that pupils, even more than the teachers, seemed to refer to religion and boys even more than girls. For them the politicians did not have a point of view to give, they must only apply the will of the citizens. They were very motivated and glad to be able to express their opinion, and they wanted to continue the discussion and annoyed to have to attend the following course... In the continuation of this work, interdisciplinary sequences (philo-bio) are constructed and implemented in class with the pupils by the pre-service teachers in order to identify the possible impact of the training on their future teaching practices; analysis of effective practices of the future teachers and their impact.

5. REFERENCES ABSTRACT AND KEYWORDS

Astolfi, J.P., 2006, Préface, In, Legardez, A. & Simonneaux, L., 2006, *L'école à l'épreuve de l'actualité. Enseigner les questions socialement vives*. Paris : ESF.

Bayrhuber, H. (1999) : « Analyse éthique de la thérapie des cellules germinales », In Simonneaux, L. (1999) *Les biotechnologies à l'école* (pp. 97-108). Dijon: Educagri.

Funtowicz, S. O., & Ravetz, J. R. (1993): « Science for the post-normal age ». *Futures, 25*(7), 739-755.

Legardez, A. & Simonneaux, L. (2006) : *L'école à l'épreuve de l'actualité. Enseigner les questions socialement vives*. Paris : ESF

Simonneaux, L. ; Ducamp, C. ; Albe, V. ; Simonneaux, J. & Hirtzlin, N. (2005) : « La perception des sciences par les lycéens est-elle modifiée par la présentation par des chercheurs de leurs travaux ? ». *Quatrième rencontres de l'ARDIST,* pp.347-354, Lyon, 12-15 octobre 2005.

RAISING SOCIOSCIENTIFIC ISSUES TO INTRODUCE STSE RELATIONS AMONG PROSPECTIVE HIGH SCHOOL PHYSICS TEACHERS: A REPORT OF SOME OUTCOMES

Roberto Nardi[6]
São Paulo State University. School of Sciences. Science Education Group.
Education Department. Brazil
Email: nardi@fc.unesp.br

Washington Luiz Pacheco de Carvalho[3]
São Paulo State University. Physics and Chemistry Department.
Science Education Program. Brazil
Email: washcar@dfq.feis.unesp.br

Fernanda Cátia Bozelli[7]
São Paulo State University. School of Sciences. Brazil
Email: ferboz@fc.unesp.br

Adriana Bortoletto[4]
São Paulo State University. School of Sciences.
Science Education Program. Brazil
Email: adriborto@hotmail.com

▼ Abstract

In this paper we present partial outcomes of a broad research related to a project called *Center for Training and Development of Resources for Scientific and Technological Education (**Cienci@Edu**)* supported by FINEP[8], a Brazilian Science and Technology Ministry Department, that was carried out in a public university in the State of São Paulo, in Brazil. The project is specifically oriented to introduce Secondary and High School students and teachers in discussions involving science, technology, society and environment relations (STSE) through the domain of modern media technologies and to increasing the communication between basic school and university. Here we relate results from one of the actions carried out with prospective teachers in an undergraduate major program in physics, designed to prepare High School Physics teachers (called *Licenciatura* in Brazil). Forty prospective teachers, divided into various

[6] *Support: FINEP and CNPq – Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil*
[7] *Support: FAPESP – Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil*
[8] *Support: FINEP - Financiadora de Estudos e Projetos. Science and Technology Ministry (MCT/ Brazil)*
[4] *Support: CAPES – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (MEC/Brazil)*

small groups, were asked to make their own diagnosis of a social environmental problem they experienced, to transform it in a school project and to communicate it in a short essay to be presented and discussed with their colleagues. Discussions were audio/video tape recorded and data were collected along one school year. We detach here the discussions that took place in one of these groups that developed an essay named '*The environmental impact caused by the school awareness deficiency*' in which they tried to verify environmental education conceptions present among primary and secondary school students and teachers. We analyze how this project' activities were designed, the data they raised and we discuss how activities like that can help educators to promote socioscientific discussions as a science education content.

Key Words Physics Teaching; Environmental Education; Scientific Literacy; Physics Teachers Formation; Science, Technology, Society and Environment (STSE) Relations

INTRODUCTION

The importance that science and technology have in today's society makes the scientific literacy so fundamental that every citizen should be involved in this debate. Issues like genetic engineering, *in vitro* fertilization, transgenic food, energy generation/consumption and the socioscientific and environmental impact of these matters in our lives are daily exposed in the media.

Discussions involving socio-environmental impacts, in general, occur whether in government or third sector levels by not taking into consideration the school role of contributing to transform individuals in active persons. There are, by other hand, political, economical, religious and other different restrictions to people's access to details of cultural, scientific or economic knowledge. In this sense, tensions present in society also have to be present in school debates and could be an important tool to make teachers and students aware of important problems of social life, in order to have them conscious of their rights and duties, and probably engaged and able to discuss and act in a variety of social-scientific issues.

Behind ideas and values like these presented above, there is a conception that learning science is not just acquiring several fragmented concepts and/or theories, but also is to appropriate of a scientific language, by promoting a dialogical process between two cultures: the scientific and the humanistic. The dialogicity inherent to such humanistic-scientific culture promotes an empowerment in the relation teacher-student, a political strengtheness towards to the critical thinking, the conscientization and the upbringing of opinions concerning to the nature of science and technology. According to this scientific-humanistic educational view, the STSE approach has characteristics that seem to respond adequately to challenging issues present in modern society, whether in the teaching or in teachers' education. To educate prospective teachers in this perspective is a challenge for universities, because this task generally means to fight against instrumental rationality, mainly in underdeveloped countries, where teachers come from different social backgrounds, having quite different his-

tories and specific idiosyncrasies, and where the oversimplification of the concept of teacher education is held by the political system as a necessity to give account of enormous shortage of teachers in basic schools. Also, we cannot forget that ethics, moral and religious issues permeate teachers' decisions and judgments and have to be worked and questioned since the beginning of teachers' education. In fact, teachers' initial education, in general, has not been promoting the necessary knowledge, from the multidisciplinary point of view, which a STSE approach requires.

As an attempt to change the situation that was somewhat, described above, it was developed in Brazil a Project called *Center for Training and Development of Resources for Scientific and Technological Education (Cienci@Edu),* supported by FINEP, a public department of the Brazilian Science and Technology Ministry. Here we present partial outcomes of a broad research related to this project. The research was undertaken in one sample of students, prospective teachers, in an undergraduate program oriented to prepare High School Physics teachers in a public university in Brazil[9]. Data were constituted along one of the activities proposed in a course (*Methodology and Practice of Physics Teaching)* that is considered essential in this teacher's initial formation program. In this activity, the prospective High School Physics teachers were divided into groups and were asked to make diagnosis of a social environmental problem they experienced and to transform it in a small project to be developed in a school, and to communicate it in an essay that should be presented and discussed with their pairs. We detach and analyze here how a group of them managed this task and developed their project, named '*The environmental impact caused by the school awareness deficiency*', which aimed at verifying the conceptions of environment present among Primary and Secondary School students and teachers. We describe here the analysis of how this project's intention was designed, the data they raised and we discuss how these activities can help educators to insert socioscientific discussions in prospective teachers' education.

Research's context and methodology

The data were constituted along the parts one and two of the mentioned course, in the year of 2007. It is important to emphasize that this course belongs to a new curricular structure that has its foundations in the relations among science, technology, society and environment (STSE), what means that in all the subjects present in this curriculum discussions about the relation STSE have to be present (CAMARGO, 2007). In the first part of the course, the forty prospective teachers involved were introduced to various issues related to the current physics teaching research outcomes like: students' spontaneous reasoning, the role of history and philosophy of science in physics teaching, science, technology, society and environment (STSE) relations in science education, scientific language and school language etc.. Particularly, in issues related to the theme STSE, these students were asked to read a selected textbook[10], by means

[9] This undergraduate program is called "Licenciatura in Physics", it has a four-year curriculum and students concludes it with a license to teach Physics at High School level. It belongs to the São Paulo State University, School of Science, Bauru Campus.

[10] CARVALHO, W. L. P.; ORQUIZA, L. M. **Ciência, tecnologia e implicações sócio-ambientais**. Bauru: FC/CECEMCA, 2005. (Cadernos CECEMCA, v. 7).

of which they were presented to subjects like as STSE relations, education, work, consumption and industrialization, health, communication, and ethics. After the study, these students were asked to raise issues considered by them as important and controversial in a socio-environmental perspective. They raised issues like: water consumption, waste generation, alternative energy sources, alcohol as fuel, basics sanitation, waste recycle, the practice of burning sugar cane before harvesting etc.

After all discussions based on these issues, the university professor responsible for the course asked to the prospective teachers to think about a problem which could be considered as having a socio-environmental nature and that was close to their social reality, in their community, city, village etc. The aim was to develop from these detected problems a small project to be developed and presented at the end of the next semester. The student teachers were free to gather in groups (three or four students), according to their geographic or personal affinities.

The students worked on their projects up to end of the second semester of 2007. Some of the problems raised and studied by them and submitted to discussion with their colleagues were: *The environment pollution and the subversion of the working relations in Franca*[11] *region*; *Tietê*[12] *River importance and problems*; ***Environmental impact caused by the school awareness deficiency***; *Sugar cane burning x employment (job positions)*; *Problems caused by cities urbanization*; *Leishmaniose epidemic in Bauru City*[13] and *Batalha River and the cities it crosses*[14]. All these problems studied during the semester were presented and discussed by the students in classroom, under professor mediation. All the classes in which the debates to place were video and audio recorded, with students' consent, and also it was authorized by them the report of the data collected only for research proposals. The prospective teachers had their non-identification guaranteed by the professor, in case of publication of the research outcomes.

The recorded discussions among the students produced a significant amount of data, which were afterwards transcript, and carefully analyzed. We will detach here data related to the student teachers' project named *The environmental impact caused by the school awareness deficiency*, which was designed to verify the environment conceptions present in students and in-service teachers. The prospective High School teachers prepared the questions and they interviewed some Primary School children (n=62) from third to sixth grades, and also beginning and experienced in-service teachers (n=5). We decided to detach these data among the other ones by understanding the relevance given by the prospective teachers in school field as data source. Differently from this group, the other ones had only interest in making diagnosis of local environmental impacts without elaborating discussions about the importance

---

11 Franca is a city in the Northern region of São Paulo State, known in Brazil as the "world's shoes capital". However, the shoes production brings pollution caused by the leather tanning industries, which are spread in that region.

12 Tietê River is the largest river that crosses all long São Paulo State.

13 *Bauru is a 360,000 inhabitant's city located in the center of São Paulo State, where the research was carried out. One of the São Paulo State University campi is located in this city.*

14 *Batalha River is the most important river in Bauru's neighborhood. This river is the most important potable water source for the city.*

whether or not to approach these matters in the traditional curriculum or about difficulties to insert these discussions in the school environment. In other opportunities, however, the other data analysis will be reported.

Data Analysis

According to Ratcliffe and Grace (2003), people's perception of environmental education varies considerably, although it can be realized a recent tendency to refer to the environmental education as an education for the sustainable development. In this paper we argue about the importance of what should be the content and the teaching approaches that a program of environmental education could include, and if those approaches are engendered in a way that could promote a convergence among the environmental education, science & technology and an education for citizenship. By taking these theoretical perspectives into account, we used as parameter for data analysis four categories: *environment conceptions*, *environmental conscientization conceptions*, *environmental preservation conceptions* and *the teacher's role in science teaching*.

1. Environment Conceptions

According to Martinho (2004), to know students' representations on subjects related to environment could help teachers to understand how these individuals are capturing and interpreting them. This may favorable to increase the understanding of how students think and act in their close reality, since it is fundamental to start teaching from the vision different social group attribute different meanings to the term *environment* and, mainly, to the extent of certain environment. Thus, it would be possible, according to Azevedo (1999), to verify whether it is necessary or not to work in order to overcome distorted views students could have. Take into consideration that there is a great range and diversity of understandings with respect to the term environment, to interpret data collected we will share Reigota's (2001, p. 14) environment definition. He defines environment as the determined or perceived place, where the natural and social elements are in dynamic relations and in interaction. These relations imply in cultural and technological creation processes and in natural and artificial setting transformation by historical and social processes.

The initial question made by the prospective High School teachers to the students and in-service teachers was: *What environment means to you?*

We noticed in the speeches, like Azevedo (1999) in his studies on social representations with respect to the definition of environment, and by Reigota (2001), that the definitions given reflect two representations: a naturalistic and an anthropocentric one. The naturalistic is characterized by notions only about natural features (biotic and abiotics elements) which could include local/space notions and circundant elements. The anthropocentric one shows the utility of natural resources to the human being survival; everything spinning around the human necessities - a utilitarian vision of environment. We can notice that the naturalistic conception is present whether in teacher's speech or in students' speeches:

"Environment is the interaction of biotic and a-biotic factors including above all its preservation. Unfortunately that is not happening, a proof of that is the global heating". (Teacher)

"It is where animals live, where there are trees, the forest." (Student, 3rd grade)
"It is a group of biomass. With a big biodiversity" (Student, 6th grade)
"A forest." (Student, 3rd grade)

According to Tilbury (1995 apud RATCLIFFE and GRACE, 2003), environment problems are not exclusively due to physical and biological factors, but one must take into consideration the role of esthetic, social, economic, political, historical and cultural factors. In this way, the environment is understood as scenery, an autonomous reality, independent of the society and of the social subject. The anthropocentric kind of vision could be found in the following passages:

"Environment is all around us, that means, everywhere we are, is an environment; our bedroom, our sitting room." (Student, 6th grade)

"One can consider environment as the biosphere interaction as a whole, but this interaction has been interrupted by man's greed. To make the environment well it is needed a management, above all a conscious management." (Teacher)

In these passages it is possible to catch a glimpse on students and teachers' environment reductionist conception. There is a negative as social, cultural, political and economical factors that overlap to the modern reality. Sterling (2001) mentions that the environmental education assumed various reductionist expressions, all of them presenting environment as being only the nature.

The other question made by the prospective High School Physics teachers was: *In your opinion, what is missing in order to people become conscious in relation to the environment?*

2. Environmental Conscientization Conceptions

Analyzing the speeches bellow, we notice that there is an interiorization of information spread by the mass communication media, which means, television, radio, newspapers, magazines and internet become responsable by the scientific-humanistic enculturation process.

"Ask for not setting fire in trees, not putting them down". (Student, 3rd grade)
"Do not throwing garbage in forests and planning many trees." (Student, 3rd grade)

According Pechula (2007), the mass media vehicles look for playing their function to inform about discoveries and scientific inventions. During the production process there happen the reproductions of some signs which represent an ingenuous world, which present science as a ready for use knowledge and capable to solve all the problems. In that perspective, this ingenuous representation promotes a spontaneous conception about nature of science, environment conflicts and the moral values that involve them. There are no evidences in the discourses of points that characterize attribution of meaning from a codification and decodification processes[15]. The singularity and the meaning that could be present in students' discourses were dissolved and linearized. "Don't throw garbage" and "Don't set fire to", does not characterize the conscientization, but rather a conscience capture (the way through we are related to

[15] *To Freire (1979), codification is the act to get distance from the reality or from the object that becomes cognizable, while decodification is the process in which the individuals perceive the relation among the codification elements and among the real situation they present; relations not perceived before.*

the reality in a first moment, without thinking or acting critically). The semi-formative character present in the modern society, through its cultural products offers a ready answer to our questions. Nevertheless, the individual identity is suppressed in the absence of an elaborated knowledge acquired via critical-reflexive process. The individual silently delegates his authority to social actors, which function is to promote a search for knowledge in democratic process and not an authoritarian-imperative as expressed in the discourse:

"The city mayor has to speak more about the municipal garbage disposal system; teachers have to tell us about problems in throwing garbage in the street and in scrub". (Student, 6th grade)

This kind of discourse is present in another student speech, when asked about which should be the way for the acquisition of "knowledge" about this subject:

"Speaking more on the subject; making campaigns, to advertise for consuming more natural products". (Student, 6th grade)

"It is missing a focused education, not only to preservation (like in general has occurred) but also must be focused in the conscientization to set up a harmony between the nature and the man, to guarantee a balanced and healthy environment." (Teacher)

After the question about conscientization, the prospective High School teachers asked students and in-service teachers to talk about preservation: *"Why do we have to preserve it (the environment)? What do you think you can do to help preservation?"*

3. Environmental Preservation Conceptions

By taking into account the definition of environment proposed by Reigota (2001), and what Tilbury (1996) says about environmental problems, we must consider that environment preservation is the search for tools which minimizes the socio-environmental impacts due to human activities. So, the environment preservation would include the search for equilibrium in terms of natural resources consumption, generation and energy consumption, demographic growth, biodiversity conservation, agricultural sector efficiency, forest preservation and its relation to the consumption of goods and services, and its relation to the maintenance of ancient cultures threatened by the globalization process. The conceptions present in the following discourses do not correspond to the plausible way the environment preservation was just defined. They result from an environmental education that considers only local problems, that means, specific and reductionist definitions.

"Not putting down trees." (Student, 3rd grade)

"Not throwing garbage on the streets, in the rivers." (Student, 3rd grade)

"Not throwing garbage in plants, in the ground, do not take leaves from trees, not picking flowers in the field." (Student, 3rd grade)

In the following excerpts, we can notice environment anthropocentrical characteristics. The imperative tone of the speech reveals a "*control of the nature*" view.

"*We have to preserve them for our survival, and also to take care with what we consume.*" (Student, 6th grade)

"*Because, otherwise, it will be over.*" (Student, 3rd grade)

"For not damaging it." (Student, 6th grade)

It is remarkable, in these discourses, a naturalistic and anthropocentric environment characteristic in detriment of other preservation concept dimensions. Also we understand that any human intervention, whether related to energy generation, food production or scientific-technological innovations in medicine, they will be considered invasive from the environmental point of view, once they will generate controversial issues related to normative ethics or to implicit moral values.

The last question made by the prospective High School teachers to the students and in-service teachers were: *"Do you think teachers need to talk more about these issues?"*

4. The teachers' role

Traditionally science teaching focus has been on teaching and learning disciplinary knowledge (Roth & Desautels 2002 apud Pedretti et al. 2006). This kind of approach reflects on the student speech. In our study this was realized when we asked about student's interest in obtaining knowledge related to environment conception and to socio-environmental impacts. The need of information or the laconic answers are symptoms of that focus:

"Yes, not only teachers but everybody; more news about the environment". (Student, 6th grade)

"Yes." (Student, 3rd grade)

According to Hodson (2003 apud Pedretti et al. 2006) science teaching, in general, is based on well established and safe knowledge, while approaches that take into consideration challenging knowledge, multiple solutions, controversial and ethical values have been excluded. Fundamentally, to promote the possibility of a scientific literacy for citizenship, it is necessary that teacher stop being afraid of facing the complexity of the knowledge about environment and perceive that, like pointed out Farias and Carvalho (2007), that inherent complexity allows us to comprehend a multiplicity of dimensions that compose a certain phenomenon and to recognize the articulation that exists among these dimensions, and with social phenomena and their temporal and spatial contexts. According to the perspectives expressed by Hughes (2000), the unfamiliarity and difficulty of STSE content for both, teachers and students, and the lack of training and expertise in discussion of complex issues, could partly explain the prompt marginalization of STSE. Probably the existence of this marginalization is expressed in students' speech, as it tends to present few and natural elements as what were learned about the environmental contents in science classes:

"*The science teacher always speaks about trees and the animals.*" (Student, 3rd grade)

Also, we realize in the words of the student that what was said were the repeated words of the teacher. As the complexity is not explored, even in an initial level, the recollection involves just simple and repeated words that produced no meanings for the student. Maybe the student know that the meanings are still kept with the teacher: *always speaks about…* But at the same time, we can notice in teacher speech certain concern about the lack of interest of her/his.

"Thus, we come across with a big trouble: who really is interested in that?" (Teacher)

Students should come to school previously interested in learning about the complexity of environmental issues? As social and cultural views about environment are generally oversimplified, is this expectance of the teacher acceptable?

Concluding Comments

Although this research presents initial results, mostly because just recently some Brazilian Physics teachers' curricula have been emphasizing a STSE approach, we believe that the teachers and students analysis and interpretations accomplished in this study may contribute to further researches that may enrich our science teachers' courses. We believe that it was possible to unveil important aspects of the naturalistic and anthropocentric views of environment, and reducionist and linear views about conscientization and preservation that are held by our basic school students and even by prospective teachers. It was possible to observe that neither the students of the sample nor the teachers were capable of differentiating/justifying what they thought it would be necessary for increasing consciousness about environment. Their answers suggested just mitigating measures, expressing more an advice or warning character and less an educational and/or cultural perspective. In this sense, they also presented anthropocentric and naturalistic views of environment and did not take into account social and cultural aspects of human activities. Before the obtained results, we believe that efforts and commitment have to be obtained from students and prospective teachers in order to have them understanding the complexity and multiplicity of dimensions that are involved in social-scientific phenomena. In addition, it is important to recognize the great variety of not so evident or explicit relations that can be found among environmental, social, historical and geographical dimensions. In this sense, we believe that with this study, a step ahead was given in order to acquire basis to demolish barriers that traditionally are placed by teachers and prospective teachers in order to keep their class planning based just on a conceptual route and to avoid that "strange" contents, like those offered by a STSE perspective, be part of their teaching.

REFERENCES

AZEVEDO, G. C. (1999). Uso de jornais e revistas na perspectiva da representação social de meio ambiente em sala de aula. In: REIGOTA, M. (Org.). Verde Cotidiano: o meio ambiente em discussão. Rio de Janeiro: DP&A. p. 67-82. (O sentido da Escola).

CAMARGO, S. (2007). Discursos presentes em um processo de reestruturação curricular de um curso de licenciatura em Física: o legal, o real e o possível. Bauru. Tese (Doutorado em Educação para a Ciência). Faculdade de Ciências, Universidade Estadual Paulista, UNESP.

FARIAS, C. R. O.; CARVALHO, W. L. P. (2007). O direito ambiental na sala de aula: significados de uma prática educativa no Ensino Médio. Ciência & Educação, v. 13, n. 2, p. 157-174.

FREIRE, P. (1979). Conscientização: teoria e pratica da libertação: Uma introdução ao pensamento de Paulo Freire. São Paulo: Cortez e Moraes.

HUGHES, G. (2000). Marginalization of socioscientific material in science–technology–society science curricula: some implications for gender inclusivity and curriculum reform. Journal of Research in Science Teaching, v. 37, n. 5, p. 426–440.

MARTINHO, L. R. (2004). As representações sobre meio ambiente de alunos da 4ª série do Ensino Fundamental. 2004. 141f. Dissertação (Mestrado em Educação para a Ciência). Faculdade de Ciências, UNESP, Bauru.

PECHULA, M. R. (2007). A Ciência nos meios de comunicação em massa: divulgação de conhecimento ou reforço do imaginário social? Ciência & Educação, v. 13, n. 2, p. 211-222.

PEDRETTI, E. G. et al. (2006). Promoting issues-based STSE. Perspectives in Science Teacher Education: problems of identity and ideology. Science & Education. DOI: 10.1007/s11191-006-9060-8. Springer.

RATCLIFFE, M.; GRACE, M. (2003). Science Education for citizenship: teaching socio-scientific issues. Philadelphia, USA: Open University Press.

REIGOTA, M. (2001). Meio Ambiente e representação social. 4. ed. São Paulo: Cortez, 2001. 87p. (Questões da nossa época, 41).

STERLING, S. (2001). Sustainable education: re-visioning learning and change. Bristol, UK: Green Books.

TILBURY, D. (1996). Environmental education for sustainability in Europe: philosophy into practice. Environmental Education and Information, Salford, UK, v. 16, n. 2, p. 123-140.

LITERATURE OF SCIENCE FICTION IN SCIENCE EDUCATION: AS CRITICAL DISCOURSES FOR SCIENTIFICALLY AND POLITICALLY LITERATE CITIZENS

Ioanna Stavrou and Costantine Skordoulis
National & Kapodistrian University of Athens, Faculty of Primary Education
Department of Physical Science, Technology and Environmental Studies
Navarinou 13A str., Athens 10680, Greece
ioannakstavrou@yahoo.gr

▼ Abstract

This work pertains to the contribution of science fiction texts to Science Education. We argue that science fiction, as cultural form, but above all as a way of thinking might help us to generate new ways of imagining global transitions in social environments and civil society in our present times and circumstances, and therefore could invite a more social and critical approach in the context of Science Education. We also argue that the conjunction of disciplines / cultures figured by the term "science fiction" bears re-examination as a resource for science studies and a potential mediator in science-humanities encounters. Moreover, science fiction, as product and part of the social consciousness of the contemporary world, could be an important participant in critical negotiations with techno scientific discourses. We conclude that these creative and critical conversations around sciences, such as science fiction, function as an enormously fertile environment of socio-cultural understanding of Science and Technology, and situate science fiction as a resourceful agent to respond to the political and ethical consequences that Science has in the world (human and non-human). Such approaches go a long way to develop culturally sensitive and sociocultural perspectives in Science Education, and contribute to educate a new generation of scientifically and politically literate citizens who actively take part in social processes.

Key Words science fiction, science education, literate citizens

1. INTRODUCTION

The fact that we live in an age of rapid, ongoing scientific and technological changes in the one hand, and poverty, wars, social injustice and environmental degradation on the other, calls for a need of a sober approach towards these challenges through Science Education. This ambiguous development needs approaches that will help us think through not only the impact of scientific and technological developments on our lives, but also the deeper social and ethical implications of science and technology in facing the above controversies. As these problems require sound scientific un-

derstanding, critical analysis, and responsible solutions, there is a need for a more socio-cultural and ethical approach towards the society and the environment through Science Education (Noblit *et al.* 2007).

In this world transformed by technological, economic, and ecological changes, the role of literary culture seems more important than ever. This is a fact that is recognised as an imperative in the field of Science Education, as recent decades have seen an increase in sociocultural perspectives within Science and Environmental Education that are reflective of the cultural turn in intellectual theory more generally. These critical, historical, political, and socioecological views, interested in access to scientific knowledge, education, and power, have become part of enlightened Science and Environmental Education discourses (Carter, 2008). In this perspective, the gap between the sciences and the humanities and the urgent need to confront it, do not exist on the theoretical level alone. Indeed, we face an increasing number of situations that Bruno Latour, variously describes as 'borderline' questions or 'sociotechnical' and 'ethico-scientific' imbroglios (Latour, 2003). These are intricately woven mixes that pertain simultaneously to the domains of the natural sciences and the humanities. Therefore, a sort of composite sciences-humanities literacy is required to help a democratic citizenry not only to scrutinize but also to contribute to science-and technology-based decisions about such imbroglios.

One way of investigating into these issues is through the literature of science fiction. With the genre's license to create new societies and worlds, it seems an ideal tool with which to explore socio-scientific alternatives. Moreover, as science fiction is so often taken to be the expression of political opinion or ideology of the scientific and technological society aimed at presenting alternatives to social condition, it functions as thought experiment and critical discourse which can also bring more skepticism about politics, ideologies and epistemological certainties in the context of Science Education (Gough, 2006, Weinstein, 2006).

Science fiction is an incubator for imaginative minds to create visions that help us to glimpse not only the scientific present and future, but also something about ourselves, and functions as the integrator of socio-cultural space that supports the dialogue between science and humanities. Yet more, science fiction is a genre well-suited to express the concerns about environment and explore humanity's place in ecological systems since it encompasses a broad range of issues that derive from the interaction of humans with the natural word, and this literary genre's articulations contribute significantly to the broad rethinking of the relations between human and nature that is currently taking place specially in western societies (Merrick, 2005, Miller, 2005).

Fuelled by the extrapolation of "what is" into "what can be", science fiction transports us beyond the horizon of our current technologies enabling us to observe the possible incarnations of scientific progress and to experience and appreciate the many ways this may impact upon society and environment, as well as to serve as a focal point for discussion about our attitudes, perceptions, hopes and fears about science, technology, society and how they interweave. As Deery argues science fiction performs "a vital social function, which is to offer a testing ground, a thought experiment, where the social consequences of science and technology can be extrapolated

in an intuitive, holistic and empathetic manner", thus offering "humanistic-cultural" as well as political dimensions to Science Education (Dritsas, 2007).

2. WHY SCIENCE FICTION IS "GOOD TO THINK WITH" - SCIENCE FICTION AS 'THOUGHT EXPERIMENT'

Creative forms such as science fiction can offer a wider field, when we are concerned with critiquing and unpacking techno scientific practices, cultures and knowledge. Furthermore, as "cross-cultural" narrative in encounters between the humanities and sciences - this conjunction of disciplines figured by the term science fiction - bears re-examination as a resource for Science Studies, and a potential mediator in science-humanities dialogues which could illuminate the social and cultural meanings and consequences of scientific research (Merrick, 2005, Gough, 2006).

A basic element of science fiction is the challenges and the questioning articulated in its reading process whose necessary and sufficient conditions are the presence and interaction of *estrangement* and *cognition* or *cognition effect* (Freedman, 2000:16-23). As theoretical models – abstract constructions of subject, of representation – become fleshed out in the particularized worlds of the science fiction imagination, science fiction articulates and explores those models through its narrative experiments and, in the ongoing dialectical relationship between abstraction and concretization science fiction continues to influence the development of the new worlds and the new futures. The mixing of science fictions with science 'facts' and theories serves the immediate function of undermining universal claims to 'truth', and in emphasizing narrativity, it potentially opens up scientific discourses to challenge and interpretation. In this essence, science fiction is called upon as useful space, "reading practice" or "dream laboratory" in which to reflect upon and engage with scientific cultures, practices and knowledges and configures a more productive interaction relation between fictional and theoretical writings on science, especially in the field that opposes the authority of the natural sciences as "crafts for distinguishing between fact and fiction" (Haraway, 1989: 3-4). Placing the narratives of scientific fact within the heterogeneous space of science fiction produces a transformed field. This transformed field sets up resonances among all of its regions and components. No region or component is 'reduced' to any other, but reading and writing practices respond to each other across a structured space (Haraway, 1989:5). The resulting stories are not simply programmatic 'mirrors' of particular theoretical arguments, but rather they incorporate those arguments into the lives and actions of imagined human subjects in imaginary worlds, subjecting them to detailed fictional examination. In Le Guin's terms "such stories are 'thought experiments' whose purpose is not to predict the future…but to describe reality, the present world," (LeGuin, 1976) the more defensible representations of present realities. The particular reading practices and protocols of science fiction make overt the way that "stories" may construct worlds, indeed in science fiction it could be said what we know of the world cannot be assumed from prior experience or context but must be constructed anew from the observations, actions and actors of the story. Obviously, then, science fiction reading strategies offer fertile ground for reconstructions and revisions of world-shaping stories.

As creative form, science fiction offers different ways of situating or positioning the observer / reader, whether through the deliberate use of metaphor, cognitive dissonance, or the inherent undermining of the notion of the objective reader and works to create critical distance between observer and observed, to defamiliarize certain, taken for-granted, aspects of ordinary human reality, 'denaturalizing' situations of historical inequity and oppression that otherwise may appear inevitable to us. In these texts, confrontations between 'human' and 'other' are ripe with possibilities for denaturalizing the boundaries and allegiances which infuse traditional depictions of human / non-human dichotomy, a process that arouses questions about the artificiality of dualism between humans and animals, cultures and nature, science and technology and highlights the ways in which these stubborn dichotomies intersect to produce alienated and estranged subjects (Merrick, 2005).

Consequently, these texts provide the possibility "to remap the borderlands between culture and nature" and force the individual to sense the limitations of his or her rationality of a different, not-alienated relationship with nature, or in other words, a reconciliation between human beings and nature that would not be based on domination and control. Such questions about "nature-culture" are intimately connected to the ways we approach and understand the notions of 'human', 'other', 'life' and the difference in the discourses of Science and contemporary techno scientific cultures (Merrick, 2005). They are also educationally relevant because they represent important ways of articulating our understanding of the human situation, whereas, the present environmental predicament provides an exciting opportunity to re-focus education on them (Bonett, 2008) and productively promote socio-ecological sustainability while accepting and embracing socio-ecological change (Buell, 2005:56).

Science fiction, also, offers a point of negotiation between a critique of the future and the present mapping of the world. As a critical function, science fiction per formatively demonstrates what Jameson simply calls "future history", that moment in which the project of imagining the future is seen to be conditioned by the social, scientific, and technological dynamics of the present and it provides a critique of the very ideological underpinnings of the task of imagining the future. In this sense, imagining the future is not an issue of imagination versus actualization, and neither is it an issue of affirming the future, or 'keeping the future alive'. Rather, science fiction can configure the future as the conditions of possibility and constraint for social change in the present. What the imagined space and time of science fiction thus offer the reader is not a vision of a possible future, but an interrogation of the present. In such an instance, science fiction becomes not merely a genre that refers to Science and Technology but it actually begins to embody the very technologies it critiques (Jameson, 1982). As in science fiction texts the representation of science and technology goes beyond mere depiction, these texts spotlight the ownership and control of the means of production and consumption of the products of science. In contemporary science fiction the assumptions and effects of science and technology are always scrutinized. Likewise, they have a lot to say about the ideological dynamics of science or of the ruthless exploitation of science and the 'dual use' of technology, as the latter far from being neutral, carries encoded politics (Burling,

2006, McLeish, 2006). This quality lends a sense of urgency to the work, an appeal to social ethics. So, science fiction represents mandates to act on the concerns expressed, and to act now.

In this regard, science fiction is read not only for alternative representations but because it digs into scientific concepts with imagination, creativity, and a thorough appreciation of consequences and functions as valuable sources of knowledge when evaluating new scientific and technological developments (Martijntje Smits, 2006).

3. SCIENCE FICTION AS LITERARY RESPONSE TO SOCIAL AND ENVIRONMENTAL CHALLENGES

Science fiction texts, having references to ethical, social, or political implications of technologies, can be used as a medium for speculation on the philosophical basis and ethical implications of science and can offer a criticism of science regarding these implications as part of the processes of discovery and development in a cross–disciplinary critique.

The intriguing and multifaced interrelationships between science and culture are explored and the context is created in which important questions without easy answers are raised, engaging the student in critical thinking about novels, stories and essays. Such approach acknowledges social, emotional, and political aspects of science and seeks to develop a new kind of scientific literacy, an awareness of the complex ways in which science gets across, and emphasizes the common grounds where science, literature, and politics are integrated (Gough, 2006). This is a fact that leads towards both cognitive awareness and critical awareness of scientific activity taken as cultural activity which can effectively contribute to the solution of contemporary social and environmental problems. Such critical approach shifts focus towards the possibilities for meaning making and social action of the literate person and allows us to think which sorts of contexts are set out in society for participation and what the individual and collective expectations are for social action in science related situations. Being literate involves, therefore, the possibility to become aware of one's own socio-conceptual horizons as well as tolerate individual and societal levels.

This awareness of scientific knowledge enables a different kind of participation in society, namely, one in which subjects not simply reproduce, reinforce or consolidate relationships already established but actively engage in questioning and transforming society. By expanding their consciousness of scientific knowledge as the product of social practices which are not neutral and marked by power struggles, subjects can situate themselves – as well as their knowledge systems and beliefs – with respect to such practices, expand their awareness about questions which matter to them and take part in dialogues which might lead to a more democratic basis for social consensus. Therefore, the development of such scientific literacy necessarily entails a less factual, fragmented science education where the science can be discussed critically in terms of its deferent procedural aspects and of the political, economic, social, environmental, and ethical issues it arouses (Gough, 2003, 2006).

These literacy practices add to traditional notions of scientific literacy possibilities of criticism to the traditional perceptions of scientific and environmental literacy regarding the ambivalence towards science, forming, according to Weinstein, a network of "counter scientific literacies" which potentially open up the curriculum in a variety of ways that are crucial for teaching science. This network of *multiliteracies* or *multidimensional scientific literacy* offers the possibility of a more nuanced, more appropriately ambivalent, and more politically and ethically engaged subject of science than the one offered by the current version of literacy dominating science educational discourse (Weinsten, 2006). This perspective of scientific literacy incorporates an understanding of science that extends beyond the concepts of scientific disciplines and procedures of scientific investigation. It includes philosophical, historical, and social dimensions of science and technology. In this context, students develop some understanding and appreciation of science and technology regarding its relationship to a multitude of socio-scientific and socio-technical issues. More specifically, they begin to make connections within scientific disciplines, and between science, technology, and the larger issues challenging society. Science fiction offers multiliteracy in science education with the faithful engagement through writing and reading in science from multiple perspectives rather than merely from one. A process that enables students to understand and to challenge inequalities, and to be critically aware of the ideological functions of all cultural forms, as these cultural forms have different interests in the natural and social worlds and tend to ask different questions about their realities. These resources direct different kinds of inquiry projects that produce different systematic patterns of knowledge and ignorance (Harding, 2003). Thus, it may be necessary to integrate scientific knowledge with other systems of knowledge in order to understand how understanding of science is formed. Given the fact that the emphasis on the interconnections between science and society has entailed a focus on science-related social issues, which have a basis in science, frequently that at the frontiers of scientific knowledge (Ratcliffe & Grace:2) and the fact that most people gain information about these socio-scientific issues through both media and science fiction (but they do not process the messages through the linear) it is important to explore how these cultural works shape the knowledge about these socio-scientific issues and attitudes to them. It has also been argued that to empower the students as citizens, there is a need to emphasize science as an institution and the processes by which scientific knowledge is produced. One argument has been that knowledge of the human character of science, values in science, limits of science and its tactics for decision making are prerequisite knowledge for thoughtful decision making (Ratcliffe & Grace:21-38).

Getting to know cultural works, such as science fiction is a part of a collective process of knowing the world, both the natural and the human, in the context of Science Education. The path of knowledge and action that goes through such approaches is for the most part a roundabout one, a route that turns away from knowing or acting in the most direct or immediate way possible. The reception and use of cultural works, such as science fiction, is thus a complex, indirect, and often subtle way of sending

a feedback signal to the ongoing processes. It is a way of adding to the richness of human life and activity, of noticing things that would otherwise not be noticed, and perhaps thereby of provoking kinds of action or decision-making that would not otherwise be envisioned or investigated (Paulson, 2001:120). Such treatments produce different meanings if we encourage their connections with a multiplicity of other cultural materials and provide opportunities to engage students in analyses of the social meanings of scientific research (Gough, 2006).

Science fiction highlights the ethical and policy issues raised by science and technology. The narrative elements from science fiction literary genre are used in the discourse of Science and Technology to bridge the gap not only between what is technically possible today and its inflated promises for the future but also the ethics about science and technology and thus, science fiction could be used as a tool with which students might navigate the ethical and societal dimensions of unfamiliar technological terrain (Berne & Schummer, 2005)

In this regard, science fiction could function as an important cultural arena, where scientific knowledge is mediated, and as an important space where the critical analysis of issues and perspectives is negotiated promoting a (multi) cultural practice of science communication (van Dijck, 2003) thus leading to cross-disciplinary discussions which can illuminate our understanding of science (Saunders *et al,* 2004, Dritsas, 2007)

In addition, science fiction is a genre well-suited to express the concerns about the environment and explore humanity's place in ecological systems since it encompasses a broad range of issues that derive from the interaction of humans with the natural word (Miller, 2005), as many of the texts spell the agonizing struggles of the future between near-term utilization and long-term preservation of a planet's natural resources and ecosystems, as well as examine a range of moral problems, requiring ethical reflection, that are associated with the environment (Stavrou *et al*, 2007).

Indeed these texts are good shorthand expressions for capturing a prevalent contemporary sensibility regarding our place in nature and our responsibility for discovering ecologically sustainable futures and can be read as 'sociotechnical thought experiments' that produce alternative representations of present circumstances and uncertainties, and anticipate and critique possible futures (Gough, 2003).

As a result, critical readings of such stories can help us to anticipate critique and respond to social and cultural changes. Consequently, thought experiments, like science fiction texts, invite a socially critical approach to curriculum and curriculum inquiry because they foreground socio-political structures and agency as well as techno scientific responses to social and environmental crisis. Therefore, the inclusion of literature, especially literature of science fiction in the procedures of science education could liberate thinking about sedentary points of view and judgmental positions that function as the nodal points of science education discourse and generate questions, provocations and challenges to some of the dominant discourses and assumptions of contemporary science education (Gough, 2003, 2006, Roth & Desautels, 2002: 65-91)

4. CONCLUSION

Although any literary genre can lend itself to teaching critical thinking skills, science fiction could be an excellent curriculum source in that it encourages discussion topics, such as problem-solving, issues of moral responsibility and issues of race and milieu. Therefore, an integrated unit on science fiction which encompasses not only the Language Arts, but also, Science and Social Studies is possible.

Good science fiction is story, science, and speculation all wrapped up in a package custom-made for improving literacy and critical-thinking skills. Through science fiction, students are given opportunities to move beyond ideas of present reality into the domains of the imagined future, where they can work with moral questions of the future with science and technology in creative and active ways. From their engagement with science fiction they can ask where we may possible move with these technologies, and how they may affect social, moral, and environmental conditions of human life (Czerneda, 2006).

Cultural works provide multiple, varied, and indirect paths of feedback; they add diversity and subtlety to the process of knowing and acting on the world. Their contribution is crucial, because the effective working of feedback control systems depends on the quantity and quality of the feedback signals they can process.

What literary culture may best be able to contribute to today's transformed world are not theories but stories, not accounts of worlds revealed to be words but offerings of words to touch the world (Paulson, 2001:76). Similarly, cultural works in science education can contribute significantly to our understanding of the barriers to effective science education. Science fiction can force students to think about our present society, including its strengths and weaknesses. It encourages students to consider what might make a better society, or just as important, what would make a worse society.

Such approaches aspire to shape a new kind of scientific, technological and environmental literacy, where the emphasis falls on the realization of the complex routes and common ground where science, literature and political ideologies meet (Gough, 2006, Merrick, 2005, Weinstein, 2006). A fact that leads to critical awareness as well as cognitive awareness of scientific activity as cultural activity, able to contribute to effective solutions to contemporary social and environmental problems.

We need literary culture, which is offered by science fiction because we live in a human world that is social, open, competitive and conflicting, that is inherently concerned with far more getting at the truth about the objective condition of things, and because we live in a historically and culturally complex world that we must seek to know with some degree of thoroughness and subtlety if we are to act effectively within it.

However, by means of science fiction critical discourses, we can make a beginning, committed to the view that it is important to develop, as a matter of civic responsibility, an understanding of the interactions between science and humanities and their functions as complex enterprises that take place in specific contexts shaped by, and in turn shaping, the cultural, moral, and political values. This can be accomplished in the context of educating a new generation of scientifically and politically literate citizens who actively take part in social processes.

5. REFERENCES

Berne, R. &Schummer J. (2005). Teaching Societal and Ethical Implications of Nanotechnology to engineering students through Science Fiction. *Bulletin of Science, Technology and Society,* vol.25, 459-468

Bonett, M. (2008). Environmental education and the issue of nature. *Journal of Curriculum Studies,* 1-15

Buell, L.(2005). *Future of Environment Criticism: Environmental Crisis and Literary Imagination.* Blackwell Publishing Professional

Carter, L. (2008). Sociocultural Influences on Science Education: Innovation for Contemporary Times. *Science Education,* vol. 92, 165-181

Czerneda, J. (2006). Science Fiction & Scientific Literacy. *The Science Teacher,* 73(2), 38-42

Dritsas, L. (2007). Cultures of science fiction. *Metascience,*vol.16, 345-348

Freedman, C. (2000). *Critical Theory and Science Fiction*. Wesleyan University Press. Published by University Press of New England, Hanover and London

Gough, N. (2003). Speculative Fictions for Understanding Global Change Environments: Two Thought Experiments. *Managing Global Transitions,* vol.1(1), 5-27

Gough, N. (2006). Shaking the Tree, Making a Rhizome: Towards a nomadic geophilosophy of science education. *Education Philosophy and Theory,* vol.38 (5), 625-645

Haraway, D. J. (1989). *Primate Visions: Gender, race, and nature in the world of modern science.* Routledge, New York

Harding, S. (1994). Is Science Multicultural? Challenges, resources, opportunities, uncertainties. *Configurations: A Journal of Literature, Science and Technology,* vol. 2, 301-330

Jameson, F.(1982). "Progress versus Utopia, or, Can We Imagine the Future?" Science Fiction Studies, 9(2), 147-158

Latour, B. (2003). Morality and Technology: The End of the Means. *Theory, Culture & Society,* vol. 19(5/6): 247-260

LeGuin, U.K. (1976). "Introduction", *The Left Hand of Darkness.* [no pagination], New York: Ace

Martijntje, S. (2006). Science Fiction: A Credible Resource for Critical Knowledge?. *Bulletin of Science, Technology & Society,* vol. 26 (6), 521-523

McLeish, C. (2006). Science and Censorship in an Age of Bio-weapons Threat. *Science as Culture,* vol.15 (3), 215-236

Miller, R. (2005) "Millennial Fever, Extremophiles, NASA, Astroenvironmentalism and Planetary Protection". *Electronic Green Journal,* issue 22. http://egj.uidaho.edu/egj22/miller1.html

Paulson, W. (2001). *Literary Culture in a World Tramsformed.* Cornell University Press, USA

Ratcliffe, M. & Grace M.(2003). *Science Education for Citizenship.* Open University Press, UK

Roth, W-M. & Desautels, J. (2002). "Educating for Citizenship: Reappraising the Role of Science Education" in Roth, W-M. & Desautels, J. (eds) *Science Education as/for Sociopolitical Action,* Peter Lang, New York

Saunders, D., Brake, M., Griffiths, M., Thornton, R. (2004). Access, Astronomy and Science Fiction: A Case study in Curriculum Design. *Active Learning in Higher Education,* vol. 5(1): 27-42

Schneider, J. (2006). Science Fiction and Science Policy. *Bulletin of Science, Technology & Society,* vol. 26 (6): 518-520

Stavrou, I., Skordoulis, K, Halkia, K. (2007). Environmental issues / problems in science fiction texts translated and published in Greek. Paper presented at International Conference of ESERA (European Science Education Research Association) in Malmö, Sweden, August 21-25, 2007

Van Dijck, J. (2003). "After the 'Two Cultures': Toward a '(Multi) cultural Practice of Science Communication". *Science Communication,* vol.25, 177-190

Weinstein, M. (2006). Slash Writers and Guinea Pigs as Models for a Scientific Multiliteracy. *Educational Philosophy and Theory,* vol. 38(5): 607-623

BIOTECHNOLOGY CAPACITY DEVELOPMENT IN SOUTHERN AFRICA: ASPIRATIONS, INSPIRATIONS, AND PERSPIRATIONS

Jean Mollett, Chrissie Rey
School of Molecular and Cell Biology, University of the Witwatersrand
Private bag 3, WITS, 2050, Johannesburg, Gauteng, South Africa
jean.mollett@wits.ac.za

▼ Abstract

This paper describes the process and approach of biotechnology capacity development in three universities in the Southern African Development Community (SADC) region. The objectives are to enhance co-operation and build partnerships at the Universities of Namibia (UNAM), Eduardo Mondlane (UEM) in Mozambique and Witwatersrand (WITS) in South Africa. The principal reason for introducing or strengthening the undergraduate curricula in biotechnology at the institutes is to build capacity in both the theory and applications in this field, especially in the critical areas of crop agriculture, animal and human health and bioprocessing. The approach of WITS, where biotechnology is already established, is to engage with UEM and UNAM in a participatory collaborative process, rather than being prescriptive. This falls within the objectives of the SADC protocol on education, one of which is to maximize the effective utilization of existing expertise, institutions and other resources for education and training and to ensure long term sustainability. To this end it will also eliminate needless and costly duplication at the tertiary education level and facilitate staff and student exchange between institutions. Through the participatory process, we have adopted a qualitative approach to research which engages with the teacher and learner epistemologies of science and biotechnology at these diverse, multicultural Southern African institutions.

Key Words biotechnology, epistemology, teaching and learning

1. INTRODUCTION

1.1. Rationale and motivation for the project: Aspirations

The Southern African Development Community (SADC) includes 14 countries in Southern Africa, and amongst its objectives are development and economic growth and the promotion and defence of peace. This project involves a study into the process of biotechnology capacity development in three universities in the SADC region. It involves the theory and application of biotechnology courses and a study of the epistemology of the teacher and learner involved. This project will be car-

ried out within the landscape of the objectives of the SADC countries, where it is envisaged that biotechnology can play an important role in the economic enhancement of the region. It falls within a larger project which has as its major objective to enhance co-operation and build partnerships at the Universities of Namibia (UNAM), Eduardo Mondlane (UEM) in Mozambique and Witwatersrand (WITS) in South Africa, and to build capacity in both the theory and applications of biotechnology through strengthening and introduction of relevant curricula. This is a Norwegian-funded, government-to-government development project called the South African-Norway Tertiary Education Development Programme (SANTED). SANTED's intention is to assist the South African Department of Education with transformation of the higher education system. This project also meets the objectives of the SADC protocol on education, one of which is to maximize the effective utilization of existing expertise, institutions and other resources for education and training and to ensure long term sustainability. This will hopefully eliminate duplication at the tertiary education level and facilitate staff and student exchange between the institutions.

Areas such as crop agriculture, animal and human health, food security and environmental sustainability are of utmost importance in southern Africa. It is envisaged that biotechnology can play an important role in addressing critical problems in these areas, and that the skills required to establish biotechnology knowledge is through capacity training at tertiary institutions. African countries cannot rely on R&D from the West because of the expense, thus there is a need to develop capacity in a sustainable way. Biotechnology has huge economic potential and a multidisciplinary training potential. It has become one of WITS's major research thrusts, in accordance with the global trend within the discipline. In recognition of this, UNAM and UEM have started introducing new courses to be included in their curricula through the SANTED programme. Regional co-operation will help build up and develop these current activities (Mthembu, 2006).

1.2. Literature Review: Inspirations

1.2.1. The nature of biotechnology

The area of biotechnology, which involves the manipulation of organisms to make products useful to man, dates back many centuries. Modern biotechnology involves manipulating DNA, and refers to the use of genetically modified (GM) organisms in agriculture and industry (Campbell and Reece, 2005). The first generation of biotechnology involves the use of biological organisms to produce food and drink. The second generation is the use of pure cell or tissue culture to yield new products, such as antibiotics. Plant tissue culture also has many applications, such as disease eradication and rapid clonal multiplication (Trigiano and Gray, 2000). The third generation involves the use of recombinant DNA technology. This has many uses from bioremediation to pharmaceuticals for human health care. There is a close relationship between universities and research institutions for the development and application of biotechnology which includes areas such as drug design, environmental remediation

and plant genetic engineering (Ireland and Hine, 2007), showing that biotechnology requires a convergence of skills of biochemistry, genetics, microbiology, information technology and engineering (Suslow, et al. 2002). Today's biotechnology is built on knowledge from areas of genomics and proteomics.

1.2.2. The nature of epistemology

Personal beliefs about the nature of knowledge and how humans develop knowledge has been termed 'epistemological beliefs' (Hofer, 2006). In education it is believed that these are closely related to how students learn. There is evidence of links between students' epistemological beliefs and the way they learn and their outcomes (Kang 2008). This also alludes that teacher's personal epistemologies are relevant to teaching actions. According to Kang (2008), research is beginning to show that the teachers' views influence teaching in terms of content and the way they teach and assess. In his study, Kang focused on identifying possible connections among teaching goals, epistemological beliefs and teaching actions and he argues that "*sophisticated epistemological beliefs about science reject the objective truth, recognize multiple realities and consider science knowledge as human construction*".

In an article (11 case studies) by Ryder and Leach (1999) they look into the impact that students images of science have on their activities in project work and the influence project work has on their images of science. In this article, epistemology is a key feature which runs through the different areas of the students' images of science. The authors feel that if there are images of science which limit student learning then such images would be a legitimate focus for future curriculum development, especially since they argue that teachers and supervisors have a critical role in identifying and developing students' images of science. Epistemic demand is important in teaching contexts, and hence it may then be significant to match the epistemic demands of the teaching task to students' understandings of the epistemology of science, and in the case of this study the epistemology of biotechnology.

1.2.3. The nature of science curricula and learning

Science curricula vary widely among countries; the most obvious differences are concerned with the particular topics and /or concepts to be included (Lederman, 1992). The same would apply to a biotechnology curriculum. The differences in course material and curricular content, which will be developed at the different SADC Universities, will be influenced by the environment within the different SADC countries and will take into account the effect globalization is having on the way learners and teachers view and receive knowledge at these different institutions. This term 'globalization' is used to represent global economic, political and social transformations which have reorganized capitalism in the West and it influences how people in developing countries view their world (Carter, 2005).

According to Lederman (1992), the development of adequate student conceptions of the nature of science has been an objective of science instruction regardless of chosen pedagogical or curricular emphases. Carter (2005) further states that globalization is implicated in the discourses of science education although it remains

under- acknowledged and under -theorized. She feels that it is important to find out to what degree current discourses in science education are improved following quality research into science teaching and learning. There appears to be wide agreement on one of the objectives of science instruction, which is the development of an adequate understanding of the "nature of science" or an understanding of "science as a way of knowing" (Lederman, 1992).

Laugksch (2000), argues that in education, the term 'scientific literacy' equates to the development of a person who is able to understand the nature of scientific knowledge, to use science in solving problems, and to appreciate the connections between science and technology, and between these two and society (Mollett and Hadingham, 2007). This demonstrates that there is a need for effective communication between the learner and the teacher as it requires that the teacher assumes how much scientific background knowledge can be taken for granted within the cohort of students s/he is teaching (Mollett and Hadingham 2007). In the southern African context this is especially true, since science is taught to students from widely diverse multicultural and multi-linguistic backgrounds. Rollnick (2007) argues that one of the great dilemmas internationally in educating learners in science is the tension between designing curricula that promote science for the scientist as opposed to science for the citizen. This would apply to the biotechnology curriculum development in this project, which would need to address a combination of science for the scientist with science for the community within a broader landscape of the epistemological access of the African teacher and learner.

Carter (2005) sums it up beautifully when she argues that knowledge is a fundamental resource of globalization, education is a major player in globalization and neoliberalism is the ideology of globalization. Educational studies are expanding as these relationships are being investigated. It has become clear that contemporary education needs to be considered together with globalization, especially since diversity, identity and fragmentation are recurring themes of globalization (Lederman 1992). Kang (2008) shows that we have personal epistemologies in two dimensions, the rational epistemological dimension, which represents knowing either as active construction of meaning or as receiving knowledge, and the ontological dimension which is either science as a collection of facts or information or science as both product and process of inquiry and thinking.

1.2.4. Objectives of this study

The background of this research is the regional and global landscape of biotechnology which will inform the development of skills and curricula in this field in the three SADC institutions. Within this landscape, the Teaching and Learning research objectives are to devise creative pedagogical methods for a biotechnology curriculum, incorporating the study of the epistemological access of teachers and learners in the SADC regions. In this paper we report progress of curricula development to date and the construction of a questionnaire designed to collect data which will demonstrate epistemological information.

2. METHODOLOGY

2.1. Development of biotechnology curricula

The first task was to develop a biotechnology curriculum at UNAM and UEM. The approach taken was a series of participatory workshops between the 3 institutions during 2006 and 2007. Due to a lack of resources, as was identified at the SANT-ED curriculum workshops, the development of creative and innovative pedagogical methods for the biotechnology curricula was identified as an important component in the future. It will be necessary to visit the SADC institutions in 2009 to collaborate in the development of teaching material and use team teaching to promote exchange of ideas and establish the epistemological images.

2.2. Epistemological access

According to Opie (2004) it is impossible to engage in research and not be concerned with epistemology and with epistemological questions and issues. The research problem in this project will require an in-depth study of teacher and learner epistemologies of biotechnology. We have chosen to do action research, within a

case study approach of teachers' and learners' epistemologies at the different universities. The literature on personal epistemology in science education will serve as a framework for data collection and analysis in biotechnology. Usually in a case study a global issue is explored through a specific case (Merriam, 1998), i.e. biotechnology is becoming a major research thrust globally and in this case at the micro level, the development of biotechnology capacity at WITS, UNAM and UEM. Action research is a methodological approach which involves interviews, questionnaires, observation tests and documentary analysis to collect information in order to evaluate teacher interventions of interactive learning. The data collected in this study will deal with identifying teachers' personal epistemologies at the beginning of the biotechnology courses and it will explore how they use their epistemologies to teach. This data will also identify learners' understanding of the presented material in order to accommodate both epistemologies (Mollett and Hadingham, 2006).

2.2.1. Data collection

In order to gather epistemological information, questionnaires for assessing biotechnology teaching and learning have been designed based on the case studies of Kang (2008). Triangulated data collection through these questionnaires will be gathered from the 3 institutions. We will also need to know the topic involved, the number of students, gender, ethnicity, characteristics of students and other parameters. Lecturers involved in teaching the biotechnology courses will be included in the case study. The learners selected for this study are final year (3rd year) undergraduate Bachelor of Science (BSc) students in the School of Molecular and Cell Biology at WITS (currently 60 students registered), and 3rd and 4th year students in the Department of Biological Sciences at UNAM (currently 49 and 22 registered respectively), and final year BSc students at UEM.

3. OUTCOMES

3.1. Development of biotechnology curricula

Through SANTED, various workshops between the 3 institutions have been held since 2006, and objectives that guide and direct the project activities have been identified, such as: (1) Cooperation in the design of academic programmes, (2) Collaboration in material development, (3) Review and sharing of teaching and learning materials, (4) Promotion of staff and student exchange programmes and (5) Development to address the challenges in the regions. Generic and Specific objectives were set for each institution, and the different skills and competencies in both human and other resources at each University were identified. Lists of available resources, desperately needed resources and wish lists were compiled. The tasks set at the last workshop were for UEM and UNAM to get the new courses approved and accredited. The Biotechnology curriculum at UNAM was approved by Senate at the end of 2007. These modules are in the 3rd and 4th years of the new curriculum and will be taught in 2009 and 2010. This will involve team teaching at UNAM in 2009. The Biotechnology topics developed for UNAM include an introduction to biotechnology; issues around GMOs; Genomics, Proteomics and Bioinformatics, together with all the genetics, biochemistry and microbiology applications and techniques involved for each topic. UEM have not finalized their curriculum yet, although there was agreement on the content to be included at the last workshop.

3.2. Epistemological access and data collection

These are in the process of being collated for presentation at the symposium..

4. PERSPIRATIONS

The success of this project will be evaluated on its sustainability and results of the questionnaire will be analysed and discussed.

5. REFERENCES

Campbell N.A. and Reece J.B. (2005) Biology. 7th edition. © 2005 Pearson Education, Inc., publishing as Benjamin Cummings.

Carter L. (2005) Globalization and Science Education: Rethinking Science Education Reforms. Journal of Research in Science Teaching, 42(5). pp 561-580.

Hofer K. (2006) Domain specificity of personal epistemology: resolved questions, persistent issues, new models. Educational Research, 45. pp 85-95.

Ireland D.C. & Hine D. (2007) Harmonizing science and business agendas for growth in new biotechnology firms: case comparisons from five countries. Technovation, 27. pp 676-692.

Kang N.-H. (2008) Learning to teach science: Personal epistemologies, teaching goals, and practices of teaching. Teaching and Teacher Education, 24. pp 478-498

Laugksch R.C. (2000) Scientific literacy: A Conceptual Overview in Science Education, 84. pp 71-94

Lederman N.G. (1992) "Students' and teachers' conceptions of the nature of science: A review of the research" Journal of Research in Science Teaching, 29(4). pp 331-359.

Merriam S.B. (1998) Qualitative research and case study applications in education: Revised and expanded from case study research in education. Jossey-Bass Publishers: San Francisco, CA.

Mollett J. and Hadingham J. (2006) Teaching and learning conversations for transformation: Practical teaching innovations and student growth. International Journal of Learning, 13(3). pp 65-72. Eds. Mary Kalantzis and Bill Cope. Commonground Publishing, ISSN 1447-9494 (Print), ISSN 1447-9540 (Online).

Mollett J. and Hadingham J. (2007) Metamorphosizing Madiba's Matrics: From Molecules to Mutants. The International Journal of Learning, 14(4), pp. 61-66. Eds. Mary Kalantzis and Bill Cope. Commonground Publishing. ISSN 1447-9494.

Mthembu T. (2006) South Africa-Norway Tertiary Education Development Programme. Institutional co-operation in the SADC region. Business Plan. March 2006.

Opie C. (2004) Doing Educational Research. A Guide to First Time Researchers. Sage Publications Ltd: London

Rollnick M. (2007) Key challenges in science education. The ABC of Learning. The Star Wednesday 6 June 2007, p 13.

Ryder J. and Leach J. (1999) University science students' experiences of investigative project work and their images of science. International Journal of Science Education, 21. pp 945-956

SADC History, Evolution and Current Status. http://www.sadc.int/about_sadc/history.php [Accessed: 31/ 01/ 2008]

Suslow T.V., Thomas B.R. & Bradford K.J. (2002) Biotechnology provides New Tools for Plant breeding. Agricultural Biotechnology in California Series. Publication 8043. © 2002 by the regents of the University of California, Division of Agriculture and Natural Resources. All rights reserved.

Trigiano R. and Gray D. (2000) Plant Tissue ulture Concepts and Laboratory Exercises. 2nd Edition. ISBN 0-849302029-1. CRC Press.

6. ACKNOWLEDGEMENTS

The authors would like to thank SANTED and the Faculty of Science at the University of the Witwatersrand for financial support.

ENHANCING PRE-SERVICE STUDENT PEDAGOGICAL CONTENT KNOWLEDGE AND SUBJECT CONTENT KNOWLEDGE OF THE ROCK CYCLE USING DIFFERENT REPRESENTATIONS

Bill MacIntyre
School of Curriculum and Pedagogy, College of Education, Massey University PN 900
Palmerston North, New Zealand
w.r.macintyre@massey.ac.nz

▼ Abstract

Recent research on the use of multiple and multi-modal representations provide the background for this exploratory study on how pre-service primary teachers interpret (translate) different representations of the rock cycle into pedagogical and subject content knowledge. Pre-service teachers' interpretations are presented and discussed. The findings are linked to *The New Zealand Curriculum* (2007) and the planning and teaching of the rock cycle to primary and/or middle school students.

Key Words representations, pedagogical content knowledge, rock cycle

1. INTRODUCTION

This exploratory study investigated the premise that if pre-service teachers interacted with carefully sequenced multiple and multi-modal representations of the rock cycle that they would develop a scientific understanding of the subject knowledge content. In addition to understanding the subject knowledge content the pre-service students would perhaps develop their pedagogical content knowledge.

There are three inter-weaving threads in the thinking behind the premise. The first is the expanding literature into the research of multiple and multi-modal representations (Ainsworth, 1999; Prain & Waldrip, 2006; Tytler, Prain & Peterson, 2007) with primary, middle and secondary school students and the lack of research into pre-service student's interactions with representations and learning subject knowledge content. The second thread was the revised *New Zealand Curriculum* (Ministry of Education, 2007) that places an emphasis providing students in classrooms with opportunities to learn and develop a range of key competencies, one of which is *using language symbols and texts*. The third thread is aligned with the notion implied in the Van Driel, De Jong, and Verloop (2002) literature review of pedagogical content knowledge (PCK) that specific courses or workshops might help with the development of PCK. The three threads came together in the following question: Could a brief but planned intervention, using multiple and multi-modal representations, as-

sist with the development of the subject and pedagogical content knowledge in pre-service students?

2. BACKGROUND

As science education moves further into the 21st century there is a growing recognition that science understanding develops through the use of multiple and multi-modal representations of the same concept or process (Ainsworth, 1999; Prain & Waldrip, 2006; Tytler, Prain & Peterson, 2007). There is general agreement that representations can be categorised as descriptive, gestural, figurative, experimental, mathematical, or kinaesthetic of the same concept/process.

Tytler et al(2007) distinguishes between 'multiple' and 'multi-modal' representations. Multiple representations refers to the strategy of using a different form to represent the same concept / process over a series of repeated visits. Multi-modal representation on the other hand is the integration of different forms of representation during the teaching. The act of integrating different modes (multi-modal) during the discourse demonstrates how the same science concept can be represented in different forms (Tytler et al, 2007); provides students with an understanding about scientific inquiry (Prain & Waldrip, 2006) and it gives opportunities for students to decode features and make links across the representations (Ainsworth, 1999). As suggested by Tytler (2003), integrating multi-modal representations is an effective teaching strategy however does it also enhance pedagogical content knowledge of the teacher?

Much has been written and researched since Shulman (1987) included pedagogical content knowledge (PCK) as a knowledge base for practising teachers. He defined PCK as "represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (1987, p. 8). The discourse around the inclusion of PCK in teacher education, in particular science education, has been articulated by Appleton, 2006; Bucat, 2004; Loughran, Berry & Mulhall, 2006; Van Dijk & Kattmann, 2006; Van Driel, De Jong & Verloop, 2002 and Van Driel, Verloop & De Vos, 1998. In particular Bucat (2004) and Van Driel et al (1998) note that that topic specific PCK research on science teachers is lacking.

In this exploratory study the attempt is to focus on what Van Dijk & Kattmann (2006) identify as 'PCK as a knowledge domain' in teacher training rather than 'PCK as an educational concept'. They assert that prospective teachers cannot transfer *teachers' PCK* directly from expert teachers' PCK. Van Dijk & Kattmann go on to say that, "the *teachers' PCK* (author's emphasis) has to be structured or 'reconstructed' in order to be transferred from expert teachers to other, prospective teachers in teacher education" (2006, p. 889). In many ways this is the *art* of teaching for understanding in teacher education. A *new media* is selected for a particular concept or an *existing media* is manipulated to ensure understanding of the concept. In the context of the rock cycle, a range of existing representations is used to develop pre-service students' subject content knowledge.

3. METHODOLOGY

3.1 The exploratory study involved pre-service students (n = 24) who were enrolled in a thirty-hour compulsory science curriculum (methods) paper taught by the author. The students are studying in the one-year Postgraduate Diploma in Teaching (Primary) programme. One component in the paper focuses on a 'Planet Earth and Beyond' concept – the rock cycle. It is a common science topic taught by teachers in school years 7-10 (age 12-15).

Pre-service students require a subject content understanding, pedagogical understanding and a pedagogical content understanding of the rock cycle if effective teaching and learning is to take place in the classroom. Rather than focus on how pre-service students negotiated classroom representations in general as has been happening in previous classes, there was a narrower focus on representations for a specific science concept – the rock cycle. The author re-structured his PCK to teach the science content knowledge so that the students would experience multiple and multi-modal representations of the rock cycle and therefore provide continued development with their nature of science understanding. The re-structuring in this preliminary study was guided by the following three questions.

Question one: What science understanding of the rock cycle do students decode (translate) from each representation?

Question two: Is there a pattern in the students' interpretation of the representations?

Question three: Were students able to generate a personal PCK for the teaching of the rock cycle? If so, is there a pattern?

In order to select appropriate representations that lead to rock cycle understanding, specific science sub-concepts were identified. They are:

1. is a closed system on planet earth.
2. involves three (3) general forms of rock – sedimentary, igneous and metamorphic that are linked to each other.
3. involves specific processes to change from one form of rock to another.
4. involves an intermediate product when changing to sedimentary or igenous.
5. has cycles within *the cycle* and may never have been all three forms.
6. movement from one form to another is by 'chance' and it is not predetermined.
7. involves what Dodick & Orion (2002) note as a cornerstone of earth science - 'deep time'.

3.2 Three representations were chosen to communicate the science understanding listed above. The first representation (Figure 1) is taken from *Weathering and Erosion – The Shaping of our landscape* Book 2 (Ministry of Education, 2000). The mode for the first was a figurative – pictorial representation – a simple 2D diagram of the rock cycle illustrated with arrows linking the three types of rocks. It also demonstrated in brief form the structure of the three rocks.

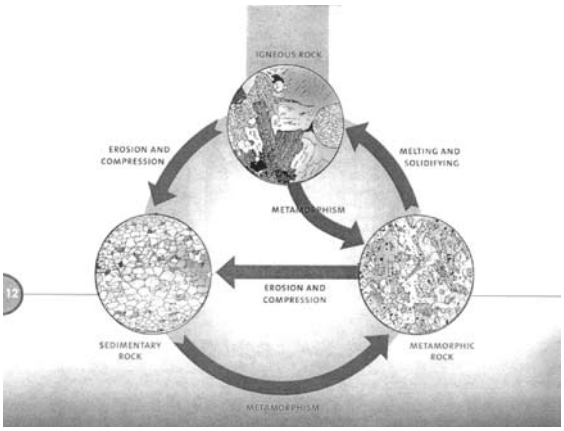


Figure 1 The Rock Cycle (MoE, 2000)

3.3 The second uses a representation from *Stories in stone* (Cuff, 1995). The mode for the second was the same as the first, figurative – pictorial, but consisted of 4 overhead projector transparencies that could be laid on top of one another to demonstrate the complete rock cycle by the fourth transparency. This series of transparencies is shown in Figure 2.

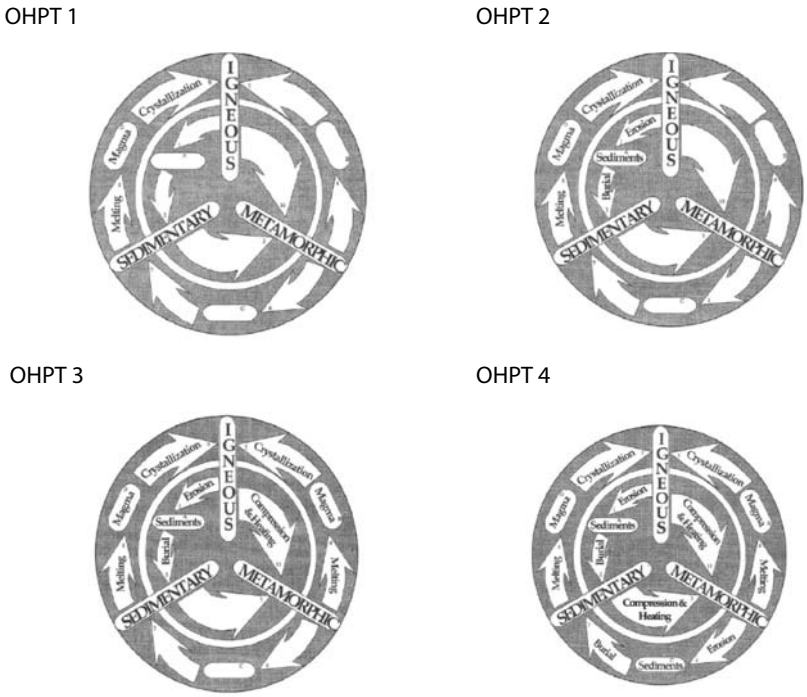


Figure 2 The rock cycle represented by four transparencies (Cuff, 1995)

3.4 The third involves an activity described in *The Science Teacher* - Rock Cycle Roulette by Schmidt & Palmer (2000). Where as the first two representations are figurative – pictorial, the third representation is a multi-modal representation that involves the kinaesthetic, figurative (analogous & metaphoric) and mathematical. The students are actively participating in the role-play during the multi-modal representation. The students identify a mineral (jasperite, halite, galena etc) or element (gold, iron, zinc, platinum etc) that they want to be in the role-play.

Each station has a die with instructions on each side and students can start at any station. Student throws the die and follows the instruction. Each throw of the die accounts for 250,000 years of time. Students record the time, the station and the instruction on a paper. Twenty or so minutes are sufficient time for this representation.

3.5 At the beginning, students were asked to record their prior knowledge about the rock cycle. The teaching and learning sequence during the class followed the same sequence as presented above. The author introduced each representation. Students' previous experience with representations prompted the question: *what do I see?* This strategy ensured that students were observing the same symbols / features on the representation before any discussion on *what those symbols / features might translate into*. Discussion about the representation and the 'decoding' of the symbols / features into science understanding of the rock cycle was done for each. In the third representation a series of questions guided the 'decoding' of the role-play. Students were asked to respond, in written mode, to two questions at the end of each representation. Those questions are:

- What specific science understanding did you learn by engaging / interacting with this representation?
- How does this representation assist in developing your science understanding of the rock cycle?

In bringing closure to the session students were asked, how did all three representations assist in developing their (a) science understanding of the rock cycle? and (b) pedagogical content knowledge (PCK) for the rock cycle?

4. RESULTS

4.1 There were sixteen (16) students who provided statements or diagrams about their prior knowledge of the rock cycle. Statements such as *there are 3 types of rock; I think that it involves some rocks called igneous, sedimentary and some others I can't remember*; and *the rocks change from one type to another; the two main types are volcanic and sedimentary; loose materials become rocks* are typical of those that responded.

4.2 Figure 3 provides a summary of the students' response (> 4) for the science understanding that was decoded for each representation. A decision was made to include all original science sub-concepts (indicated by *) as well as those science understandings that had student response greater than 4 but could not be placed in the seven sub-concepts.

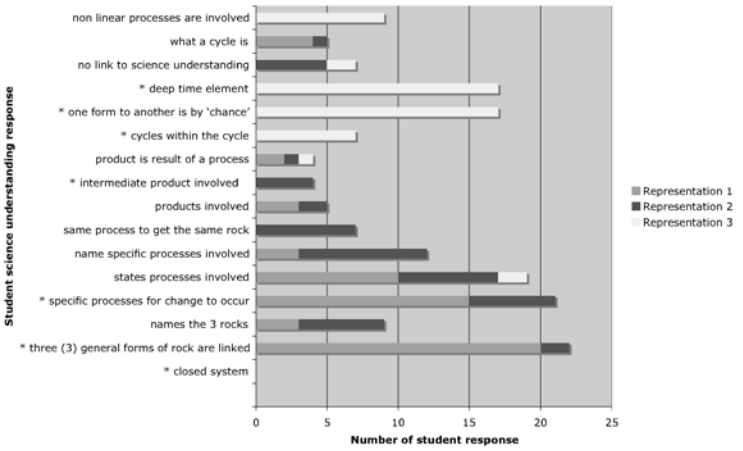


Figure 4 Student science understanding response to three representations

4.3 The responses of the students to developing their pedagogical content knowledge (PCK) from the three representations are summarised in Table 2. Multiple responses from students were allowed and recorded. The responses were analysed and then categorised.

Table 1 Summary of students' responses to their developing pedagogical content knowledge (PCK) for the rock cycle

Areas of response to the question: how did the three representations assist in developing their pedagogical content knowledge (PCK)?	Number of students responding
❖ representations, all or some, are mentioned as useful	5
❖ need to use multiple representations	5
❖ need to use multiple representations to enhance deeper (greater) understanding to enhance rock cycle understanding	7
❖ need to sequence rock cycle representations carefully	3
❖ identifies a characteristic of rock cycle representations that enhances learning	1
❖ critiques rock cycle representation(s) with supporting science understanding	2
❖ critiques rock cycle representation(s) with supporting learning and teaching justification	1
❖ each rock cycle representations has value	3
❖ use simple, repetitive and informative rock cycle representations	1

It should be noted that nine (9) students focussed on the science understanding and did not mention or link rock cycle representations to their developing PCK.

5. DISCUSSION

5.1 What science understanding of the rock cycle do students decode (translate) from each representation? and is there a pattern in the students' interpretation of the representations?

In the first representation, the students' response focused on either the 'processes' concept or that the 'three types of rocks are linked' in the rock cycle. The decoding of the arrows and the three circles in the diagram indicate that some students were successful in acquiring some rock cycle understanding – two of the seven identified science sub-concepts. What is encouraging is the science understanding that specific processes are require for rocks to change from one type to another. What is not shown in Figure 4 is the fact that five (5) students indicated that they have learnt that 'representations can be interpreted differently' for their rock cycle understanding. This clearly demonstrates a PCK link but one has to wonder if these statements were place under the wrong question.

The second representation's intentions was to develop rock cycle understanding that the same process is used to form igneous, or form sedimentary or form metamorphic rock no matter what is the source of the rock. The students (n = 7) that responded with a similar statement support this assertion. The sequential overlays were meant to assist in the decoding and it appears that it has achieved its intention. This representation also indicates that both igneous and sedimentary have an intermediate product between two processes. There is little support (n = 4) that students decoded this feature for themselves.

Overall the 'processes' appear to be much clearer to decode from these features than the first but the total number for both are similar. In the first n = 31 and for the second n = 31. What appears to have happened is that different students decoded different aspects for the processes. One should also note that more students (n = 6) identified the three types of rocks with this representation. On a negative side is the fact that five students could not make any links to rock cycle understanding with this representation.

The questions linked to the last representation should have allowed students to decode the features of their role-play with an rock cycle understanding of geological time, the randomness of the process and the cycles within *the rock cycle*. The decoding success is evident with the high number of responses (n = 17, n = 17 and n = 7) for those three science sub-concepts. What is important to note in this representation is the nine responses that indicated the rock cycle does not have linear processes. Perhaps the thinking behind this response is that there was no arrows in this representation to direct the processes and for them arrows decode as linear. So when these students see arrows they decode them as linear.

None of the three representations on the rock cycle was decoded as a close system. This could be due to a missing representation that could be decoded or perhaps the understanding of open and closed systems was missing from their personal understanding. It appears that many pre-service students chose to select the easiest path to developing their science understanding and as a result did not achieve an in-depth understanding of the rock cycle. Their responses were simple, short and did not re-

flect the decoding that should have taken place even though the focus was made explicit to them. On the other hand it could have been the way the representations were presented or the selection that did not matched the understandings embedded in the rock cycle concept.

5.2 Were students able to generate a personal PCK for the teaching of the rock cycle? If so, is there a pattern?

Van Driel, De Jong & Verloop (2002) indicate that PCK is the professional 'practical' knowledge that cannot be learnt from a textbook and is believed to be developed through experience with teaching subject content knowledge. In doing so, the teacher gains an understanding of the learning difficulties associated with the specific subject content knowledge. The pre-service students encountered their own difficulties with understanding the rock cycle and would those difficulties allow a personal PCK of the rock cycle to develop.

The evidence in Table 2 does appear to support the notion that some of the pre-service students did develop a personal PCK for the rock cycle. Eight of the nine response areas reflect the professional 'practice' knowledge that Van Driel et al (2002) talk about. All eight link to teaching the rock cycle with four (n = 14) of the eight areas articulating specific relevance to science understanding, teaching and learning. The students (n = 3) who responded that each rock cycle representation has value demonstrate an indirect practical knowledge that representations have on student learning. This response could not have been made without internalising their learning experiences with the multiple and multi-modal representations. To say that the internalisation of linking multiple and multi-modal representations with students learning will actually occur in the classroom remains unclear at this time. It is the nine students (37% of the students who participated) who did not respond about their developing PCK that one should be concerned about in the classroom. Was their PCK understanding an 'educational context'? If so, what is their next step?

6. CONCLUSION AND NEXT STEPS

There is evidence that the structured sequence of the rock cycle multiple and multi-modal representations did develop science understanding but not to the level that the author expected. At the same time, the pre-service students appeared to have responded with statements that indicate a 'developing' understanding of their own PCK.

In reflecting on the methodology, there are some obvious features that need to be included if specific science understanding is to be enhanced as a student moves from one rock cycle representation to the next. Explicit questions such as: What is different in this representation from the previous? What is similar in this presentation to the previous? are important for the development of meta-thinking in students. Inclusion of an activity that allows students to make their own rock cycle representation not only enhances development of science understanding but it also helps students understand how scientific understanding is communicated. Refinement of the questions after each representation is essential as there is indication that the students' response could have been misdirected by the question.

7. REFERENCES

Ainsworth, S. (1999). The functions of multiple representations. *Computers & Education, 33*, 131-152.

Appleton, K. (2006). Science pedagogical content knowledge and elementary school teachers. In K. Appleton (Ed.), *Elementary science teacher education: International perspectives on contemporary issues and practice* (pp 31-54). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Cuff, K. (1995). *Stories in stone.* Berkeley, CA: Lawrence Hall of Science (GEMS).

Bucat, R. (2004). Pedagogical content knowledge as a way forward: Applied research in chemistry education. *Chemistry Education: Research and Practice, 5*, 215-228.

Dodick, J. and Orion, N. (2002). Measuring student understanding of geological time. *Science Education, 88*, 708-731.

Loughran, J., Berry, A., & Mulhall, P. (2006). *Understanding and developing science teachers' pedagogical content knowledge.* Rotterdam, The Netherlands: Sense Publishers.

Prain, V. and Waldrip, B. (2006). An exploratory study of teachers' and students' use of multi-modal representational of concepts in primary science. *International Journal of Science Education, 28*(15), 1843-1866.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 1-21.

Tytler, R. (2003). A window for a purpose: developing a framework for describing effective science teaching and learning. *Research in Science Education*, 33(3), 273-298.

Tytler, R., Prain, V. and Peterson, S. (2007). Representational issues in student learning about evaporation. *Research in Science Education*, 37(3), 313-331.

Van Dijk, E. M. and Kattmann, U. (2006). A research model for the study of science teachers' PCK and improving teacher education. *Teaching and teacher education, 23*, 885-897.

Van Driel, J.H., Verloop, N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching, 35*, 673-695.

Van Driel, J.H., De Jong, O., & Verloop, N. (2002). The devlopment of preservice chemistry teachers' pedagogical content knowledge. *Science Education, 86*, 572-590.

SOLVING FRACTION PROBLEMS WHICH ARE REPRESENTED IN A CONTEXT

Dr. Yeliz Yazgan, Prof. Dr. Murat Altun
Uludag University Education Faculty Istanbul University Education Faculty
yazgany@uludag.edu.tr maltun@uludag.edu.tr.

▼ Abstract

In this study, answers of Turkish 317 fourth and fifth grade students to a written test that includes 6 open-ended and 2 multiple choice questions about fractions were evaluated to obtain information about their understandings of fractions. In the open-ended questions, students were asked to make drawings about situation in the questions. For 2 multiple-choice questions, written explanations about the choices of students were asked. Answers of pupils were coded as 0, 1, 2 and 3. Results showed that students could hardly reason or develop strategies when the questions about fractions were open-ended or were presented in a contextual framework.

Key Words fractions, teaching of fractions, primary school

1. INTRODUCTION

Many children have difficulty in developing conceptual knowledge about fractions concerning number sense, operation sense and algorithmic skills (Behr et al. 1992). Procedural knowledge, such as algorithms for operations, is often taught without context or comprehension and this implies that algorithms are only mastered through memorization.

There are many studies about children's understandings of fraction. CSMS (Concepts in Secondary Mathematics and Sciences) team (Hart, 1981) constructed and conducted two tests for fractions, for 12 - 13 years olds, one for 14 - 15 years old, respectively. For the first group, test involved giving a fractional name for parts of a given shape or for a subset of a collection of objects, comprehending the idea of equivalence, adding fractions with the same denominator and with a denominator that was a multiple of other, and subtracting a fraction from 1. For the second group, the test included testing how well the children could generalise the concept of fraction in addition to the item described above. Multiplication was put in the context of finding area and also in rate. Results obtained by those tests can be summarized as followed: a) In many cases, contextual problems proved easier than their comparable computations, which suggests that children used strategies other than algorithms. b) Many children do not feel confident in the use of fractions and try whenever possible to apply the rules of whole numbers to fractions. c) Another sign of lack of ease with fractions is the insistence on giving an answer in remainder form rather than

fractional form. d) Diagrams often help towards the solution of the problem. e) The ability to solve addition and subtraction computations declines as the child gets older. f) The hardest problem group for children concerns of multiplication and division problems.

Aksu (1997) investigated differences in student performance when fractions were presented in the contexts of (a) understanding the meaning of fractions, (b) computations with fractions, and (c) solving word problems involving fractions. A test on fractions involving three parts (a concept test, an operations test, and a problem-solving test) was administered to 155 sixth-grade students. The results of this test showed that student performance was highest on the operations test and lowest on the problem-solving test. No differences in performance on four operations were observed when fractions were presented in computations. Addition problems were the simplest to perform in word problems, and multiplication problems were the most difficult.

Leen Streefland (1991), designed an experimental study including numerous examples of intuitive, fractional knowledge building with 16 middle primary school children followed over a two year period. They linked fractions and ratios and emphasized connections and relations. Clinical interviews resulted in 5 indicators of development of rational number learning: (1) concept acquisition and IN-Distractor errors (2) progression in schematising (3) flexible use of models (4) the application of schemes and diagrams (5) ability to imagine or contextualize formal problems; and individual constructions and productions on a symbolic level.

As for the place of fractions in standards and curriculum, in the Principles and Standards for School Mathematics (NCTM, 2000), expectations about fractions are expressed as followed: In grades 3–5, all students should develop understanding of fractions as parts of unit wholes, as parts of a collection, as locations on number lines, and as divisions of whole numbers; use models, benchmarks, and equivalent forms to judge the size of fractions; recognize and generate equivalent forms of commonly used fractions; develop and use strategies to estimate computations involving fractions in situations relevant to students' experience; use visual models, benchmarks, and equivalent forms to add and subtract commonly used fractions.

According to primary school mathematics curricula of Turkey (Milli Egitim Bakanligi, 2004), 4th grade students should have those abilities about fractions: naming fractions by using unit fractions, showing fractions on number line, comparing fractions, ordering (maximum 4) fractions with same denominators or numerators, finding a common fraction of a given whole, adding and subtracting two fractions with same denominators, solving problems that require addition or subtraction of common fractions. 5th grade students should be able to convert mix numbers and improper fractions to each other, to compare a natural number and a fraction, to order (maximum 5) fractions that have same denominators or denominators that are multiple of each other, to write fractions that equal to a given fraction, to determine a whole from a given common fraction, to add and subtract that have same denominators or denominators that are multiple of each other, to add and subtract a natural number and a fraction, to solve and construct problems that require addition and subtraction and to find "fraction of a fraction".

To sum up, when the findings in the prior studies, objectives in the standards and curriculum about teaching of fractions are examined, those points are conspicuous: Students must be provided rich and concrete contexts at the beginning of teaching of fractions, and they should have sound knowledge about basic concepts and skills such as unit fraction, ordering fractions, judging size of the fractions before they have been taught too formal rules. Based on these theoretical framework and findings of studies, the aim of the present study was to evaluate answers of fourth and fifth grade students to a written test in which questions about fraction were represented in contexts instead of direct computations or classical word problems in order to obtain information about their understandings of fraction.

2. INFORMATION ABOUT INSTRUMENT

The test that was used in the present study is the pre-test of an experimental part of a research by the author. Theoretical framework of research was based on Realistic Mathematics Education and Constructivism, and its aim was to examine effects of an experimental learning environment that focused on sharing situations and concepts constructed in group- and whole class discussions on students' fraction concepts. To choose an experimental and control group, pre-test prepared by the author was applied to all 4^{th} and 5^{th} grades of two randomly selected primary schools in Bursa, Turkey (206 4^{th} grades students, 111 5^{th} grade students). All student answers were coded as 0 (not correct), 1 (partly correct), 2 (almost correct) and 3 (completely correct). Based on this coding system, Croanbach Alfa coefficient of test was founded as 0.80.

Content of the instrument was prepared in the according to primary school mathematics curricula of Turkey. However, questions in Hart (1981)'s study, activities in Streefland (1991)'s study, explanations about teaching of fractions in the Principles and Standards for School Mathematics (NCTM, 2000) were taken into account for contexts and forms of questions.

In the following, all questions in the test and aims of each question are represented:

Question 1: *Meryem and Ibrahim got their weekly allowance from their fathers Mustafa and Yusuf, respectively. Meryem spent 1/4 of her allowance and Ibrahim spent 1/2 of his allowance in one week. Choose one of choices that you believe it is true and explain shortly why you have chosen it.*

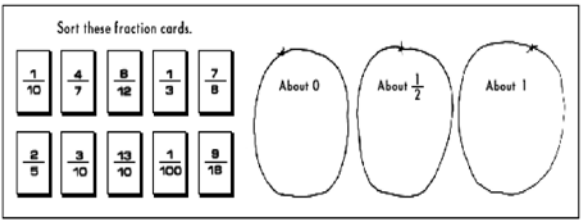
a) Meryem spent more. Explanation:
b) Ibrahim spent more.
c) Both of them spent equal amount.
d) It can not be decided that who spent more.

In the question above, students are expected to realize that amount of money at the beginning should be known to allow for a comparison.

Question 2: *Vedat, Gul and Ege go to a pizza restaurant and they order 3 pizzas. But when the pizzas are served, they think that pizzas won't satisfy them and they order two more pizzas. Can you help them sharing the pizzas by drawing pictures? Please express by fractions that how much pizza each person eats.*

Second question is used to find out whether students can deal with equal sharing and if they can write the result of this sharing as a fraction. In addition, knowledge of students about improper fractions and mixed numbers can be examined in this way.

Question 3:



In third question, we aimed to determine that whether students have any notion of comparing fractions by referencing 0, 1/2 and 1. Students may use different methods like taking advantage of equal fractions or drawing pictures to decide whether a fraction is equal to a half; or bigger/smaller than a half.

Question 4:

Can you write fractions for shaded parts of the shapes above? If you can, please write fractions under each shape (you are allowed to make drawings on the shapes).

Aim of Question 4 is to understand soundness of unit fraction concept of students. To be able to write fractions for shaded parts, students should identify unit fractions for each of them. They can do this by drawing extra lines on shapes, or in their minds.

Question 5: *A family consisting of Father, Mother, Mete and Ceren had 2 pizzas for lunch. The first one was shared equally. Mother then cut the second pizza into four parts too, but said, "I've had enough. You three can share this one." But Ceren said "No, one of these pieces (of the second pizza) is enough for me." She turned to Mete and her father and said "You two can divide the rest." How much pizza did each person eat? Show with pictures and write as fractions.*

To solve Question 5, students have to make careful drawings for share of each person and express those as fractions. They can make use of finding common denominators or adding fractions to determine shares of Father and Mete.

Question 6: Elif's father brought chocolate for her. On the first day, she ate 1/3 of whole chocolate. And on the second day, she ate half of the chocolate that she ate on the first day. Show the chocolate that Elif ate on the second day by drawing pictures and express what fraction of whole chocolate it is?

Purpose of Question 6 is to establish whether students can find "fraction of a fraction" by drawing. They need not to know formal rules for multiplication of fractions.

Question 7: Mehmet and Cem prepared lemonade for themselves. Mehmet used 4 spoonfuls of sugar for 3 lemons and Cem used 8 spoonfuls of sugar for 6 lemons. Select one of choice that you believe it is true and explain shortly why you have selected it.

a) Two lemonades are sweet at the same extent. Explanation:
b) Mehmet's lemonade is sweeter.
c) Cem's lemonade is sweeter.
d) It cannot be decided whose lemonade is sweeter.

Question 7 is about understanding fractions as ratios. Students are expected to be able to see relationship between numbers, and to determine that their levels of sweetness are the same.

Question 8: Oya and Nil were discussing about a task. The task was to compare 5/6 and 7/8. Oya said: "I think 5/6 is bigger." As opposed to her, Nil said: "No, 7/8 is bigger. You can look at the parts that complete the whole." Can you explain what Nil meant? (If you want, you can draw picture/s.)

For Question 8, children may come up with argumentation like: "7/8 is bigger than 5/6. Because in case of 7/8, 1/8 remains, and in case of 5/6, 1/6 remains. 1/8 is less than 1/6, so 7/8 is bigger."

3. FINDINGS

In this part, findings that were obtained from research will be explained. First, the quantitative data (frequencies and means) are represented in Table 1. We may summarize the results as follows:

- For the first question, only 7 students noticed that determining who spent more is impossible since there is no information whether amounts of the allowances are equal or not,. 28,1 % of the students made a direct comparison between a half and a quarter.

		Frequences (Percentages)			
Q	**Means**	**0**	**1**	**2**	**3**
1	0,35	221 (69,7)	89 (28,1)	0 (0)	7 (2,2)
2	0,78	195 (61,5)	27 (8,5)	66 (20,8)	29 (9,1)
3	0,94	148 (46,7)	70 (22,1)	68 (21,5)	31 (9,8)
4	0,96	144 (45,4)	97 (30,6)	20 (6,3)	56 (17,7)
5	0,38	235 (74,1)	48 (15,1)	29 (9,1)	5 (1,6)
6	0,70	211 (66,6)	18 (5,7)	61 (19,2)	27 (8,5)
7	0,38	277 (87,4)	0 (0)	1 (0,3)	39 (12,3)
8	0,18	279 (88,0)	27 (8,5)	3 (0,9)	8 (2,5)

Table 1 Some descriptive statistics about questions.

- Answers to second question showed that only 38, 4 % of the students got any score (1, 2 or 3). Although most of these students drew correct figures, they were not able to write true fractions.
- Third question has a really high mean, compared that of the other questions. Students were able to easily sort 1/10 and 1/100 as "about 0", 13/10 and 7/8 as "about 1" and 9/18 as "about half". But rest of the fractions proved more difficult to sort.
- Reaching the highest mean, fourth question indicates that almost half of the students have a notion of unit fraction less or more. Some of the students drew extra lines in their mind instead of paper, while some of them found fractions for some pictures by changing place of shaded parts.

- For fifth question, percentage of completely correct answers is the lowest of all questions. Most of the students could find Mother's and Ceren's share easily, but as to shares of Father and Mete, only a few students managed to draw Father's and Mete's shares and express them as fractions. Some students used formal rules for addition of fractions.
- The mean of sixth question is also quite high. Although they had not been taught formal rules about multiplication of fraction, children could deal with this question by drawing pictures.
- In seventh question, some of the students reasoned like these: "6 and 8 are bigger than 3 and 4. So, Cem's lemonade is sweeter.", "4 minus 3 is 1, 8 minus 6 is 2. Therefore, the answer is c.", "4 plus 3 is 7, 8 plus 6 is 14. That is why Cem's lemonade is sweeter." Although a lower mean, percentage of completely correct answers for this question is quite high.
- Eighth question has the lowest mean. Most outstanding strategy that children tried to work out this question was to draw shapes for each fraction and than compare parts. Only 8 students considered left over parts of the fractions.

4. DISCUSSION

When results of present study are examined as a whole, it can be noticed that all of the means are below 1. These low means can stem from the fact that students are only familiar with traditional computations and word problems about fractions. That is, they could hardly reason or develop strategies when the questions about fractions were open-ended or were presented in a context. This finding partly corresponds to Aksu (1997)'s finding in which student performance was lowest on the problem-solving test.

If we look at the two questions with high means, it can be observed that most sound concepts of students are unit fractions and comparing fractions in reference to numbers, such as 1 or 1/2. In contrast, students could not figure out sometimes 1/4 can be bigger than 1/2 if wholes are not equal to each other.

Another finding is that students do not have much experience about fractions as ratios. Answers to 7th question about this subject show that students considered numbers separately and tried to apply their knowledge about whole number to solve the question. This finding is also similar to that of Hart (1981).

An interesting observation about the answers of students was that although drawing pictures contributed to solutions, most of the students were not able to reach completely correct answers with help of pictures that they drew. They needed rules or algorithms to be sure of their own answers. This is another indicator of that they learned algorithms without linking to the algorithms to conceptual knowledge.

Someone may object to combine test results of 4th and 5th grades. However, test questions were prepared by taking into consideration basic concepts and skills that both 4th and 5th grade students had to acquire by the time they had reached these grades.

Although many contemporary mathematics education approaches and mathematics curriculum had focused on understanding instead of computation many decades

ago, results of this study showed that emphasis in fraction teaching is still primarily on computation and procedural knowledge.

To solve this problem, children must be engaged in contexts relating to daily life, and for developing meaning, they must be encouraged to use the conceptual knowledge that they had constructed already.

5. REFERENCES

Aksu, M. (1997). Student performance in dealing with fractions. *The Journal of Educational Research*, Vol90 (6), 375-380.

Behr, M., Harel, G., Post, T., & Lesh, R. (1992). Rational number, ratio and proportion. In D. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 296-333). NY: Macmillan Publishing.

Hart, K. M. (1981). Fractions. In K. M. Hart (Ed.), *Children's understanding of mathematics: 11~16.* London: John Murray Ltd.

Milli Egitim Bakanligi (2004). *İlkogretim matematik dersi (1-5. siniflar) ogretim programi.* Ankara: Devlet Kitaplari Müdürlügü Basimevi.

National Council of Teachers of Mathematics (2000). *Principles and standarts for school mathematics*. Reston/VA: National Council of Teachers of Mathematics Pub.

Streefland, L. (1991). *Fractions in realistic mathematics education: A paradigm of developmental research.* Dordrecht: Kluwer Academic Publishers.

EFFECTS OF CONCEPTIONS RELATED TO FUNCTIONS ON STUDENT TEACHERS' SCENARIOS FOR CLASSROOM PREPARED BY USING CABRI GEOMETRY

Savas BASTURK
University of Marmara, TURKEY
sbasturk@marmara.edu.tr

▼ Abstract

The new secondary Turkish curriculum emphasizes adaptation of new technologies in mathematics courses as seen curriculum of several countries. One of the reasons for this recommendation is the fact that the computer is a tool often used in everyday life and, above all, it may be very well integrated with mathematics. Many researchers in teaching mathematics indicate that the quality of given formation in student teachers and in-service teachers training is very important for a successful integration. The aim of this study is to determine the effects of student teachers' conceptions related to the concept of function on their scenarios for classroom prepared by using the software Cabri geometry The sample of the research included 20 student teachers at the Department of Secondary Mathematics Education, Faculty of Ataturk Education, Marmara University. In the course entitled "Instructional Technologies and Materials Development" the working Cabri was presented and students were trained to make geometrical and mathematical applications to be able to use it. In class, we asked student to prepare a scenario for classroom to teach in first year high school students the concept function by using Cabri. Students individually worked with a computer during about 30 minutes. The research data were obtained from interview conducted by researcher with four students who can achieve to prepare a proposal activity. The data collected were analyzed and interpreted using the methods of qualitative analysis. As regards to the principal result of the research, the fact that student teachers have only the set correspondence approach to functions (conceptions linked to this approach) appears as a barrier to better using of Cabri.

Key Words Student teachers, Cabri geometry, conceptions, function concept, scenarios for classroom

1. INTRODUCTION

The new secondary Turkish curriculum emphasizes adaptation of new technologies in mathematics courses such as curriculum of several countries. One of the reasons for this recommendation is the fact that the computer is a tool often used in everyday life and, above all, it may be very well integrated with mathematics (Chaachoua & al.,

2000). Many researchers in teaching mathematics indicate that the quality of given formation in student teachers and in-service teachers training is very important for a successful integration. Student teachers should be trained with the motivation of using of new technologies in their class. In addition, several researches about students using technology show that they do not learn from simply interacting with technology. The design of appropriate tasks, the role of the teacher plays a critical role in the success of integrating technology (Laborde, 2004). So, it is necessary to organize activities well prepared and well chosen by the teacher.

The aim of this study is to determine the effects of student teachers' conceptions related to the concept of function on their scenarios for classroom prepared by using the software Cabri geometry. In the following paragraphs we briefly describe what we mean by conception and its importance in the teaching and learning of mathematics. After that, we present students' conceptions related to the function concept in the light of literature.

1.2 Theoretical Approach for Conceptions

According to the dictionary "the keys concepts in pedagogy" (Raynal & Rieunier, 1997), conceptions are "*implicit*" or "*explicit models" that learners refer to, for describe, explain, and understand an event or a situation.* In this definition, the term "learner" is not restricted to a student who learns in a classroom but it refers, in general, to an individual who has received (or receives) elements of knowledge. As a result, it is possible to talk about conceptions of teachers, students, a given social group, or a given individual. In the same way, Clément (1994) proposes conjectural conceptions: *"what a person, for example, a student or an adult expresses before or during learning…, doesn't reflect directly all of his/her conceptions, but his/her conjectural conceptions: those involved in precise situation (dialog, learning, realization of a task, …)".* Giordan (1998) reinforces this idea: *"Closely related to history of an individual, conception forms the bedrock of her/his identity and it plunges her/his roots in surrounding culture".* By including the scientists in this definition, Giordan consider that *"all knowledge recognized by a scientific community remains a conception*" (ibid).

In the case of our study, we believe that, a student teacher (placed in well determined conditions) mobilizes her/his conceptions about functions, which are constructed not only from his position agent of education system. He/she has a personal vision about functions, the way representing them and their utility in everyday life from his/her personal experience. Considering the present conceptions of student teachers allows to adapt better the formation that is destined to them. As declared by Giordan (1998), the consideration of conceptions must imperatively become the starting point of any educational project because they reveal the existence of certain obstacles which are expectable and surmountable.

1.3 Students' Conceptions Related to Functions

The concept of function is one of the most important concepts in mathematics, perhaps as important as number itself (Cooney, 1996, p.1). So, there are many researchers

who have focused on student conceptions, difficulties and errors related to this concept (Vinner and Dreyfus, 1989; Sierpinska, 1992; Basturk, 2003; Yavuz, 2005 etc.).

A brief inspection of student conceptions (or *concept images* in the sense of Tall & Vinner, 1981), in the literature (Sierpinska, 1992; Basturk, 2003), reveals the following definitions of a function given by students:

a) *Correspondence: A function is a correspondence between two sets as each element of the first set is associated with exactly one element of the second set. Example of student answers: "For all element of A, there is only one element of B".*
b) *Relation of dependency: A function is a relation of dependency between two variables. Example: "A function is a relation between two variables"*
c) *Rule: A function is a rule. A rule must contain certain regularities while a correspondence can be arbitrary. Example: "A function is the result of a certain rule applied to a grandeur variable."*
d) *Operation: A function is an operation or a manipulation (we operate on a given number, usually through an algebraic operation, in order to obtain its image). Example: "A function is a an operation made on certain values of x which associates with each of these values x a value $y = f(x)$"*
e) *Formulas: A function is a formula, an algebraic expression or an equation. Example: "A function is an equation connecting two terms".*
f) *Representation: Function is identified with one of its graphic or symbolic representations. Example: "A function is a graph which can be described mathematically" or "$y = f(x)$".*

As showed in Basturk (2003) examining in first year high school Turkish mathematics textbooks, students (15-16 age) and teachers' practices in this level, in Turkish "noosphere" (Chevallard, 1985) functions are considered as correspondence between sets. So, it is very difficult to encounter the use of functions in term of variable (e.g. (b)) and so we find the same student conceptions as presented above (a, c, d and e).

2. METHODOLOGY

In order to determine the effects of student teachers' conceptions related to the concept of function on their scenarios for classroom prepared by using the software Cabri geometry, we used the method of interview. The sample of the research included 20 student teachers at the Department of Secondary Mathematics Education, Faculty of Ataturk Education in Marmara University. In the course entitled "Instructional Technologies and Materials Development" the working Cabri was presented and students were trained to make geometrical and mathematical applications. In class, we asked student to prepare a scenario for classroom to teach in first year high school (in Turkey functions appear the first time in this level) students the concept function by using Cabri. Students individually worked with a computer during about 30 minutes. The research data were obtained from interview conducted by researcher with students who achieved to prepare a scenario for classroom. The data collected were analysed and interpreted using the methods of qualitative analysis.

3. FINDINGS

In this party, we analyse the scenarios for classroom prepared by student teachers. It is very interesting that only four students could prepare a scenario. Other students indicated that functions can't be taught with Cabri. In the interviews of these four students we asked them "how do they define functions?" and we saw that their concept images were purely based on the definition of functions in sets. So there was no student whose concept images remind of the use of functions in term of variable. The scenarios of these students indicated the following data:

3.1 Haluk's Scenario

As seen in figure 1, Haluk's scenario for classroom reflects completely the set correspondence approach to functions. In his scenario, there are three correspondences which one is a function. The purpose of the scenario is to be reached the definition of functions in sets by pupils. So we can say easily that this student uses Cabri as a demonstrative instrument, e.g. a blackboard, a projector or a map. At the same time, it is entirely possible to ask the following question: "Do we oppose one of the situations of *'didactical contract'* developed by Brousseau?". According to Brousseau (1988), the term "didactical contract" means that the set of teacher comportments expected by student, and the set of student comportments expected by teacher. So in several cases students usually tries to find an answer of all questions, even if they are very stupid, asked by teacher. We can easily answer this question as "no", because he looked very satisfied with his activity. When we asked him "Isn't there the other possibility to teach functions with Cabri?", he undoubtedly said "no" and asked us "how to teach functions with Cabri else?"

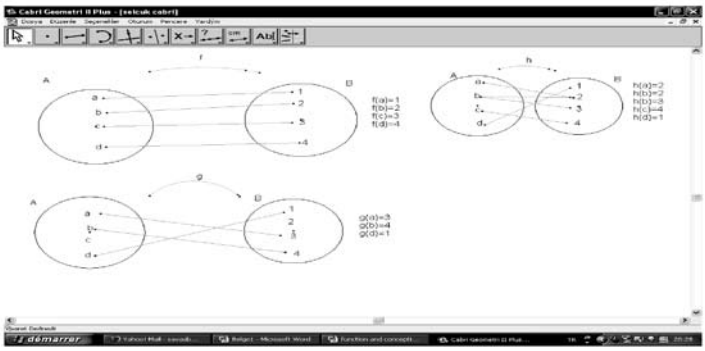


Figure 1 Haluk's Scenario

3.2 Sinem's Scenario

In Sinem's scenario, we find four functions which are represented graphically, algebraic and numerical. She first gives these four algebraically defined functions to pupil and then invites him/her to represent them by using Cabri.

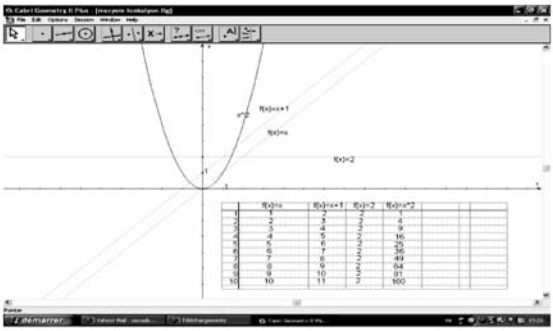


Figure 2 Sinem's Scenario

Finally pupil must calculate the images of some numbers by the functions with paper-pencil and puts them in a table. Compared to the first student teachers, we can say that Cabri is more functional. But unfortunately it is used only to represent the graphs of the functions.

3.3 Nurettin's Scenario

The figure 3 indicates that this student refers to a technique, we can easily find in textbooks of first year high school (in Turkey), which consists to draw parallel lines to the ordinate y in the graph of a correspondence for testing if it is a function or not. It is also very facile to remark that this technique is based on the set correspondence approach to function too.

We find the graphs of two correspondences which one belongs to a linear function and other belongs to an arc. The student wants pupils to see (or remark) that the parallel lines to the ordinate y never cross the graph of a function by two points or more. By this way he/she is deciding if the graph is a function or not.

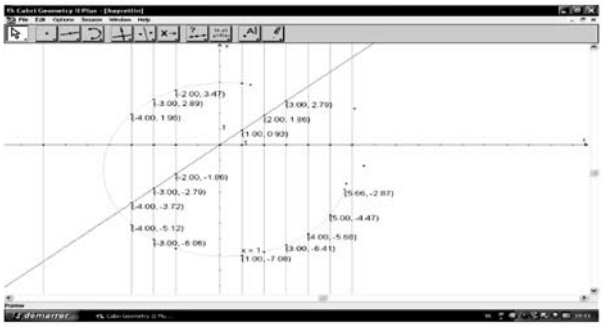


Figure 3 Nurettin's Scenario

3.4 Hasan's Scenario

As shown well in the figure 3, we can say that Hasan's proposition is the nearest proposition to the "logic of Cabri" i.e., the software isn't mainly used as a simple amplifier

for visualizing the definition of functions in sets. Pupil has some possibilities: e.g., change the figure and see the relationship between the radius and the area.

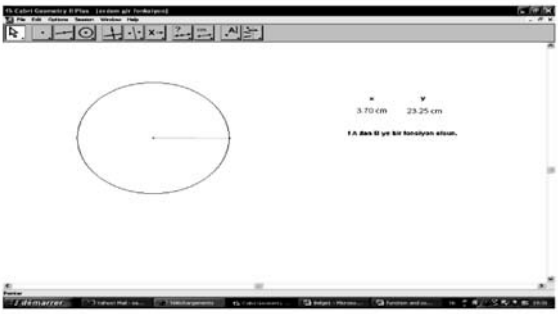


Figure 4 Hasan's Scenario

Student invites pupil to draw a circle, to find its radius and to calculate its area by using Cabri. In this way, pupil reaches a function defined as well as $f(r) = \pi r^2$. After that, Hasan says us that he conducts pupil to change the figure of the circle in motion and so to see "*there is a single value of area for each value of radius r.*" This last phrase clearly shows that he never thinks the change of the area in the value of the radius and he also makes reference to the definition of functions in sets.

4. CONCLUSIONS AND DISCUSSION

In this study, we tried to show the effects of student teachers' conceptions (or concept images) related to the concept of function on their scenario for classroom prepared by using the software Cabri geometry.

Particular interest in studies related to student teachers has been focused on adequate subject knowledge that is because the lack of it has been seen as a barrier to better mathematical teaching (Halim & Meerah, 2002; Smith, 1999). In the same way, here we saw that the function conceptions limited with correspondence between sets of student teacher appear as a barrier to better Cabri using.

Certain researchers (René de Cotret, 1988; Neil & Shuard 1972) indicated that with only the set correspondence approach to functions, it is very difficult to give students the true meaning of functions. However, in Turkey functions are purely teaching and learning as correspondences between sets. Students (see Basturk, 2003) even student teachers (after taking mathematics courses) have difficulties as considering functions as a relationship between two quantities and so primary conceptions associated with function concept consist of *correspondence between sets, rule, operation or formulas.* We can easily conclude that this type of conceptions is very static and far from being adopted at Cabri. So it is not very surprising that most students cannot envisage a teaching of functions with Cabri and certain other prepare inappropriate scenarios.

At the same time, the new secondary Turkish curriculum emphasizes adaptation of new technologies in mathematics courses. As this study has showed, the integration of new technologies also requires the integration of new contents in programs and

textbooks. So it is clear that the approach to teaching concepts (e.g. functions) in our country need considerably more focus in the context of its convenience of dynamic software as Cabri.

5. REFERENCES

Balacheff, N. (1995). Conception, connaissance et concept. *In Séminaire Didactique et Technologies cognitives en mathématiques*, D. Grenier, Grenoble, IMAG, pp. 219-244.

Basturk, S. (2003). *L'enseignement des mathématiques en Turquie : le cas des fonctions au lycée et au concours d'entrée à l'université*. Paris : IREM de Paris 7.

Brousseau, G. (1988). Le Contrat Didactique : Le Milieu. *Recherches en Didactique des Mathématiques*, 9 (3), pp. 309-336.

Chaachou A et al. (2000). Usage des TICE dans l'enseignement : Quelles compétences pour un enseignant des mathématiques?, *Séminaire INRP*.

Chevallard, Y. (1985). *La transposition didactique du savoir savant au savoir enseigné*. Grenoble: La Pensée Sauvage.

Clément, P. (1994). Représentations, conceptions et connaissances. *In conceptions et connaissances*, A. Giordan, Y. Girault et P. Clément, Ed. Peter Lang, Berne, pp. 15-45.

Cooney, T. J. (1996). *Mathematics, pedagogy, and secondary education: Developing a topic across the curriculum: functions*. Portsmouth, NH: Heinemann.

Giordan, A. (1998). *Apprendre*. Paris: Belin Editions.

Halim, L., & Meerah, S. M. (2002). Science teachers' pedagogical content knowledge and its influence on physics teaching. *Research in Science and Technological Education*, 20(2), 215-227.

Laborde C. (2004). Instrumentation processes of pre-service teachers using dynamic geometry software. *II YERME summer school*, Podebrady, Czech Republic.

Laborde C. (2004). New technologies as a means of observing students' conceptions and making them develop: the specific case of dynamic geometry. *ICME 10 – TSG 22*, Copenhagen, Denmark.

Neil, H. & Shuard, H. (1972). *From graphs to calculus*. Blackie

Raynal, F. et Rieunier, A. (1997). *Pédagogie: dictionnaire des concepts clés*. Paris: ESF.

René de Cotret, S. (1988). Une étude sur les représentations graphiques du mouvement comme moyen d'accéder au concept de fonction ou de variable dépendante. *Petit x*, 17, 5-27.

Sierpinska, A. (1992). On understanding the notion of function. In G. Harel and E. Dubinsky (Eds.), *The Concept of Function, Aspects of Epistemology and Pedagogy*, (Vol. 25, pp. 25-58). USA: Mathematical Association of America.

Smith, D. C. (1999). Changing our teaching: The role of pedagogical content knowledge in elementary science. In J. Gess-Newsome, & N. G. Lederman (Eds.), *Pedagogical content knowledge and science education*. Dordrecht: Kluwer Academic Publishers.

Tall, D., & Vinner, S. (1981). Concept image and concept definition in mathematics with particular reference to limits and continuity. *Educational Studies in Mathematics*, 12 (2), 151 169.

Vinner, S., & Dreyfus, T. (1989). Images and definitions for the concept of function. *Journal for Research in Mathematics Education*, 20(4), 356-366.

Yavuz, I., (2005). *Evolutions récentes de l'enseignement de la notion de fonction en France en classe de seconde: Utilisation des tableaux et de variations*. Thèse de doctorat non publiée, Université Lyon II.

6. ACKNOWLEDGEMENTS

This research was supported by BAPKO (Institute of Scientific Research Projects in Marmara University). The author would also like to thank to secondary school mathematics education students for their contribution.

DEVELOPMENT OF PRE-SERVICE CHEMISTRY TEACHERS' UNDERSTANDING OF PARTICULATE NATURE OF MATTER

Nurdane Aydemir*, *Ataturk University, nyazici@metu.edu.tr*
Ayla Cetin-Dindar*, *Selcuk University, aycetin@metu.edu.tr*
Sevgi Aydin*, *Yuzuncu Yil University, asevgi@metu.edu.tr*
Yezdan Boz, *Middle East Technical University, yezdan@metu.edu.tr*
Oktay Bektas*, *Erciyes University, obektas@metu.edu.tr*
** PhD students in Middle East Technical University*
Middle East Technical University, Faculty of Education, Department of Secondary Science and Mathematics Education, 06531 Cankaya/Ankara, Turkey

▼ Abstract

The purpose of this study is to enhance pre-service chemistry teachers' conceptual understanding via discussions on the particulate nature of matter and promoting conceptual change approach in science learning in a course "Laboratory Experiments in Science Education". One-to-one semi-structured interviews were administered to a sample of eight participants at a university in Ankara enrolled in the Department of Secondary Science and Mathematics Education. The semi-structured interviews were carried out both at the beginning in order to check the participants' pre-knowledge on the particulate nature of matter and at the end of the semester in order to check whether the discussions done in the course improved the participants' understanding on the particulate nature of matter. During the interview, participants were asked to describe the structure of matter and to draw the atomic model that they accept as true. Analysis of the transcribed interviews showed that the majority of the participants exhibited conceptual understanding of particulate nature of matter at the end of the course. The course involved chemistry experiments at the high school level. Every week before conducting experiments, the participants took a quiz about related subject and discussions were done with every group on their experiments. Most of the participant had overcome their misconceptions which were determined at the beginning of the semester.

Key Words Particulate Nature of Matter, Chemistry Education, Conceptual change, Misconception

1. INTRODUCTION

In the last three decades, there are many studies on learners' understanding of particulate nature of matter (PNM) (Novick & Nussbaum, 1978, 1981; Ben-Zvi, Eylon & Silberstein, 1986; Gabel, Samuel & Hunn, 1987; Stavy, 1988; Andersson, 1990; Griffiths

& Preston, 1992; Gabel, 1993; Lee, Eichinger, Anderson, Berkheimer, & Blakeslee, 1993; Kokkotas, Vlachos & Kloudis, 1998; Harrison & Treagust, 2002; Boz, 2006; Gomez, Benarroch & Marin, 2006). Chemistry, perhaps more than other sciences, is dependent on a single central model – the atomic model (Abraham, Grzybowski, Renner, & Marek, 1992).The understanding and use of atomic and molecular concepts are essential in teaching chemistry.

Many students at all levels struggle to learn chemistry, but are often unsuccessful. Since students construct their own concepts, their constructions of a chemical concept sometimes differ from the one that the instructor holds and has tried to present (Nakhleh, 1992). Therefore, students have misconceptions because of their own constructions. Misconceptions can be seen on many students in the particulate nature of matter. In general, misconceptions arise from factors that family, culture, attitude, environment, textbooks, belief, teacher, teaching method, and so on (Griffiths & Preston, 1992; Haidar & Abraham, 1991; Harrison & Treagust, 1996; Nakhleh, 1992; Nakhleh & Samarapungavan, 1999; Novick & Nussbaum, 1978; Novick & Nussbaum, 1981; Stavy, 1988; Stavy, 1990; Stavy, 1991; Tsai, 2001).

Understanding the PNM is essential to the learning of chemistry concepts (Griffiths & Preston, 1992; de Vos & Verdonk, 1996; Bektaş, 2003; Gilbert & Randall, 2006). Any misconceptions that students hold about the concepts of atoms and molecules hinder further learning (Griffiths & Preston, 1992). Although learners take many chemistry courses, they cannot understand the PNM meaningfully (Gabel, Samuel, & Hunn, 1987). Ben-Zvi, Eylon, and Silberstein (1986) claim that students can not make a distinction between the properties of a substance and the properties gave to a single atom.

Using constructivist approaches in teaching and learning improve the conceptual understanding. According to constructivist theory, students take an active role in constructing new knowledge. When students actively engage in lessons, they integrate their existing knowledge with new experiences and conceptual change approach is based on constructivist theory (Vosniadou, 2007). Posner, Strike, Hewson, & Gertzog (1982) suggested that four conditions as dissatisfaction, intelligibility, plausibility and fruitfulness were necessary for conceptual change. The students' conceptual understanding can be facilitated with classroom discussions (Niaz, Aguilera, Maza, & Liendo, 2002).

Conceptual change teaching strategy can help students overcome misconceptions and learn difficult concepts. Conceptual change is generally defined as learning that changes an existing conception, belief, idea. In conceptual change, an existing conception is changed, or even replaced with new ones. However, traditional methods in science education do not focus on alternative conceptions; even it is not aware of their existence. Traditional methods directly inform students about the topic (Çelebi, 2004).

The purpose of this study is to enhance pre-service chemistry teachers' conceptual understanding via discussions on the PNM and to promote conceptual change approach in science learning in a course "Laboratory Experiments in Science Education".

Research Question

1. How do pre-service teachers improve their conceptual understandings via discussions on the PNM in a course "Laboratory Experiments in Science Education?

2. METHODOLOGY

2.1 The sample

One-to-one interviews were administered to a sample of eight pre-service chemistry teachers (3 female and 5 male) enrolled in the course Laboratory Experiments in Science Education at a university in Ankara. All the participants volunteered to be interviewed.

2.2 Instrument

The semi-structured interviews were carried out both at the beginning to check the participants' pre-knowledge on the PNM and at the end of the semester to check whether the discussions done in the course improved the participants' understanding on the PNM. Each interview was tape-recorded; and they were all transcribed for further analysis.

Interviews were semi-structured and the participants were asked to describe the structure of matter and to draw the atomic model that they accept. Interview questions were based on assessing pre-service chemistry teachers' conceptions about structure of matter with respect to meaning of particles, ions, molecules, atoms, PNM and atomic model. Ten weeks later the semi-structured interviews based on the same questions were conducted.

2.3 Interview Questions

1. What is the structure of matter?
   a) What is the matter composed of?
   b) What are these particles?
   c) What do these particles form at macroscopic level?
2. Can you draw the atomic model that you accept as true?
   a) According to which theory have you done this drawing?

2.4 Procedure

The course was designed based on four conditions of Posner et al (1982). There were four groups and there were two pre-service chemistry teachers in each group. Each group was responsible for conducting their own experiment which was assigned before the class. After finishing their experiments, they all explained what they had done to others by expressing the related theory and misconceptions about the subject. When each group finished their presentation about the experiment, the discussion session based on misconceptions and conceptual questions was done in order to provide dissatisfaction. In some cases, students realized that they had similar miscon-

ceptions mentioned in the literature. For example, some students had the alternative conception that NaCl is a molecule. In that case, in order to provide dissatisfaction, some confusing questions were asked.. To provide cognitive conflict, questions such as "What is a molecule?", "What is an ion?", "How are molecules formed?", "How are ions formed?" "What is the difference between a molecule and an ion?" were asked. Intelligibility and plausibility were achieved by giving persuasive examples and theoretical explanations. Ion, molecule, and atoms concepts were explained and specific examples were given. For example, "if we think about particulate nature, O_2 and O_3 are molecules. These are not atoms. There is no $MgCl_2$ molecule because Mg gives two electrons and Cl takes these electrons. Thus, there are Mg^{2+} and Cl^- ions here. CH_4 is a molecule because C atom and H atoms share the electrons. Carbon and Hydrogen have nonmetallic properties. However, while sodium has metallic property Chlorine has nonmetallic property. Finally fruitfulness was promoted by encouraging the participants to link PNM with daily life and other concepts in chemistry. It was shown the different dissolution examples in the whiteboard. How to dissolve of the sugar and salt in the water in the particulate nature was shown to students. Drawings were done regarding these dissolutions in the whiteboard and discussed the difference between two dissolutions with students. Thus, ion and molecule concepts were detailed by drawing. These drawings regarding dissolution of sugar and salt in the water were asked in the pre-interview and post-interview. Also, students were asked in the final exam these drawings.

3. ANALYSIS OF DATA

Interviews were used to collect data. To analyze the data, coding was made and categories were formed. Codes came from both the literature and the researchers' experiences.

Four main categories including "correct answers", "partially correct answers", "incorrect answers", and "no answers" were formed. "Correct Answers" category includes correct answer fully. In "partially correct answers" category, there are correct but deficient ideas. "Incorrect answers" category includes wrong ideas. There are no responses in the "no answer" category.

Interviews' recording and transcribing were made in order to provide validity in this study. Triangulation and peer debriefing were made for credibility (Lincoln & Guba, 1985). In this study, triangulations were achieved by using interview and observation. In peer debriefings, some colleagues with respect to appropriateness of the interview and observation schedules were consulted before conducting study.

4. FINDINGS

At the beginning of the course, it was found that participants had some misconceptions about the PNM. For example, there was some confusion between the terms used like particle, atom, molecule, neutron, proton, electron and their interrelationships. Participants viewed particles as electron, proton, and neutron rather than atom, molecule, or ion. Additionally, seven of them mentioned that matter had a particulate nature, but only one of them added that there were empty spaces among particles.

At the end of the semester, one of the participants has improved his ideas about PNM, and added the concept of empty spaces. One of the misconceptions faced was that "There are molecules in the matter". Moreover, many of the participants represented an atom as a simple circle within a large circle similar to the Bohr Atomic Theory at the beginning. However, one of them emphasized that the drawing about an atom was based on this theory, and this participant resembled the atomic model to solar system (Nakiboğlu, 2003). Although one of them mentioned the electron cloud, she drew the atomic model reflecting the Bohr Atomic Model. This shows that the participant could not internalize Modern Atomic Theory.

Table 1 Drawings of the participants related to atomic model before and after instruction

Before Instruction	After Instruction

After the ten-week period some of the participants have overcome their misconceptions. Results revealed that there was an improvement in the participants' view of atomic model. All of the participants drew the atomic model consisted with Modern Atomic Theory (Table 1).

5. CONCLUSIONS AND IMPLICATIONS

The ability to represent matter at the particulate level is important in explaining phenomena or chemical reactions, phase changes and the gas laws, stoichiometric relationships, and solution chemistry (Gabel, Samuel, and Hunn, 1987; Haidar & Abraham, 1991). Therefore this study is important because if the atom, molecule, ion, atom models, and matter concepts are understood well by students, they can realize the meaningful learning at this subject.

In the light of these results, there is a big enhancement in participants' conception about nature of matter and atomic models. Results were similar to Ben-Zvi et al, (1986), instruction which underlines the ever developing model is successful. This has some implications for teacher education programs. Education faculties need to devote continuous efforts to prepare teachers who are able to help their students learn

properly and to know how to identify students' conceptions and implement teaching approaches that promote conceptual understanding among students.

6. REFERENCES

Abraham, M. R., Grzybowski, E.B., Renner, J.W., & Marek, E.A. (1992). Understandings and Misunderstandings of Eighth Graders of Five Chemistry Concepts Found in Textbooks. *Journal of Research in Science Teaching, 29,* 105-120.

Andersson, B. (1990). Pupil's conception of matter and its transformation (age 12-16). *Studies in Science Education, 18,* 53-85.

Bektas, O (2003). *The misconceptions of 9th grade students related to the particulate nature of matter, the reasons behind them, and their elimination.* Unpublished Master Thesis. Gazi University, Ankara.

Ben-Zvi, R., Eylon, B., and Silberstein, J. (1986). Is an atom of copper malleable? *Journal of Chemical Education, 63,* 64-66.

Boz, Y. (2006). Turkish pupil's conceptions of the particulate nature of matter. *Journal of Science Education and Technology, 15* (2), 203-213.

Çelebi, Ö. (2004). *Effect of conceptual change oriented instruction on removing misconceptions about phase changes*. Unpublished Master Thesis, Middle East Technical University, Ankara.

De Vos, W. & Verdonk, A. H. (1996). The particulate nature of matter in science education and in science. *Journal of Research in Science Teaching, 33,* 657-664.

Haidar, A.H., & Abraham, M.R. (1991). A comparison of applied and theoretical knowledge of concepts based on the particulate nature of matter. *Journal of Research in Science Teaching, 28*(10), 919-938.

Harrison, A.G. & Treagust, D.F. (1996). Secondary students' mental models of atoms and molecules: Implications for teaching chemistry. *Science Education, 80* (5), 509-534.

Harrison, A. G. & Treagust, D. F. (2003). The particulate nature of matter: Challenges in understanding the submicroscopic world. In Gilbert, J. K., Jong, O. D., Justi, R., Treagust, D. F., & Van Driel, J. H. (Eds.), *Chemical Education: Towards Research-based Practice* (pp189-212). London, Kluwer Academic Publisher.

Gabel, D. L. (1993). Use of the particle nature of matter in developing conceptual understanding. *Journal of Chemical Education, 70,* 193-194.

Gabel, D. L., Samuel, K. V., & Hunn, D. (1987). Understanding the particulate nature of matter. *Journal of Chemical Education, 64,* 695-697.

Gilbert, O. M. & Randall, E. (2006). Some aspects of students' understanding of a representational model of the particulate nature of matter in chemistry in three different countries. *Chemistry Education Research and Practice, 7,* 226-239.

Gómez, E.J., Benarroch, A., Marín, N. (2006). Evaluation of the degree of coherence found in students' conceptions concerning the particulate nature of matter. *Journal of Research in Science Teaching*, 43 (6), 577-598.

Griffiths, A. & Preston, K. (1992). Grade-12 students' misconceptions relating to relating to fundamental characteristics of atoms and molecules. *Journal of Research in Science Teaching, 29,* 611-628.

Kokkotas, P., Vlachos, I., & Koulaidis, V. (1998). Teaching the topic of the particulate nature of matter in prospective teachers training courses. *International Journal of Science Education, 20* (3), 291-303.

Lee, O., Eichinger, D. C., Anderson, C. W., Berkheimer, G. D., & Blakeslee, T. D. (1993). Changing middle school students' conceptions of matter and molecules. *Journal of Research in Science Teaching, 30* (3), 249-270.

Lincoln, Y. S., & Guba, E. G. (1985). Establishing trustworthiness. In Naturalistic inquiry. Newbury Park, CA: Sage. 289-331.

Nakhleh, M.B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education, 69*(3), 191-196.

Nakhleh, M.B. & Samarapungavan, A. (1999). Elementary school children's beliefs about matter. *Journal of Research in Science Teaching, 36* (7), 777-805.

Nakiboğlu, C. (2003). Instructional misconceptions of Turkish prospective chemistry teachers about atomic orbitals and hybridization. *Chemistry Education: Research and Practice, 4* (2), 171-188.

Niaz, M., Aguilera, D., Maza, A., & Liendo, G. (2002). Arguments, contradictions, resistances and conceptual change in students' understanding of atomic structure. *Science Education, 86,* 505-525.

Novick, S. & Nussbaum, J. (1978). Junior high school pupils' understanding of the particulate nature of matter. *Science Education, 62* (3), 273-281.

Novick, S & Nussbaum, J. (1981). Pupil's understanding of the particulate nature of matter: A cross-age study. *Science Education, 65,* 187-196.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change. *Science Education, 66* (2), 211-227.

Stavy, R. (1990). Children's conception of changes in the state of matter: From liquid (or solid) to gas. *Journal of Research in Science Teaching, 27* (3), 247-266.

Stavy, R. (1991). Children's ideas about matter. *School Science and Mathematics, 91*(6), 240-244.

Stavy, R. (1988). Children's conception of gas. *International Journal of Science Education, 10* (5), 553-560.

Tsai, C.C. (2001). Probing students' cognitive structures in science: The use of a flow map method coupled with a meta-listening technique. *Studies in Educational Evaluation, 27*, 257-268.

Vosniadou, S. (2007). Conceptual Change and Education. *Human Development, 50,* 47-54.

PRE-SERVICE CHEMISTRY TEACHERS' MISCONCEPTIONS ON EVAPORATION, BOILING, AND VAPOR PRESSURE

Ayla Cetin-Dindar*, *Selcuk University, aycetin@metu.edu.tr*
Nurdane Aydemir*, *Ataturk University, nyazici@metu.edu.tr*
Oktay Bektas*, *Erciyes University, obektas@metu.edu.tr*
Yezdan Boz, *Middle East Technical University, yezdan@metu.edu.tr*
Sevgi Aydin*, *Yuzuncu Yil University, asevgi@metu.edu.tr*
** PhD students in Middle East Technical University*
Middle East Technical University, Faculty of Education,
Department of Secondary Science and Mathematics Education,
06531 Cankaya/Ankara, Turkey

▼ Abstract

The purpose of this study was to detect the pre-service chemistry teachers' misconceptions regarding evaporation, vapor pressure, and boiling at the beginning of a course "Laboratory Experiments in Science Education". One-to-one semi-structured interviews were administered to a sample of eight participants enrolled in the Department of Secondary Science and Mathematics Education at a university in Ankara. During the interview, participants were questioned to determine their conceptual understanding on vapor pressure, boiling, factors affecting the vapor pressure, the daily life examples on evaporation, and the knowledge about vaporization heat. Analysis of the transcribed interviews showed that the majority of the participants hold some misconceptions on related subjects such as the volume of the vapor affect the value of the vapor pressure and macroscopic properties of matter are attributed to the particles. It is important to diagnose the learners' misconceptions before the instruction. In order to overcome these misconceptions, alternative views of learners should be discussed in class and then different teaching strategies and methods such as conceptual change, cognitive conflict should be implemented.

Key Words Misconception, Chemistry Education, Evaporation, Boiling, Vapor pressure

1. INTRODUCTION

In recent years, there has been a shift from the notion that considers students as empty vessels to be filled in to the one stating that learners have already some prior knowl-

edge about scientific concepts in their mind before instruction and take an active role in the learning process. As Driver, Guesne and Tiberghien (1985) state, students come to science classes with already formed conceptions as a result of their daily life experiences, interaction with people, and media. In some cases, these conceptions are not consistent with the scientifically accepted view and they interfere with students' learning since students construct new knowledge based on their existing knowledge. Conceptions, which do not match with the scientifically accepted view, are called misconceptions. Several research studies conducted in order to find out students' conceptions revealed that many students had alternative conceptions about different scientific concepts despite science instruction (Abraham, Williamson, & Westbrook, 1994; Boo, 1998; Garnett & Treagust, 1992; Hackling & Garnett, 1985; Haidar & Abraham, 1991; Ross & Munby, 1991; Thomas & Schwenz, 1998).

Evaporation, vapour pressure, and boiling are one of the basic concepts in chemistry and similarly research studies indicated some common misconceptions of students related to these concepts (Osborne & Cosgrove, 1983; Bar and Galili, 1994; Bar & Travis, 1991; Chang, 1999; Canpolat, Pinarbasi, & Sozbilir, 2006; Hatzinikita & Koulaidis, 1997). To illustrate, Osborne and Cosgrove (1983) found that even 15 year old students in New Zealand thought that water changed into oxygen and hydrogen during boiling. Similarly, in the context of evaporation, some 15 year old students stated that water changed into air. Moreover, students were found to understand scientific terms, for example, condensation or evaporation superficially since they couldn't give scientific explanations when they were asked further questions about it. In another study, Bar and Travis (1991) found that understanding of boiling comes prior to the understanding of evaporation. Bar and Galili (1994) studied the development of the evaporation concept among students aged 5-14 in Israel. This study revealed that the evaporation concept develops by following four phases. In the first phase, students younger than seven years old mostly claim that water disappears from the floor, and then at around age seven students begin to think that water penetrates. Students at around the age of nine say that water is transferred into another location such as air, sun, ceiling etc., different from the absorption view, in that it assumes the movement of water in a downward direction. By the age of 13, many pupils hold the accepted scientific view that water turns into vapour dispersed in the air, to explain evaporation. However, Hatzinikita and Koulaidis (1997), investigating 10-18 age range Greek students' conceptions, reported that students could explain the reasons behind drying of water in a saucer at an earlier age than the research of Bar and Galili (1994) suggested, although it was completely different with the problem of the drying of laundry; Greek pupils reached the correct view about that at a later age than the pupils in Israel.

Differently from the above studies, Chang (1999) explored prospective teachers' conceptions about the conceptions about evaporation and boiling. This study revealed that most prospective teachers had problems in understanding the concept of saturated vapour. Moreover, Canpolat, Pinarbasi and Sözbilir (2006) found that prospective teachers had a lot of misconceptions about the vaporization and vapour pressure concepts. For example, more than half of the prospective teachers ignored

the liquid-vapour equilibrium during explaining the vapour pressure. Some students thought that vaporization started with boiling. In addition, some students were not aware that liquids could evaporate at every temperature and stated that a liquid has to be heated in order to vaporize. Another common misconception was the change of the vapour pressure value with the change of the volume of vapour in equilibrium with its liquid at a constant temperature. Some of them used the ideal gas equation (PV=nRT) to decide the value of vapour pressure. Another misconception this study indicated was the thought that boiling liquids at atmospheric pressure have different vapour pressures.

As stated above, various research studies have been conducted about evaporation and boiling. However, most of these studies focused on primary and high school students' conceptions. There are few studies conducted at the university level as well as in the context of vapour pressure. The purpose of this study was to detect the pre-service chemistry teachers' misconceptions regarding evaporation, vapour pressure, and boiling.

Research Question

1. What are the pre-service chemistry teachers' misconceptions regarding evaporation, vapor pressure, and boiling?

2. METHODOLOGY

2.1 The sample

Semi structured interviews were administered to a sample of eight pre-service chemistry teachers (3 female and 5 male) enrolled in the course Laboratory Experiments in Science Education at a university in Ankara. All the participants volunteered to be interviewed.

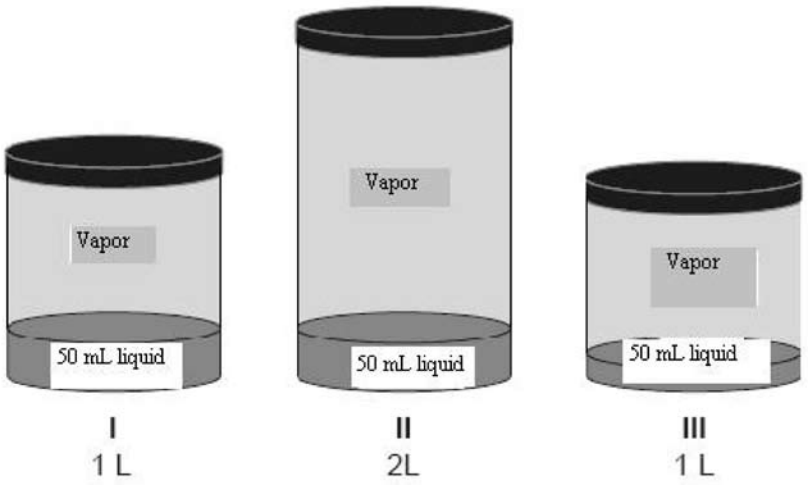
2.2 Instrument

At the beginning of the semester, the pre-service teachers were interviewed in order to check their misconceptions on vapor pressure, boiling, and evaporation. These interviews were designed as semi-structured. Each interview was tape-recorded; and they were all transcribed for further analysis.

Interview questions were about whether the participants understood the vapor pressure, boiling, factors affecting the vapor pressure, the daily life examples on evaporation, and the knowledge about vaporization heat.

2.3 Interview Questions

1. In the below, there are three containers; two of them contain 50 ml and the other contains 25 ml liquid which is at the equilibrium with its vapor, at constant temperature. What can be said about the vapor pressure of these containers (Canpolat, et al, 2006)? Please give detailed explanations.



2. Can you give some daily life examples about evaporation? Explain why.
3. What can be said about the liquid's temperature, when does it start to boil? Explain.

   a) Explain the boiling event.

3. ANALYSIS OF DATA

In order to collect data, interviews were used. Coding was made and categories were formed to analyze the data. Coding was formed both from the literature and the researchers' experiences.

Two main categories were formed, which were "correct answers" and "incorrect answers". "Correct Answers" category includes correct answer completely. "Incorrect answers" category includes incorrect ideas and misconceptions on related subjects.

Interviews' recording and transcribing were made in order to provide validity in this study. Peer debriefing was made for credibility (Lincoln & Guba, 1985). In the peer debriefings, some colleagues with respect to appropriateness of the interview were consulted before conducting study.

4. FINDINGS

Results revealed that some of the pre-service chemistry teachers had misconceptions about evaporation, vapor pressure, and boiling. Two of the participants thought that the volume of the vapor affected the value of the vapor pressure. It was very interesting that one of the participants viewed the vapor pressure as ideal gas, in other words, they did not think vapor pressure in terms of physical equilibrium. Moreover, he used "PV = nRT" equation to explain this phenomena.

Another misconception was that the value of the vapor pressure depended on the amount of the liquid. Two of the participants had this misconception.

Yet another misconception detected was the attribution of macroscopic properties of matter to the particles. Three of the pre-service chemistry teacher had this miscon-

ception. Two of them mentioned the phase change of particles: *"…The energy gained from outer system was consumed to change the phase of molecules from liquid to gas state…"* On the other hand, one of them stated that the particles got hotter.

Additional misconception was that the heating was necessary for evaporation. Two of them stated: *"…In very hot air, water in dam evaporates…"*

Another was that two of them explained the evaporation as drying. Moreover, one of them added that the vapor went into air.

Finally, six of the participants did not mention the liquid-vapor equilibrium to compare the value of the vapor pressure in closed system. Only two of them referred to equilibrium; however they did not specify which equilibrium they mentioned.

Table 1 Misconceptions in evaporation, vapor pressure, and boiling.

	Misconceptions
Misconception 1	The volume of the vapor affects the value of the vapor pressure.
Misconception 2	The value of the vapor pressure depends on the amount of the liquid.
Misconception 3	Macroscopic properties of matter are attributed to the particles.
Misconception 4	The heating was necessary for evaporation.
Misconception 5	Viewing evaporation as drying.
Misconception 6	The vapor goes into air.

In addition to these misconception mentioned above, another interesting result which was found that three of the pre-service chemistry teachers did not prefer to use the particulate nature of matter to explain the phenomena although the phenomena was related with the particulate nature of matter. Four of the participants mentioned the particulate nature of matter, but the explanation of three of them included the misconception which was given as a third misconception in Table 1. Only one of the participants clarified his idea by using the particulate nature of matter in a correct way.

5. CONCLUSIONS AND IMPLICATIONS

This study shows that pre-service chemistry teachers have some misconceptions in evaporation, vapor pressure, and boiling, which are consistent with the literature. The misconceptions detected in this study are:

- The volume of the vapor affects the value of the vapor pressure (Canpolat et.al, 2006).
- The value of the vapor pressure depends on the amount of the liquid (Canpolat, et al, 2006).
- Macroscopic properties of matter are attributed to the particles (Boz, 2006; Kokkotas, Vlachos, & Koulaidis, 1998; Novick & Nussbaum, 1978, 1981).
- The heating was necessary for evaporation (Canpolat, et.al, 2006).
- Viewing evaporation as drying (Osborne & Cosgrove, 1983; Bar & Travis, 1991; Hatzinikita & Koulaidis, 1997).
- The vapor goes into air (Osborne & Cosgrove, 1983).

One of the causes of the participants' inadequate knowledge may be textbooks because representations and explanations in textbooks do not support conceptual understanding (Çalık & Ayas, 2005; Canpolat, et al., 2006). Though three of the pre-service chemistry teachers tried to explain the boiling and evaporation by using sentences and graphs given in the textbooks, they could not conceptualize these events.

One of the participants could not differentiate vapor-water equilibrium and ideal gas as found in Canpolat, et.al. (2006). He used "PV=nRT" equation to answer the question.

In the study of Haidar and Abraham (1991), it was found that if the researchers did not ask the questions including the formal class language, the participants did not explain the phenomena with particulate theory; on the contrary, they used every day language. In the present study, although researchers did not mention particles in the questions, four of the participants used the particulate theory. The reason of this may be the level of the participants' conceptual understanding.

In this study, the pre-service chemistry teachers could not differentiate the boiling and evaporation. Except one of the participants, they did not mention the equality of vapor pressure of liquid to atmospheric pressure at the boiling point.

It is important to diagnose the learners' misconceptions before the instruction. In order to overcome these misconceptions, alternative views of learners should be discussed in class (Bar & Travis, 1991) and then different teaching strategies and methods such as conceptual change, cognitive conflict should be implemented (Posner, Strike, Hewson, & Gertzog, 1982).

6. REFERENCES

Abraham, M. R., Williamson, V. M. & Westbrook, S. L. (1994) A cross-age study of the understanding of five chemistry concepts, *Journal of Research in Science Teaching, 31*, 147-165.

Bar, V. & Galili, I. (1994). Stages of children's views about evaporation, *International Journal of Science Education, 16* (2), 157-174.

Bar, V. & Travis, A. S. (1991). Children's views concerning phase changes. *Journal of Research in Science Teaching, 28,* 363-382.

Boo, H. K. (1998) Students' understandings of chemical bonds and the energetics of chemical reactions. *Journal of Research in Science Teaching*, *35*, 569–581.

Boz, Y. (2006). Turkish pupil's conceptions of the particulate nature of matter. *Journal of Science Education and Technology, 15* (2), 203-213.

Canpolat, N., Pinarbasi, T., & Sozbilir, M. (2006). Prospective teachers' misconceptions of vaporization and vapor pressure. *Journal of Chemical Education, 83* (8), 1237-1242.

Chang, J. Y. (1999). Teachers college students' conceptions about evaporation, condensation, and boiling. *Science Education, 83*(5), 511-526.

Driver, R., Guesne, E. & Tiberghien, A. (Eds) (1985). *Children's Ideas in Science*, Open University Press: Milton Keynes.

Garnett, P.J., And Treagust, D.F. (1992). Conceptual difficulties experienced by senior high school students in electrochemistry: Electrochemical (galvanic) and electrolytic cells, *Journal of Research in Science Teaching*, *29*, 1079-1099.

Hackling, M. W. & Garnett, P. J. (1985). Misconceptions of chemical equilibrium, *European Journal of Science Education,* 7, 205–214.

Haidar, A.H., & Abraham, M.R. (1991). A comparison of applied and theoretical knowledge of concepts based on the particulate nature of matter. *Journal of Research in Science Teaching, 28*(10), 919-938.

Hatzinikita, V., & Koulaidis, V. (1997). pupils` ideas on conservation during changes in the state of water. *Research in Science and Technological Education, 15* (1), 53-70.

Kokkotas, P., Vlachos, I., & Koulaidis, V. (1998). Teaching the topic of the particulate nature of matter in prospective teachers training courses. *International Journal of Science Education, 20* (3), 291-303.

Lincoln, Y. S., & Guba, E. G. (1985). Establishing trustworthiness. In Naturalistic inquiry. Newbury Park, CA: Sage. 289-331.

Novick, S. & Nussbaum, J. (1978). Junior high school pupils' understanding of the particulate nature of matter. *Science Education, 62* (3), 273-281.

Novick, S & Nussbaum, J. (1981). Pupil's understanding of the particulate nature of matter: A cross-age study. *Science Education, 65,* 187-196.

Osborne, R. J. & Cosgrove, M. M. (1983). Children's conceptions of the changes of state of water. *Journal of Research in Science Teaching, 20* (9), 825-838.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change. *Science Education, 66* (2), 211-227.

Ross, B. & Munby, H. (1991). Concept mapping and misconceptions: a study of high school students'understandings of acids and bases, *International Journal of Science Education*, *13*, 11-23.

Thomas, P. L. And Schwenz, R. W. (1998). College physical chemistry students' conceptions of equilibrium and fundamental thermodynamics. *Journal of Research in Science Teaching*, *35*, 1151–1160.

PRE-SERVICE TEACHERS' MATHEMATICAL KNOWLEDGE NEED FOR JUSTIFICATION ON A GEOMETRICAL CONSTRUCTION PROBLEM

Dr. Menekse Seden TAPAN Dr. Cigdem ARSLAN
Uludag University Education Faculty Istanbul University Education Faculty
tapan@uludag.edu.tr arslanc@uludag.edu.tr.

▼ Abstract

Geometrical competence has to be considered as an important factor for reasoning in mathematics. The axiomatic structure of the Euclidian geometry constitutes a favorable ground for the learning of the reasoning and justification. In geometry, even if the reasoning is assisted by concrete elements such as drawings, it is not based on actions or spatio-visual elements. Arguments based on mathematical properties are required in geometrical reasoning. A successful teaching of the geometry directly depends on the subject knowledge of the teachers. The main purpose of this article is to determine to what extent pre-service teachers use visual elements and mathematical properties when they are faced to a geometrical construction activity. Another purpose is to map out the different kinds of justifications implemented by teachers related to such an activity. Analyses of the responses indicate that a large proportion of pre-service teachers use visual elements for their geometrical constructions and they are tended to use naive empiricism concerning their justifications.

Key Words Justification, pre-service teachers, geometrical construction

1. INTRODUCTION

Although geometry plays an important role in mathematics teaching and in history of mathematics, it takes a restricted part of the Turkish National Elementary School Curriculum. Despite this limited place, mathematicians as well as mathematics educators agree that geometry should be an important part of education (Leher & Chazan, 1998).

The successful teaching of geometry at the elementary school depends crucially on the subject knowledge of teachers. Many studies reveal the difficulties teachers face if they are uncertain or if the content unfamiliar to them (Ball & Bass, 2003).

In fact, geometry forms a natural field for the learning of the reasoning, rigueur, exactness, justification and proof. These notions are not only very important for a scientific formation; but they are also omnipresent in the human interactions within the society; and thus they seem to be also important concerning a citizen formation (Kahane, 2002).

For not to be misunderstood, it should be underlined that reducing the reasoning to the domain of the geometry is evidently not sufficient for a rational argumentation formation as indicated by the college group of IREM d'Aix-Marseille (GRT, 2000).

In geometry, reasoning is not only based on words or on symbols, but also on drawings and visual images (mental pictures). In addition to this, the reasoning controls not only the relationship of these visual images to the ideal geometrical objects but also the constructions or handling of drawing tools (Richard, 2000).

Researches indicate that the most encountered difficulty in the learning of the geometrical reasoning is to leave off the concrete drawing. Hence, it becomes important to throw light on the concrete drawing's role for the teachers and visual elements' usage while realizing a geometrical construction. It seems also important to find out how teachers are situated in a typology related to reasoning and proof in geometry. In this study it has been tried to find out how student teachers are situated among proof levels indicated by Balacheff (1988).

2. METHODOLOGY

The sample of this research consists of 60 pre-service elementary teachers at Uludag University, Faculty of Education in Bursa, Turkey. The participants were third grade students who were taking mathematics teaching course. In the experimental part of the study, all of the participants responded the geometrical construction problem indicated below:

"*Draw an equilateral triangle. Explain your drawing. Demonstrate that your triangle is an equilateral triangle*".

Student teachers were only allowed to use compass and straightedge for their construction. This construction problem is at the elementary school level and the student teachers have to teach the construction once nominated as teachers. The analyses of the experimental part are planned in two perspectives. One of them took into account student teachers' drawings and the other one was related with their written justifications.

3. RESULTS

In order to investigate students' drawings, we coded their responses into two main categories. Based on a priori analyses of possible response-types, the main categories were divided into several subcategories. Table 1 shows this categorization and frequency of student teachers' drawing responses.

Table 1 Categorizations and frequency of drawing responses

Mathematically Acceptable	(f)	Mathematically Not Acceptable	(f)	Failed
Construction with Euclidean method	7	Proper mathematical property but visual construction	17	4
Radius length chord	2	Non proper mathematical property	4	
Regular hexagon	-	Purely visual construction	26	

The category called "Construction with Euclidean method" is concerned constructions based on the one that Euclid provides in The Elements as the first proposition of the first book.

Constructions classified as "Radius length chord" are those obtained by constructing a chord in a circle with the same length of the radius and then joining the center of the circle with the end points of this chord.

The construction method called "Regular Hexagon" is the one which is made by constructing a circle, then marking the radius off six times around the circumference. The vertexes of the triangle are then the three non-adjacent marks of the compass on the circumference. This last construction method is taught at the elementary school level. Constructions classified as "Proper mathematical property but visual construction" are those constructed using spatial properties or visual elements but related explanations are given by mathematical properties.

The category called "Non proper mathematical property" concerns non correct construction where the explanation is given by a geometrical property not appropriate to the construction problem.

Constructions classified as "Purely visual construction" are those based on perception (with an explanation based on perception).

And "Failed" indicates that student is not able to give a coherent explanation.

Analyses of students' drawings and explanations bring to light the important usage of the perception for geometrical constructions (26 constructions on 60 classified as purely visual). We also notice the dominance of the perception in the constructions by the raised number of students' answers classified in the "Proper mathematical property but visual construction" category. Indeed, mathematically acceptable constructions appear only at few students' responses; and the construction method "Regular hexagon", at the level of the elementary school that they will have to teach, does not appear.

Concerning the justifications of students, they are characterized by using Balacheff's hierarchical proof levels: naïve empiricism, crucial example, generic example, and thought experiment (Balacheff, 1987). In the case of naïve empiricism and crucial example, considered as pragmatic proofs, statements are validated by concrete or mental actions. Naïve Empiricism concerns an inductive perspective where conclusions are based on small number of cases. For the Crucial Experiment, the question of generalization is considered with the examination of extreme cases. Concerning generic example and thought experiment, considered as intellectual proofs, arguments are based on concepts and language. Intellectual proofs are not necessarily formal, but they are detached from concrete actions (Knipping, 2001).

This categorization of different types of proofs given by Balacheff contributed to our research for the analyses of the pre-service teachers' answers concerning the question related to the justification of their construction. Table 2 shows this categorization and frequency of responses resulting from the analysis.

Table 2 Categorizations and frequency of justification responses

Proof levels	(f)
Naïve empiricism	25
Crucial example	6
Generic example	6
Thought experiment	1
Failed	6
No answer	16

As seen from the Table 2, student teachers' responses accumulated on naive empiricism. These responses rarely took the form of crucial example and generic example. The corresponding analysis using frequencies shows that pre-service teachers judge a justification sufficient when used on a unique example. Most of the justifications are made through careful measurements on the drawing and the student teachers do not express an argument for the generalization of their justification.

4. CONCLUSION

One dimension of our research was to determine whether pre-service teachers were able to make a geometrical construction at the elementary school level that they will have to teach as teachers. Other dimension was look for how the student teachers were situated concerning justifications connected to geometrical construction activities.

In spite of the fact that the student teachers had sufficient mathematical knowledge, analyses of their responses showed a restricted number of construction using geometrical properties (and not those spatio-visuals), Indeed, it can be thought that pre-service teacher have restricted achievements on transmitting their geometrical knowledge to an activity of construction or a task of justification.

This research showed that pre-service teachers use excessively visual elements (for realizing geometrical constructions as well as for formulating justifications). It can be supposed that this difficulty may result from the fact that an interrelation between usage of the geometrical tools and the formal mathematical knowledge was not established for the student teachers. Additionally, pre-service teachers maybe couldn't manage to organize their reasoning in order to succeed in the geometrical construction using the appropriate mathematical properties.

All these results show a deficiency concerning construction tasks and geometrical reasoning; and brings to light the importance of researches, in the future, on this domain to analyze more exactly causes of this deficiency noticed on the pre-service teachers and to find solutions for filling this gap.

Finally, we can say from our research that geometry should lie more in the design of the National Curriculum and at university level; this can only be realized through researches showing the importance, on the reasoning, of the geometry learning and geometrical justifications.

5. REFERENCES

Balacheff, N. (1987). Treatment of Refutations: Aspects of the complexity of a constructivist approach to mathematics learning. *Radical Constructivism in Mathematics Education*. Von Glaserfeld, Ernst ed. Kluwer Academic Publishers. Netherlands. p 89-110.

Balacheff, N. (1988). Etude des processus de preuve chez des élèves de Collège. Thèse. Grenoble: Université Joseph Fourier.

Ball, D.L., & Bass, H. (2003). Toward a practice-based theory of mathematical knowledge for teaching. In E.Simmt & B. Davis (Eds.), *Proceedings of the 2002 annual meeting of the Canadian Mathematics Education Study Group* (pp. 3-14). Edmonton, Alberta, Canada: CMESG.

Leher,R. & Chazan, D. (1998). *Designing Learning Environments for Developing Understanding of Geometry*, Lawrence Erlbaum

Richard, P. R. (2000). The figurative inference. Proof and Proving in Mathematics Education. *Proceedings of ICME 9 TSG 12*. Tokyo/Makuhari, Japan.

Kahane, J.P. (2002). *L'enseignement des sciences mathématiques : Commission de réflexion sur l'enseignement des mathématiques,* Odile Jacob eds., San Diego, London

GRT-IREM d'Aix-Marseille Groupe Collège (2000). L'apport du numérique dans l'apprentissage du raisonnement au collège, *IREM de Marseille Num. 24*, France

Knipping C. (2001). Argumentations in proving discourses in mathematics classrooms, *Proceedings of the Annual Meeting of the GDM (Gesellschaft für Didaktik der Mathematik)*, Ludwigsburg

UNIVERSITIES OF TECHNOLOGY ITS ROLE IN SOUTH AFRICA'S DEVELOPMENT

Dhiro Gihwala
Faculty of Health Sciences, Cape Peninsula University of Technology
Box 1906, Bellville 7535, South Africa
gihwalad@cput.ac.za

▼ Abstract

The advancement of science and technology capacity in South Africa requires major changes in two areas: (a) the system of education and training and (b) the relationship between industrial development, education and training. Based on the understanding that South Africa is a developing industrial country in a global context, the paper presents a general background on science and technology issues and suggests ways of enhancing a synergic relationship between universities and socio/economic growth of the country. A case is presented for Universities of Technology – higher education institutions who are ideally positioned to facilitate and optimize the cooperation between all relevant sectors at the appropriate levels.

Key Words Universities of Technology, science & technology, world-of-work

1. INTRODUCTION

It is widely recognized that no country can ensure genuine development without its universities providing a critical mass of skilled scientists and technologists. From this it can be inferred that action at national level should aim to tighten the links between higher education and industry, taking into account that education and research performed at universities are closely related elements in the establishment of knowledge that is translated into commodities by industries (UNESCO 1999). Science is one of the most productive systems created by man, resulting in unprecedented progress, both material and social, for those societies that have embraced it as the major engine of growth and who incorporated it into their own economies, cultures and traditions (Salam, 1989). The relevance of science and technology to economic enterprise is not new. What has changed is that where this relevance was implicitly assumed and marginally regarded, it has come to be recognised more explicitly and emphatically. Thurow, formerly from MIT, posing a challenge to science and technology, makes the point that *"In the 21st century, brainpower and imagination, invention and the organisation of new technologies are the key ingredients"* (Thurow 1999). Still more insistent, he goes on to declare that *"Today, knowledge and skills stand alone as the only source of competitive advantage"*.

2. SOUTH AFRICA – A DEVELOPING COUNTRY

The South African economy shows a number of features characteristic of many developing countries, vast inequalities in income distribution, widespread rural and urban poverty, a strong reliance on the export of primary commodities to earn the bulk of its foreign exchange, a marked dependence on imports and vulnerability to external supply shocks, such as increasing oil prices. It is neither in a major industrial era nor in a leading information era. At best it has a mixed economy that is experiencing pressures exerted on it by international competition. The level of technological skills in South Africa's manufacturing sector is also uneven; in some cases it is relatively high, but low in others. And if one looks beyond the urban manufacturing sector, then South Africa's have even less technological capability. Hence in order to move in the direction to become a global participant there is a need for the country to:

- have more educated people;
- have more specialist skills through advanced higher education programmes;
- establish markets that are more global than local; and,
- collaborate, network and have an interdependence with other countries on all levels.

Indeed, this has proven to be the formula for successful emerging powerhouses such as China and India albeit that these competitive economies have given rise to ominous global environmental concerns because of their rapid industrial development.

South Africa's government is driving an aggressive agenda to promote science and technology at all levels of society. Its major goal is for science and technology to achieve results which in the short-term will support the process of social and economic transformation and in the long term ensure economic growth and development in the country. Sustainable economic development however requires expert knowledge, a broad skills base, and a system with the capacity to generate and apply knowledge. Developed countries have been fortunate to graduate significant numbers of experts with doctorate qualifications on a continuous basis in the field of science and technology who enter the job market. Governments and industries rely heavily on these graduates for the growth of new knowledge, inventions and innovations. Universities therefore play an critical role to increase the pool of research experts who are equipped to create new knowledge, designs and inventions, utilize it as well as contributing to the various steps needed in order to get a product into the market or implement research & development outputs successfully (van Eldik 1999).

The reality of South Africa is that there is a major paucity of doctorate students and this significantly affects the scientific and technological skills shortage in its economy. If the country aims to be globally competitive, the rate of producing skilled persons will have to improve. Its current output of doctorate graduates is about 1200 per year. The requirement is at least four times as many when compared to similar-sized or even smaller countries.

If South Africa is to compete globally, it needs to benchmark its development agenda against highly competitive counties. A proven strategy in all developed countries has been the significant and focused investment in science and technology edu-

cation, particularly at university level. For South Africa to move in that direction, two kinds of policies need to be more visible for the development of the country and its people, namely, policies which are associated with the generation and application of scientific and technological knowledge; and, policies which provide for science and technology education. In the absence of a direct manifestation of these policies, universities must play the important role of aligning the government's intended education agenda to the scientific and technological needs of the market. This cause can be championed by the Universities of Technology (UoTs) because of the distinctive scientific and technological nature of its educational programmes and its strong links with the world-of-work.

3. THE ROLE OF UNIVERSITIES OF TECHNOLOGY IN SOUTH AFRICA

Higher education systems internationally are continuously being confronted with major adjustments due to rapid changing environments which range from globalization, the information era and knowledge intensive economics to partnerships with communities, government, industry and business (Clark, 1998). Higher education institutions in South Africa are not only experiencing similar changing environments but are also challenged by the re-orientation of institutions of learning, the redress of inherent societal inequalities, and the acceleration of the transformation to a democratic society. The function of universities internationally is no longer teaching and research alone. It increasingly must also take responsibility for an active role in the more complex field of economic development, covering a portfolio of applied and basic research, consulting and community services, specialized training, distance learning and technology-based business development.

UoTs in South Africa were established to meet a set of broad stakeholder interest in today's world. These universities are nationally and internationally known institutions with a clearly defined philosophical basis which makes them unique. The broad aim of UoTs is to develop an attitude and goal orientation that will turn its students into skilled practitioners in various fields in which they are able to apply their knowledge and, in so doing, make a direct contribution to the economy and to society at large.

In carrying out their tasks, UoTs concentrate on:

- Educating and developing students with the emphasis on preparing them for intermediate and higher level occupation with a strong practical emphasis underpinned with an appropriate knowledge base;
- Training and shaping students by providing services to the community, business and industry, by finding, assessing and placing these students in these service sectors;
- Promoting the transfer of technology by continuously assessing the relevancy of course material presented to students in relation to the needs of industrial, commercial and service stakeholders;
- Developing human potential by creating the opportunity for staff and students to be engaged in applied and mostly practically-orientated research and development.

- Involving themselves with community activities which is geared in a mutually beneficial way for the application and development of appropriate technologies and processes.

Closer collaboration is constantly required in the form of "industry-education-science & technology" partnerships. UoTs have for years recognised both the potential and the need for cooperation, partnerships and joint ventures with industry linked to an entrepreneurial approach. This is manifested in the offering of formal education and training programmes and short courses to conducting research and development projects and programmes structured to allow for people's skills to be increased. UoTs realize that their graduates have to accept that in their careers there would probably be a need to change jobs, update their knowledge and learn new skills. This is because science and technology changes on a continuous basis. This in turn results in the world-of-work continuously having to be redefined and hence a large part of the specific knowledge that students acquire during their initial training becomes obsolete. It is therefore critical that the UoTs have interactive partnerships with the employer sector, identify new needs, and integrate their findings into its overall mission and function.

UoTs have for years taking the responsibility to grow and enhance the scientific and technological talents of a generation and those to follow. For too long the potential of the technologist and the technician has been under-estimated in South Africa's technological infrastructure. UoTs plays the leading role in South Africa to accelerate the training of a technological skilled workforce that is capable of managing, solving problems, stimulating growth and eventually competing with the international technological and scientific community.

The distinctiveness of many regional and local and national problems relates to the understanding that while knowledge is universal, its application is usually local. UoTs therefore depend on and have a responsibility to its local community. In developing local relevance, UoTs need to commit itself to partnerships with local government and industry in addressing specific scarce skills in their specific regions. UoTs need to integrate into its mission and plans a strategy regarding local industry cooperation, both generally and with regard to specific target sectors. Increasing local government and professional councils seek a voice in the curriculum and the programmes of the UoTs. In addition there is an increase call from national government departments for the Universities to respond to national priority issues. Cognizance of this relationship needs to be taken, particularly in order to respond to scarce skills shortages in the immediate vicinity of the UoTs and also addressing national requirements. UNESCO's Higher Education mandate (UNESCO 1998) represents significant challenges for UoTs to translate rapid scientific development and technological advances in such a way that they indeed do have a meaning to end-users. In essence, UoTs need to mobilize science and technology to empower the people of South Africa.

International developments in higher education should be noted by UoTs. Of these, the Bologna Declaration (Bologna, 1999) bears relevance. The Bologna process involves 45 European countries undertaking a series of reforms intended to create an integrated European higher education area (EHEA) by 2010. The aims of the Bologna

process involves aspects of uniform degree structures; credit transfer; ease of mobility of staff and students; standard quality assurance practices and closer international cooperation amongst others. South African UoTs need to consider how their own systems can be more closely aligned with 'Bologna' thinking so that there is benchmarking with regards relevancy and quality to international standards and requirements. Formal partnership between South African UoTs and similar Institutions on the African continent is possible. While there are a number of ad hoc arrangements between individual UoTs and its counterparts in other countries, what is required is more structured cooperation. UoTs should consider offering programmes outside the geographical boundaries with a view to establish an international presence, knowledge generation and scholarship and not do so for financial gain, but with a view of enriching their programmes.

4. RESPONDING TO NEW AREAS OF DEVELOPMENT

One of the major technological trends worldwide is the convergence of previously distinct areas of technology. This is visible in the areas of multimedia, publishing, television and computing with high band-width communication. The modeling and simulation of previously intractable systems of high complexity is becoming routine and is changing the relationship of disciplines that were previously distinct. This convergence results from advances in computing and communications technology, but it is also driven in some fields by a desire to synthesize large bodies of data in new and powerful ways. This trend is also notable in the fields of material science, engineering design and ecological modeling, amongst others.

South Africa, like the rest of the African continent's biodiversity, is a potential source of medicinal, food and chemical products. It holds great potential for poverty reduction and economic development. This potential needs to be adequately explored. South Africa also has a relatively rich body of indigenous knowledge and related technologies. Indigenous knowledge and technologies play major roles in biodiversity conservation, sustainable use and prospecting. In addition, their contributions to increasing food production, fighting HIV/Aids and other diseases, and stemming environmental degradation are considerable. Indigenous knowledge and technologies therefore need to be adequately promoted and protected. As public custodians of science and technology, UoTs has a moral responsibility to safeguard the rights of indigenous knowledge. In addition, they need to strengthen the links between themselves and the communities that hold and use the knowledge.

Manufacturing continues to a focus of innovation in the area of design, products and processing, resulting in paradigm shifts in productivity, quality and time to market. South African industries have been a slow adopter of many of the leading technologies and integrative systems. In this regard UoTs need to establish centres that would inculcate a culture amongst its students and industrial partners of more rapid and appropriate responses to the market.

The production and use of energy affects the social, economic and environmental dimensions of any country's development. The availability and use of energy will, to large extent, determine how and whether South Africa increases agricultural produc-

tivity, provide safe water, achieve higher levels of industrialization, and efficiently use information and communications technologies to get integrated into the global economy. South Africa is reliant on coal burning power stations to produce the bulk of its energy. This source needs to be juxtaposed with how well its natural environment is sustained. Hence scientific and technological investigations have to be made into the production of environmentally friendly energy sources. It is therefore encouraging to note that virtually all the UoTs in South Africa are doing investigative studies in alternate forms of energy production.

5. CONCLUSION

UoTs need to dedicate itself to advancing knowledge and educating students in science, technology and other areas of scholarship that will best serve South Africa and world. They need appropriately to continue to build strong links with industry. In this regard they need to aim in focusing on technology-related disciplines such as engineering and science.

UoTs need to ensure that they continue to offer high-quality training in order to enable its graduates to act efficiently and effectively in the world-of-work. These Universities need to be engaged in the search, creation and dissemination of knowledge, in the advancement of science and participating in the development of technological innovations and inventions. Formal and informal collaboration and initiatives should take place with various stakeholders in which important local, regional, national and international issues and solutions are identified, debated and addressed in a spirit of learned criticism. By the nature of its programmes and philosophy, UoTs need to have an international outlook, producing well-rounded students with a high sense of responsibility, an ability to pursue life-long learning, having good communication skills, able to critically and creatively think and display potential entrepreneurial and leadership skills. The Doors of UoTs have to be open for the government and other public institutions can go for scientific and reliable information as this is increasingly required for decision making in responding to societal needs. The differentiating feature of UoTs must be a single-minded focus on the systematic shift towards the implementation of a culture that will favour the development and transfer of technology.

Programmes at UoTs must be developed in direct consultation with industry and professional boards to meet the demands of the employer sector, thereby ensuring that graduates receive career-orientated and purposeful academic training. Relevance of courses must be considered to be particularly important. New conditions in the world-of-work have a direct relationship on the aims of the training that takes place in UoTs. Merely increasing curriculum content and student's work load cannot be a viable solution. Consideration should be given to develop students' intellectual ability to be free and critical thinkers and independent learners and allow them to deal sensibly with technological change, equip them with qualities such as initiative, assertiveness, an entrepreneurial attitude and adaptability and allow them to function with greater confidence in a modern work environment.

In order to succeed as a nation, South Africa must consciously strive to release the full creative and productive energies of its people. UoTs need to ensure the effective

discharge of this responsibility. This is clearly manifested in its resolve to support human resource development, engage in appropriate research activities and promote the benefit of science and technology at all levels.

UoTs in South Africa have developed sufficient competence, capacity and have a track record as relevant and effective contributors to sustainable development through science and technology education. They need to continue on the course of partnering appropriately with suitable collaborators so that a continued sustaining impact on society is made. The unique contribution that UoTs make to advance development, especially in science and technology areas, in South Africa must not be underestimated.

REFERENCES

Bologna. (1999). Declaration on the European space for higher education, Joint Declaration of the European Ministers of Education, June 1999.

Clark, Burton (1998). Creating entrepreneurial universities:organizational pathways of transformation, Oxford/New York: Pergamon Elsevier.

Salam, Abdus (1989). Notes on Science, technology and science education in the development of the South. Third World Academy of Science, Trieste, Italy.

Thurow, Lester (1999). In Visions: how science will revolutionize the 21st century and beyond by M. Kaku, Oxford University Press.

UNESCO (1998). World declaration on higher education for the 21st century: Vision and action, World Conference on Higher Education, Paris, France, October.

UNESCO. (1999). Science for the 21st century, World Conference on Science, Introductory note No 23, Budapest, Hungary, June.

Van Eldik, Peter (1999). Technikon Pretoria's strive in becoming a University of Technology. Pretoria, South Africa, Private Communication, January.

EVOLUTIONS IN MANAGING A SCIENCE SCHOOL-BASED ACTION RESEARCH PROGRAMME – THE DYNAMICS, THE TENSIONS AND THE INSIGHTS

Mpunki Nakedi and Prof Marissa Rollnick
University Of Witwatersrand
Mpunki.nakedi@wits.ac.za; marissa.rollnick@wits.ac.za

▼ Abstract

This paper reports on some of the findings and experiences within an ongoing school based action research programme, which is part of a PhD study. The study is aimed at exploring the use of reflective practice, action research as well as the promotion of collegiality as tools to mediate and enhance the development of a team of senior phase science teachers' pedagogical content knowledge (PCK). This paper reports on the insights, the challenges and the tensions that emerge as well as the strategies employed as the study evolves from the first to the second cycle of the process. The paper focuses on the practical and ethical issues that emerged around the facilitation and the researcher roles as the author endeavoured to address the complexities of the real school setting. It is concluded that a programme of such a magnitude needs to be implemented in a functioning school setup as well as be institutionalised.

Key Words School-based action research, Science Knowledge for Teaching, Reflective Practice

INTRODUCTION

A serious challenge faced by the South African education system in the advent of the new curriculum is that the quality of learning and teaching in the classroom has deteriorated to unacceptable levels (Rogan, 2003; Taylor et al, 2003; Taylor & Vinjevold, 1999). According to Rogan (2003), the level of achievement of the grade 9 science learners observed during case studies of secondary schools in Mpumalanga, is only at about Grade 4 level. This is the case because we are looking for quick fix strategies to very deep and complex problems that require intense, coherent, and focused research based strategies to turn around (Adler & Reed, 2002; Taylor & Vinjevold, 1999). The diversity in both content and focus of studies related to curriculum reform bear witness to the complexity of issues surrounding curriculum reform both in developed and developing countries. As echoed by some studies, teacher education faces critical challenges in rethinking what constitutes teachers' conceptual knowledge in-practice and how this can be developed and acquired through pre-service and in-service education programmes (Adler, Slonimsky and Reed (in Adler & Reed, 2002). Most studies (Shulman, 1986; Wilson et al, 1987; Cochran et al., 1993) attest to the complexity,

the uniqueness, the content specificity as well as the tacit nature of skills accomplished teachers come to amass in their teaching career. A concept coined by Shulman (1986) and referred to as pedagogic content knowledge (PCK). In South Africa besides the widespread shallow content knowledge, possessed by majority of science teachers, the challenge we face is that the types of teacher competencies embedded in the new science curriculum are quite complex, varied and very different from the previous curriculum and teacher practices. The problem is that teachers are expected to carry this complex curriculum forward from that shaky content knowledge without proper support systems because the present teacher training and development programmes are not appropriately aligned to support them in the challenges they face on a daily basis in their classrooms. Given the background above, this study was aimed at engaging the real complexities of the evolving setting of the South African schooling system with both an inquiry as well as emancipatory agenda. The research process in this study is guided by a multi-paradigm perspective, which draws heavily on qualitative, interpretive, social constructivist and situated cognition orientation. This paper focuses on the experiences within a school-based programme, which was aimed at enhancing the science teachers' PCK through action research. The programme was aimed at employing research-based strategies to systematise learning and teaching efforts as well as deepen the teachers' understanding of specific science concepts. Since the aim of this study is to analyse a social situation with a view of improving the quality of action within it, action research as a methodology is a logical choice. According to Cohen & Manion (1980) action research is a direct and logical outcome of the progressive position. There is a case for teacher development programmes to assist science teachers to engage in action research and reflective practice because the Natural Science (NS) Learning Outcome (LO) 1 of the South African curriculum, dictates that teachers teach and support their learners to develop skills for carrying out open-ended investigations. The task of a science teacher as implied in the National Curriculum Statements (NCS) is to create learning environments that will build on children's natural inclination to seek explanations and motivate them to find answers to questions through active investigations. This paper focuses on the first cycle of the study whose main aims evolved as:

- gaining value and insights of the teachers' personal practical knowledge
- gathering baseline data to inform the development of the school based programme as well as a starting point in mapping teacher development and growth as they continue to participate in the programme.
- enhancing my understanding of action research (AR)
- using reflective journal to establish praxis of a flexible and adaptable AR facilitation role through continuous engagement in critical reflection in order to ensure meaningful experience for the teachers involved.
- establishing a cohesive team of science teachers who are passionate and willing to commit and fully participate in the programme.

The paper reports on some parts of the of the first cycle findings which focuses on the facilitation and researcher roles as well as preliminary data findings of the first three teachers working with one specific science content area in their classrooms.

BACKGROUND & LITERATURE REVIEW

Action research as seen in this study is a process by which change and understanding can be pursued simultaneously (Dick, 1993). There are a number of various definitions for action research found in literature (Cochran-Smith & Lytle, 1993; Dick, 1993; Kolb, 1984; McNiff, 2002). There have also been some attempts by various authors (Calhoun, 1993; Cochran-Smith & Lytle, 1993; McKernan, 1988; Rearick & Feldman, 1999) to develop classification scheme by comparing and contrasting as well as tracing the development of various models of action research. McKernan (1988) identified three categories of action research based on ideological perspective. In describing education reform context which are similar to those we face today in South Africa, Fullan & Hargreaves (1998), argue that all these changes come with demands which can be very exhausting and demoralising for teachers. They point out that *too much educational reform and restructuring is destroying teachers' confidence, draining their energy, eating up their time and taking away their hope* (p.3). It is quite evident that in South Africa, the teacher's world is ruthlessly invaded, their lives harassed, their dignity degraded and our belief is that to have a claim on their time without immediate response of systematic support to issues they face on a daily basis, is becoming unethical. The critical question becomes, how do we then continue to support teachers' much needed development in these times of reform in such wise as to instil hope and ensure success in high quality education in our schools? In line with the South African norms and standards for educators, other studies (Roth K. J. in Abell & Lederman, 2007; Schön, 1983) alludes to the fact that teacher reflection should form a central and critical part of professional educator responsibility as it provides a continuous avenue for the teacher to consider many factors which should inform the decision on how to act in particular and varied situations. Loughran et al, (2006) assert that for teachers, thinking about teaching is a complex task and that it is important to promote ways of sharing teachers' professional knowledge of teaching to further enhance understanding of teaching and learning in science. This study was therefore aimed at identifying conducive conditions that support the flourishing of science teachers' PCK by drawing from powerful research based strategies and available teaching and learning resources to promote in them experiential outlook to their practice as they endeavoured to implement the new curriculum in their classrooms. Goodnough (2003) used the process of reflective practice to explore and enhance her understanding of action research process and how to foster collaborative inquiry within the context of action research group. What Goodnough (2003) learned in her study was that in order to fulfil the role of establishing a context where individuals involved are able to reach their goals, a facilitator of action research group is required to exhibit considerable flexibility. Another important learning was the realisation that it was only through critical self-reflection and group discourse throughout the process that one is able to know when to assume different roles or meet changing needs and contexts. These experiences are very critical for this study and were taken to heart during the process of this study.

RESEARCH DESIGN

Since this study hoped to capture and explore the types of environment and insights that emerged from use of reflective practice and meta-cognitive tools to enhance the teachers' practice at multiple levels, the challenge emerges on how to capture a holistic picture from a changing environment with diverse aspects. To curb this challenge, the study will employ an eclectic theoretical approach with multidimensional analytic framework, so as to ensure that the picture captured is holistic. The research process in this study is guided by three models which are the *Interconnected Model of Professional growth* by Clarke & Hollingsworth (2002), *Theory of Curriculum Implementation* by Rogan and Grayson (2003) and Loughran et al.'s (2004) CoRe and PaP-eR model for capturing and portraying PCK. Using the framework offered by these models, relevant aspects of the programme is monitored through different forms of data capturing tools. The three models are integrated according to their particular strengths to offer a framework for research planning purposes as well as analytical lenses for mapping and categorising teacher change data in terms of discerning changing patterns in the teacher's PCK. In this study, the main sources of data were field notes, video recording of the consecutive lessons covering a specific topic, with the associated pre- and post-observation interviews per teacher and the reflective journals kept by all participants. All text materials, that is, field notes of consecutive lessons covering a specific topic, with the associated pre- and post-observation interviews per teacher, the reflective journals, and other items collected during data collection will be subjected to topological analysis using the framework offered by Rogan and Grayson. Exploration of this process will be a focus of another presentation.

All lessons observed were video-taped for subsequent analysis. The main focus of the observations was to see how the teachers transfer the skills, ideas and learning gained from their participation in the research group interactions in their classrooms. To get teachers into a mode of systematising and reflecting on their teaching efforts, pre- and post lesson interviews were held with the teachers to allow them to share their plans and their reflections. Prior each lesson each teacher was encouraged to have and both research as well as learning and teaching objectives. Data collected from classroom observations, pre- and post classroom observation interviews, text analysis of learner assessment tasks and portfolios, teacher's work schedule and lesson plans, will inform this domain. Planning/reflections questionnaire and the interview were held with each teacher to get at their initial strategies. Critical feedback was given to each teacher during the reflection session by the whole team.

EMERGING FINDINGS OF THE FIRST CYCLE

The emerging findings are discussed by giving a description of the changing context of the first school, the general findings from the data gathered and the tensions and the challenges that emerged as the process unfolds as well as the strategies that were employed to try to move the process forward. Even though it was not apparent at the beginning, the high school emerged as a troubled dysfunctional school. At the beginning of the study the school was under the management of an acting principal who welcomed the researcher warmly and opened the doors of her school. The prin-

cipal had been dismissed on charge of embezzling of school funds. Within a period of two months, the school was under new management as the acting principal and the deputy had resigned under clouds of controversy. Another dynamic was that due to bad matriculation results the MEC visited the school and demanded a strategy from the management for turning the school around. T1 presented this programme as the strategy for turning her department around. The pre-testing, interviews and lesson observations took place over a period of four days. For about four hours, the three teachers completed questionnaires and underwent interview to establish where they were at in terms of conceptual understanding of the topic and their learning and teaching planning/reflection strategies and the management of learning and teaching in their classrooms. As part of the study the teachers also participated in a two hour reflection session as well as four hours in-service training session. Two of the teachers were then observed twice in their classrooms dealing with some aspect of *chemical change* concept.

PRELIMINARY FINDINGS FROM DATA

An analysis of the concept challenge results reveal that all the eight teachers have some level of conceptual challenges in making shifts between the triads underpinning clear understanding in science. There are also levels of confusion concerning microscopic categorisation of substances as mixtures, pure substances, compounds or elements as well as issues around conservation of matter. The results of the questionnaire and the interview revealed that there was no planning/reflections for teaching & learning at school and phase level at the high school and there was planning at primary school which was however very technical and not that meaningful. In both schools planning at grade level was rudimentary and although individual lesson planning processes differed they were mostly scanty. None of the teachers engaged any serious reflections about their teaching at any level. Analysis of classroom observations revealed that all the teachers operated at level 1 of Rogan and Grayson (2003) *profile of implementation* levels. Most teachers employed teacher centred classroom management and most used question and answer strategy to engage learners albeit using low ordered questions. Journal writing promises to be a great tool to assist participants in making their thoughts explicit, in practicing reflection-on-action as well as for data capturing purposes (Goodnough, 2003). The researcher used a reflective journal to engage in critical self reflection as a facilitator, a researcher as well as a teacher educator in an attempt to clarify thoughts and critically analyse what was happening and how best to move the process forward. Through this experience a format for use by all participants has been modified. The results of the first cycle served to clarify the context and inform the planning process by offering insights of where the teachers are and their challenges and gaps in their teaching and learning efforts. They also informed the starting point in mapping teacher development and growth and of even more impotence to inform the development of a school based action research framework that integrates research and responsive teacher development programme based on the identified needs.

Emerging Challenges, Tensions and Strategies

The challenges that emerge can be categorised under facilitator role, researcher role as well as teacher developer role. Because of space limitations, this paper will only focus on the first two roles. One of the main challenges that emerged was due to the demands in terms of time and efforts the programme placed on the teachers. The extensive engagement which the programme dictates poses a challenge on how to ensure the teachers' commitment, passion as well as sustained interest. The continuity of the programme will lie in the researcher's capacities to sustain the teachers' interest, passion and commitment throughout the process and the flexibility and adaptability in carrying through the interests of each and every individual will be critical. The strategy which is employed is to ensure that the process is rewarding as well as responsive to the teachers' day to day learning and teaching issues. Throughout the process and especially during reflection meetings, the researcher strives to create a learning environment where all participants are comfortable to express their ideas, are receptive to critical feedback, motivated to stay on task and committed to offering constructive feedback to others. This is achieved by being vigilant and taking every opportunity to highlight the unique strengths each individual possess and encouraging them to make their contributions. One of the central aims of the programme is to promote teacher autonomy and emancipation – therefore easy and typical power strategies (e.g. prescription, mandatory or coercive) goes against the spirit of the programme. This became a challenge when the school decided to adopt the programme as their turn around strategy because T1 kept on insisting that the new teachers should become part of the programme whether they liked it or not. I kept on insisting that all teachers should participate voluntarily from an informed position without feeling compelled to be part. Because of this attitude of trying to force participation, the four teachers were not enthused about the programme and they ultimately withdrew from the programme. Another challenge was on the issue of interferences during workshop sessions. This was resolved by looking for a venue outside the school premises (teacher centre) for running workshops. Being from the teacher and learning teaching materials development background with little research skills, I struggle to balance training & development agenda with research agenda. I find myself more inclined to respond to the teachers' development needs than I am to integrating research. I need to be very mindful not to lose critical moment for data collection as well as to continue reading on literature review. There is need to establish working understanding of action research methodology – issues of attaining rigour (dialectic, convergent interviewing) as the study progresses. Managing action research is very demanding and requires intensive focus, learning & emerging input. I find myself needing space, autonomy, flexibility as well as expertise guidance & sympathetic support. We have established a reference team of colleagues who continue to give critical feedback on an ongoing basis. Other issues that emerge around this role are ethical issues. How to handle issues of coercion from the school senior management aimed at forcing the teachers to participate in the programme. Handling and reporting on privileged information of incompetence irresponsible acts, insights into professional jealousy, sabotages and back stabbing. At this stage, I have

been using this information to encourage and foster group cohesion by actively guiding the group from an informed position.

DISCUSSIONS

Even though there were lots of potential, the challenges were just too deep and in my estimation, beyond the scope of this PhD study. The types of challenges which emerged during this phase of the study bear witness to the assertion made by Cohen & Manion that, what seems to be needed is a clear and unambiguous statement of the project's objectives such that all participants understand them and their implications; and a careful analysis of the context in which the programme is to be mounted to determine the precise, but flexible, relationship between the two components. They argue that this stage is critical for the venture in that it is at this point that the seeds of success or failure are planted because if the objectives, purposes and assumptions are not made perfectly clear to all concerned, and unless the role of key concepts is stressed (e.g. feedback), the enterprise can easily miscarry. Amongst all other challenges the present study faced, I believe that the wheels really went off when we tried to integrate the new teachers at a later stage into the programme. Another serious source of challenge was the emerging dysfunctional context of the school. The school which at the beginning and on the surface, seemed well functioning and thriving. The Rogan & Aldous (2005) study revealed that school ethos and the way in which a school is managed have the greatest impact on implementation. Consistent with some of the issues that emerged in this study, they argue that the level & style of accountability are also important. What they assert and has been experienced in this study is that whole school development is more important than professional development in particular learning areas since different approaches to curriculum change in a school can be counter-productive. The findings in this study bear witness to their argument that professional development needs should be institutionalized and approached in a systemic and systematic way or otherwise it becomes a futile exercise. Fortunately in the context of this study all is not in vain. There is a well known say that, *if you want to understand a system, try to change it*. This first phase of the study provided the researcher with insights into the practicalities most of the teachers in South African schooling system are faced with on their daily basis. The types of contextual issues which emerged during this phase contributed greatly to the emerging conceptual and data analysis framework which will be presented in this paper. Another critical contribution is the exposure to working understanding of action research methodology as well as exploration of striving for reflective practice through maintenance of reflective journal and the practical dynamics involved in establishment of collaborative teams. The un-fortunate part is that the learning will had to be transferred to and continued in a more functional and structured setting.

CONCLUSION

It's been an interesting, challenging, dynamic, frustrating and a deep learning curve in trying to sustain momentum, enthusiasm, commitment and cohesion among a team

of science teachers involved in this study. The struggle has been on how to pull the pieces together, to ensure an exciting and valuable study to report on. Unfortunately, the learning will have to be transferred to and continued in a more functional and structured setting. The main challenge which remains is on how to report the darkness and deficiencies revealed in this first cycle of the study. It was hoped that no matter how bleak the initial state of affairs was, at the end of the process all participants would have the opportunity and pride to say that, *I was here* and *now I am here*. We hope to be able to continue engaging the teachers who were part of this study in other forms of our programmes.

REFERENCES

Adler J B, Slonimsky L F & Reed Y L, "Subject-focused INSET and teachers' conceptual knowledge -in- practice", Chapter 8, pp 135-152. In Adler J & Reed Y, *Challenges of Teacher Development: An investigation of take-up in South Africa,* First edition, Van Schaik, Pretoria, South Africa, 2002.

Bencze, L., Hewitt, J. & Pedretti, E. (2001). Multi-media case methods in pre-service science education: Enabling an apprenticeship for praxis. *Research in Science Education*, *31*(2), 191-209.

Calhoun, E. (1993). *Action Research: Three Approaches. Educational Leadership*. 51(2), 62-65.

Clarke, D. & Hollingsworth, H. (2002). 'Elaborating a model of Teacher Professional Growth.' *Teaching And Teacher Education*. 18, 947-967

Cochran-Smith, M. & Lytle, S. L. (1993). Inside/outside: Teacher Research and Knowledge. New York: Teachers College Press.

Cohen, L. and L. Manion. 1980. Research methods in education. London: Croom Helm.

Dick, B. (1993) *You want to do an action research thesis?* http://www.scu.edu.au/schools/gcm/ar/art/arthesis.html

Goodnough, K. (2003). Facilitating action research in the context of science education: reflections of a university researcher. *Educational Action Research*, 11(1), 41 – 64

Kolb, D. A. (1984) *Experiential Learning: experience as the source of learning and development* New Jersey: Prentice-Hall

Loughran, J.J., Mulhall, P., & Berry, A. (2004). In search of Pedagogical Content Knowledge in Science: developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, 41 (4), 370 391.

McKernan, J. (1988). The Countenance of Curriculum Action Research: Traditional, Collaborative and Emancipatory-Critical Conceptions. *Journal of Curriculum and Supervision*, 3(3), 173-200.

McNiff, J. (1992). *Action Research: Principle and Practice*. New York: Routledge

Rearick, M., & Feldman, A. (1999). Orientations, product, reflections: A framework for understanding action research. *Teaching and Teacher Education*, 15(4), 333-350.

Rogan, J. M. and Grayson, D.J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education*, 25(10): 1171 – 1204

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational researcher*, 4-14.

Taylor, N. & Vinjevold, P. (Eds). 1999. *Getting Learning Right: Report of the President's*

Education Initiative Research Project. Johannesburg: Joint Education Trust/ Department of Education.

Taylor Report, 1999, *The Socio-Economic Context and the Need for Comprehensive Protection*. Draft Consolidated Report of the Committee of Inquiry into a Comprehensive System of Social Security for South Africa.

Wilson, S. M., Shulman, L. S., & Richer, A. E. (1987). In J. Calder (Ed), Exploring teachers' thinking (pp 104-124). London: Cassell.

NEW TRENDS IN RESEARCH: A SHIFT TOWARDS COMMUNITY DEVELOPMENT

Eunice T. Dlamini, BG Ndawonde, A Zobolo
University of Zululand
Private Bag X1001, KwaDlangezwa, 3886, SOUTH AFRICA
etdlamin@pan.uzulu.ac.za

▼ Abstract

In the past research has been about discovery of innovations and expanding our knowledge base. Research results were considered to be objective and were uncomplicated by side issues such as the context in which the research was done, or the milieu of those involved and the impact of the research on those researched. There has also been a strong but erroneous belief that scientific research is essentially a-moral and a-political. This belief has in the past resulted in the violation of the rights of researched communities, most of whom were poor and illiterate. This paper reports on a case study that investigated the nature of plants sold by medicinal plant sellers in KwaZulu-Natal (South Africa): how such plants were used, their present availability and vulnerability. Sub-issues investigated included identification of those involved in this trade and an exploration of harvesting methods employed. The results showed that the medicinal plant trade is dominated by poverty-stricken women. It was also discovered that harvesting methods as well as the practice of the medicinal plant trade were unsustainable. The issue raised by this paper is whether it would be both sustainable and ethical for the researcher to walk away from this situation. The paper outlines a case study which responds to these questions in the light of recent developments in South Africa and which supports the sustainable development of poverty-stricken rural communities. Such efforts also explore how indigenous knowledge can be used to enhance development of indigenous communities. The researcher went on to form partnerships with the communities selling medicinal plants with the aim of embarking on conservation of threatened species with their help. Informed participation of medicinal plant sellers is considered to be important so as to ensure that they understand their responsibility to conserve resources that form part of their livelihood.

Key Words Community development, indigenous knowledge, community engagement.

INTRODUCTION

Africans rely heavily on traditional medicine. This can be attributed to local availability, affordability, accessibility and local expertise among local communities

(Maundu, Kariuki and Ejong-Matig, 1999). Various factors, including a high rate of unemployment, urbanization, clearing of vegetation for agriculture and other land use and low levels of formal education have contributed to the high demand for medicinal plants. Together, these factors have resulted in the over-exploitation of medicinal plants by commercial gatherers who sell them for a living. Thousands of medicinal plants are harvested from communal areas in South Africa, thereby putting pressure on the species involved (Kalatwang and Dűvel 2002). The main problem associated with the commercialization of medicinal plants is unsustainable harvesting. This includes bulk collection of medicinal plants in the hope of gaining more profit. In some cases the commercial gatherers harvest the whole tree by ring-barking or uprooting, thereby causing low or zero regeneration of the medicinal plants in question. As a result, such plants are depleted to the extent that they become locally extinct or the genetic biodiversity of the plant species involved are eliminated.

BACKGROUND AND PURPOSE OF THIS PAPER

The purpose of this paper was to highlight the importance of community engagement in managing natural resources. The universities are looked upon by communities as sources of information the communities can tap on, to improve their adverse circumstances e.g. poverty, diseases and food security. The paper made use of the results of a case study of medicinal plant sellers. In the case study, data was collected from 63 respondents with regard to the different plant types sold at bus ranks in South Africa. The study explored the usage of medicinal plants, the parts of the plants that are used and the methods of plant harvesting. Personal data was collected by means of a questionnaire which sought information about those involved in the medicinal plant business, i.e. their sex, age and selling locations. Other data was collected though semi-structured interviews with the respondents. Crucial to this paper, are the results of the study, which showed that medicinal plant sellers are mainly elderly, poverty-stricken females. Of the 63 participants, 77% were women and only 23% male. It was also discovered that the plant selling methods of the respondents were crude and that they lacked business acumen. The respondents collected plants in bulk and their only concern was the potential profit. This is clearly an unsustainable practice driven by principles of commercialization, as opposed to sustainable indigenous practices that avoid total destruction of the plants in question. Those who advocate the recognition of indigenous knowledge (IK), realise that indigenous communities practiced and promoted sustainable development. Gorjestani (2000) writing on indigenous knowledge for development, states that IK is a key element of the social capital of the poor and constitutes their main asset in their effort to gain control of their lives. As the case study had revealed problems in the bulk harvesting of medicinal plants that threatened to drive certain plant species to extinction, a workshop was subsequently organised so as to allow the respondents to discuss the issue of sustainable harvesting of medicinal plants with the view to ensure the sustainability of their business. The researchers involved two members of staff from the Department of Agriculture and Environmental Affairs (DAEA) in the workshop.

It was interesting to note the excitement of participants when they saw the government officials. To them, the presence of these officials lent credibility to the meeting and they were therefore convinced that the workshop was significant. One of the government officials discussed the importance of communities taking care of their resources and making sure that these resources would be available, not only for the present, but for future generations as well. At the end of the workshop a joint committee consisting of medicinal plant sellers, researchers and the DAEA was formed. The committee undertook to ensure that future activities would be planned around the sustainable harvesting of medicinal plants. This partnership came at an opportune moment when the government also came to realise that communities have to become involved in the management of their resources. The South African Government now has a number of projects, for example community involvement in the rehabilitation of wetlands due to their importance in the maintenance of declining water supplies.

UNIVERSITIES AS CATALYSTS FOR POSITIVE CHANGE

There is a growing demand from the public for universities to cease being impractical ivory towers. This demand does not only appear on the national agenda of South Africa, but is an international issue of concern. Temple, Story and Delaforce (2005), speaking on community engagement by universities in Australia, state that universities are increasingly playing (or ought to be playing) an integral role in their regions, thereby contributing to the sustainability, wellbeing and economic vitality of their communities while becoming catalysts for positive change and development. The term 'ivory tower' designates a world or atmosphere where intellectuals engage in pursuits that are disconnected from the practical concerns of everyday life (http://eA.wikipedia.org/wiki/Ivory.tower). Universities need to explore opportunities for service and for the development of their communities and should also be catalysts for improvement in the poverty-stricken and marginalized communities in their midst. University engagement with communities can bring about new knowledge that is relevant to the needs of specific communities, thereby making learning relevant by enabling students to solve real-life problems. The University of Zululand's mission statement includes the following clauses:

> To promote community engagement through mutually beneficial partnerships
> To generate knowledge through publications, teaching and development, in partnership with the local and international communities

In keeping with sentiments emanating from other universities, locally and internationally, the University of Zululand embraces the concept of community engagement so as to ensure their empowerment and development. Community engagement or development is supported by the Brisbane Declaration adopted by participants to the International Conference on Engaging Communities held at Brisbane, Australia, from 15 to 17 August 2005. Among issues adopted in the declaration were the following that are important in this context:

1. Acknowledgement of the universal interest and importance of a community engagement, founded in the inherent dignity of people values, rights and responsibilities of all people expressed in the Universal Declaration of Human Rights.
2. Underscoring that community engagement is essential to the achievement of the Millennium Declaration including the Millennium Goals of Development.
3. Affirms that effective community engagement generates better decisions delivering sustainable, economic, environmental, social and cultural benefits (http://www.getinvolved).

It is therefore clear that there is a convergence of thinking in different universities around issues of engaging in research that contributes to community development and empowerment.

THEORETICAL FRAMEWORK

There are a number of principles that underpin the theoretical framework of this paper. The first principle underpins curriculum development in South Africa, which is aimed at social transformation which is necessary to address the legacy of apartheid which marginalized Black people and discriminated against them. Social transformation in education therefore aims at ensuring that the educational imbalances of the past are redressed and that equal opportunities are provided for all sections of our populations. The principle of life-long learning is well recognized and acknowledged in the country. Jickling and Suave (2008), co-chairs of the 5th World Environmental Education Congress which will be held in Montreal in 2008, state that environmental education contributes to the development of informed, enlightened and innovative citizens. These are citizens who are able to solve their local problems, use their resources sustainably and create peaceful and stable communities. In contrast, disturbing xenophobic attacks on foreigners have recently taken place in South Africa, which are not characteristic of stable communities living peacefully with one another.

The second principle concerns the role of indigenous knowledge in our society. This is a principle that highlights inclusiveness and that marks a major shift from the belief that only Western science contributes to a knowledge base that is credible. Many indigenous people have successfully managed the environment and encouraged sustainable ways of dealing with their environment. Such ways of indigenous people have been looked down upon instead of being acknowledged and developed to contribute to diverse ways of effectively managing our fragile planet. Cobo (1987) complains that educated people do not understand the deeply spiritual and special relationship between indigenous peoples and their land as basic to their existence, which includes their beliefs, customs, traditions and culture. A third pillar of the theoretical framework of this paper is the definition of environmental education (EE), which is stated as follows:

> Environmental Education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among man, his culture and his biological surroundings. It is a life-long learning process that is graded at knowledge, understanding, skills and the fostering of values and attitudes towards the natural and man-made environment. (IUCN 1971)

The significance of the EE definition is the recognition of the interrelatedness among people, their culture and their physical environment. Irwin and Lotz Sisitka (200) also confirm that the definition refers to the fact that people hold values and attitudes which, *inter alia*, relate to the environment. That is why rural communities can be educated to develop positive attitudes toward their environment, and can be empowered to take a step further so as to use and manage natural resources responsibly. Mulemwa (2006) states that good quality science and technology education (and in the authors' view, good quality environmental education, as well) should equip learners not only with knowledge but also with attitudes and skills for a healthy lifestyle, social-economic survival, self-reliance and self-sustenance.

IMPLICATIONS OF THE CASE STUDY

It would have been acceptable in a purely scientific research study for the researchers to have gathered information about the unsustainable practices of medicinal plant sellers, and to have left the issue there. However, new trends of thought about research have emerged, as captured by Crabb (2004) who, for example, states that the problems of poverty and the HIV/AIDS scourge have forced the Department of Science and Technology in South Africa to challenge scientists to adapt their research in order to address the country's social problems. Issues of sustainable development are prominent in making this planet a better world for everybody. Also, Agenda 21 – the sustainable development blueprint for the 21st Century, recognises in Chapter 36 that education, public awareness and training are critical aspects for sustainable development and that the participation and involvement of women, indigenous people and the scientific and technological communities are essential in its implantation (United Nations, 1992). It is for the reasons discussed above that the researcher who investigated medicinal plant sellers is now involved with them in a partnership which seeks to cultivate medicinal plants as crops. The advantage to this approach is that the cultivation of medicinal plants as crops makes it easier to develop and improve strains of plant life, while reducing the need for wild collection (Ndawonde, Zobolo, Dlamini & SIebert, 2007). Wild collection exposes women to dangerous situations, e.g. rape and being attacked by wild animals. The researcher has developed a strong partnership with the respondents, to the extent that they now understand the consequences of unsustainable harvesting of plants. They are willing partners in the research. While the researcher is a facilitator and participant in the partnership, she is also a learner with regard to indigenous ways of planting and managing crops, with the respondents as the instructors. Urmilla et al. in addressing interdisciplinary/multidisciplinary research state that the process of knowledge sharing and knowledge generation is in-

creasingly taking place at the interface of traditional disciplines and approaches to scientific research, which are becoming more integrative (Urmilla, Moodley, Traynor, Gausst & Chellan, 2005). A further crucial aspect of this type of research is that it encourages cooperation and collaboration of different stakeholders. In the case of this study, the research stakeholders are the researchers, the medicinal plant sellers and the Provincial Department of Agriculture and Environmental Affairs of KwaZulu-Natal.

SUMMARY OF THE RESEARCH WITH RESPONDENTS

The research project (in which the medicinal plant sellers are now collaborators with the researcher) has the following aims:

- Propagation of five selected medicinal plants at the University of Zululand medicinal plant nursery.
- Monitoring of the growth of the five selected medicinal plant species to determine the conditions in which they thrive.
- Determining the time in which the medicinal plants will be ready to be sold.
- Working with the medicinal plant sellers in order to cultivate the selected threatened medicinal plants at the University of Zululand's medicinal nursery.
- Assisting the medicinal plant sellers to cultivate the selected medicinal plants in communal gardens.

METHODS AND MATERIALS

Questionnaire administration

In the present research, a questionnaire will be used to establish the localities from which medicinal plants are harvested for subsequent sale at Mona Muthi market. We will try to establish from plant traders whether the plants are collected from grasslands, wetlands or sub-tropical forests (or even from dune forests). Such information will help to establish whether the medicinal plants are xerophytes, hydrophytes or whether they can be grown in rocky places. This information will be considered in the preparation of a medicinal plant nursery. Information will be collected by means of structured or semi-structured interviews. This method of interviewing will be used because it enables the interviewer to establish rapport with the respondents while listening to them (Mugenda, 1996). The interview permits more complex questions than other methods of data collection since it is easier to probe further if there is something that the researcher wants to be sure of. The interviews will be conducted in IsiZulu and the information will be translated into English.

Ethical issues

Information given in confidence will be kept confidential in order to protect the intellectual property of the respondents. As we know, indigenous knowledge is communal in nature and is not openly shared as in the case of scientific

knowledge. Indigenous peoples usually consent to sharing their knowledge on an individual basis but not if it is to be commercialized, distorted, trivialized or otherwise debased (http://www.siteresources.worldbank.org INTINKD-KNOWLEDGE/Resources/generalguid.pdf).

PROPAGATION AND CULTIVATION OF THE MEDICINAL PLANTS

The plants will be propagated by means of seeds and cuttings at three-month intervals in June, September and December. As many as 100 seeds and cuttings of the selected medicinal plants samples will be planted in pots to ready them for transplantation. This will allow at least 25 seedlings to be cultivated in each time interval in case some of the seeds do not grow.

COMMUNAL DEMONSTRATION GARDEN

A committee consisting of the researchers and the representatives of the medicinal plant sellers from areas close to the University of Zululand was formed in 2006.The duty of the committee is to oversee the establishment of the communal gardens in the localities of the participants. As soon as the researcher has successfully propagated selected medicinal plants (vegetatively), a workshop will be held during which the researchers will demonstrate necessary techniques to the committee members.

The garden will cover an area of 1000m^2. The seedlings that are transplanted into the garden will not receive organic manure. There will also be no provision of shade in the garden. Plants will be watered for a short period, until they are established, and then they will be left to grow without irrigation. This method is supported by Hutchings and Crouch (1998), who believe that newly planted specimens should be carefully watered and tended until established, and then purposely be left to the elements. This is necessary because medicinal plants are known to convert primary metabolites such as starch and lipids into secondary metabolites (the medical component) when they are subjected to water stress.

In order to determine the marketable size of the medicinal plants, the following experiments will be performed in the garden. Seedlings will be weighed and their length and width will be measured before transplant.

GROWTH EXPERIMENTS

Plants will be divided into two groups, namely pot-grown and field-grown experiments. Each experiment will have the following treatment:

Control	1:	plants without manure but watered once a week
Control	2:	plants without manure but watered twice a week.
Treatment	1:	plants receiving manure and watered once a week.
Treatment	2:	plants receiving manure and watered twice a week.
Treatment	3:	plants receiving manure and not watered at all until they show symptoms of wilting.

Plants will be harvested at 30, 60 and 90 day intervals after transplanting. This will be done in order to determine in which planting season the medicinal plants have the best yield. There will be ten observations per treatment. The growth parameters that will be investigated include:

a) fresh weight of individual plant organs
b) dry weight (oven dried at 70^0C to a constant weight)
c) plant height
d) branching pattern
e) number of bulbs/braches
f) leaf area index (determined using a leaf area meter)
g) chlorophyll content (determined using spectrophotometer)
h) leaf water potential (determined by using a pressure bomb).

DATA ANALYSIS

Measurements of tree densities, species diversity and richness of medicinal plants will be presented graphically. Numerical comparisons using graphs and tables on plant propagation, growth, yields and statistical inferences, such as the Statistical Package for Social Sciences (SPSS), will be used. Data on growth, morphology and physiology of medicinal plants will be analysed using a t-test as well as one-way ANOVA.

COMMUNITY ENGAGEMENT

The main purpose for the inclusion of the communities in the propagation of medicinal plants is to correct past practices of exclusion of local communities in the process of decision making and general management of resources. There is a need to establish the principle of ownership of local resources by indigenous peoples so that the duty of preserving biodiversity does not become a duty of the government but a collaborative effort between government and local communities. Walker (2005) states that, historically, Australian education, just like South Africa in the apartheid days, excluded indigenous pedagogy through colonization and assimilation leading to the cultural genocide of indigenous epistemologies. This is a powerful statement, but the good thing is that the world is beginning to realise the importance of recognizing indigenous knowledge. Governments are also beginning to see the importance of involving communities in development issues because it is believed that sustainable communities make efficient use of natural resources, while promoting sustainable production, consumption, protection and improvement of biodiversity.

CONCLUSION

The new trend in research is therefore a move toward multidisciplinary research characterized by the involvement of various stakeholders. Among the stakeholders are indigenous knowledge custodians. This type of research therefore acknowledges the world-views of different stakeholders and the fact that we can learn from one another irrespective of our cultures. Onwu and Mosimege (2004) in discussing IK, state that traditional indigenous knowledge developed through the close connectedness

with the physical and social environment that people used to enjoy. Wolfensohn, the President of the World Bank as quoted by Gorjestani (2000), states that "Indigenous knowledge *is* an integral part of the culture and history of a local community. We need to learn from local communities to enrich the development process". Basically, what this means is that there are competing perspectives and world views from which to understand and make sense of the world. Expanding information and the involvement of different stakeholders is the key to solving environmental problems, which include political and socio-economic problems.

REFERENCES

Gorjestani, N. (2000). Indigenous knowledge for Development: Opportunities and Challenges. The paper is base on a presentation made by the author at the UNCTA D Conference on Traditional Knowledge in Geneva, November1 2000.

Kelatwang, S. & Duvel, G.S. (2002). Promoting medicinal plant gardens. The challenges to successful extension of New Practices to traditional healers in South Africa. Proceedings of the 18th Annual Conference Durban, South Africa.

Maundu, P., Kariuki, P & Eyog-Ntig, O. (1999). Threats of medicinal plant species – an African perspective.

Proceedings of a global synthesis workshop on Biodiversity loss and species extinction: Managing risk in a changing world. Sub-theme: Conserving Medicinal plant species securing a healthy future.

Ndawonde, B.G., Zobolo, A.M., Dlamini, E.T. & Siebert, S.J. (2007). A survey of plants sold by traders at Zululand muthi markers with a view to selecting popular plant species for propagation in communal gardens. African Journal of Range and Forage Science, 24(2), 103-107.

Onwu, G. & Mogege, M. (2004). Indigenous Knowledge Systems and Science and Technology Education: A Dialogue. The paper was presented at a workshop at the University of Western Cape. United Nations. Agenda 21. United Nations Department of Economic and Social Affairs. New York:

United Nations, 1992. Available online: http://www.un.org/esa/sustdev/documents/agenda21/English/agenda21toc.htm.

Urmilla, B., Moodley, V., Traynor, C.H., Gausset, Q. & Chellan, N. (2005). Embracing difference and diversity: Interdisciplinary cross cultural and group dynamics. In the SLVSE model of natural resource management: From theory to practice through field-based training-experiences from Southern Africa. C.H. Traynor (Ed).

DETERMINING THE STUDY SKILLS OF STUDENT TEACHERS

Güner TURAL DİNÇER, Ali Rıza AKDENİZ, Yasemin DEVECİOĞLU
Karadeniz Technical University, Fatih Faculty of Education, Department of Secondary Science and Math Education, 61335, Trabzon
E-mail: gdincer55@gmail.com

▼ Abstract

It is known that success of a student is affected by the skills of motivation, time management. Studies have showed that there is positive relationship between academic achievement and study skills of a student. It is thought that study skills of learners should be defined to be more successful on teaching-learning process.

The aim of this study is to examine the study skills of student teachers if there is a significant difference regarding to discipline and gender. The sample of this study consists of 135 student teachers from the Science and Technology Education Program at Department of Primary Science Education and from Department of Secondary Science and Math Education (Physics, Chemistry and Biology Education Programs) in Faculty of Education in KTU. Data gained from a questionnaire developed by Bay et al. (2005) consisting of 26 items on a 5 point likert scale.

The findings of the questionnaire showed that study skills of student teachers' from each department were at the average level. There was not found any significant difference between the study skills of science student teachers on the gender.

Key Words Study Skills, Time Management, Motivation, Exam Anxiety, Science Student Teachers.

1. INTRODUCTION

Teachers are seen as the most important element of instruction. However, learning is the responsibility of the students. He/she should prepare himself/herself for learning mentally.

Students generally use some study skills which is developed by the students themselves during their education process from elementary to higher education. These study skills are generally inefficient and inappropriate. Studies have showed that there is a positive relationship between academic achievement and study skills of a student (Yip and Chung, 2002; Lammers et al., 2001; Carter, 1999; Atılgan, 1998; Jones et al., 1996; Kleijn et al., 1994; Agnew et al., 1993; Lawler-Prince et al., 1993; Elliot et al., 1990; Schultz, 1989).

There are factors which influence study skill of students such as motivation and time management, exam anxiety. The success of students is affected by these factors (Bay et al., 2005). Student motivation can be described as a student's willingness,

needs, desires and passions to participate in and be successful in learning process (Bomia et al., 1997). Time management expresses using time profitable while studying to reach the aims (Telman, 1996). Moreover, exam anxiety influences students' success. This factor may influence the success negatively (Hill& Wigfield, 1984). Anthony's (2000) study compared to the perceptions of the faculty and the students in relation with academic achievement in the first year math courses. According to this study, motivation was thought an important factor influencing the student's success.

The aim of this study is to examine if there is significant difference regarding the study skills of student teachers according the department and gender.

1.1. Problem

The problem of this study is whether there is significant difference regarding the motivation, time management, preparation for the exam-exam anxiety skills and general of study skills of student teachers according the department and gender.

2. METHODOLOGY

The study is conducted with 135 student teachers from the Science and Technology Education Program at Department of Primary Science Education and from Department of Secondary Science and Math Education (Physics, Chemistry and Biology Education Programs) in Fatih Faculty of Education in KTU. The sample of the study is given in Table 1.

Table 1 The Sample of the Study According the Disciplines.

Department	Discipline	N
Primary	Science	87
Secondary	Physics	16
	Chemistry	11
	Biology	21
	Total	135

Data was gained from a questionnaire developed by Bay et al. (2005) consisting of 26 items on a 5 point likert scale. The answers of the students for the scale items were scored from 1 (strongly agree) to 5 (strongly disagree).

The scale has three dimensions: motivation, time management and preparation for the exam-exam anxiety. The questions of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 are related to motivation dimension. The scores for motivation dimension are between 11 and 55. The questions of 12, 13, 14, 15, 16, 17 and 18 are related to time management. The scores for time management dimension are between 7 and 35. The questions of 19, 20, 21, 22, 23, 24, 25 and 26 are for preparation for the exam-exam anxiety dimension. The scores for this dimension are between 8 and 40.

The study skills of student teachers gain positive direction while the total score of scale goes up. The maximum score for the scale regarding the study skills is 130. Data were analyzed by using SPSS version 13.0 for Windows. The cronbach alpha value of scale is 0, 89.

3. FINDINGS

In this part, the data of student teachers from the Science and Technology Education Program at Department of Primary Science Education and from Department of Secondary Science and Math Education (Physics, Chemistry and Biology Education Programs) about dimensions of motivation, time management, preparation for the exam-exam anxiety and general of study skills are compared according the gender and department.

Table 2 The Means of All Student Teachers about Dimensions of Motivation, Time Management, Preparation for the Exam-Exam Anxiety and General of Study Skills

Dimensions	N	Minimum	Maximum	Mean	Std. Deviation
Motivation	135	16,00	52,00	33,93	6,94
Time management	135	8,00	32,00	19,12	4,36
Preparation for the exam-exam anxiety	135	10,00	39,00	23,21	5,95
General of study skills	135	52,00	119,00	76,26	13,28

According the Table 2; all of the students' mean score of motivation dimension is 33, 93 (average level); mean score of time management dimension is 19, 12 (average level); mean score preparation for the exam-exam anxiety dimension is 23, 21 (average level); general of study skills mean score is 76, 26 (average level)

Table 3 The Mean Scores and P (Significance Level) Values for the Gender

Dimensions	Department-Discipline	Gender	N	Mean	Std. Deviation	p
Motivation	Primary-Science	Female	46	34,43	8,08	0,62
		Male	41	33,68	5,66	
	Secondary-(Physics+ Chemistry+Biology)	Female	29	32,24	6,42	0,09
		Male	19	35,84	7,17	
Time management	Primary-Science	Female	46	19,85	4,63	0,17
		Male	41	18,56	4,03	
	Secondary-(Physics+ Chemistry+Biology)	Female	29	17,69	3,88	0,02
		Male	19	20,74	4,50	
Preparation for the exam- exam anxiety	Primary-Science	Female	46	22,48	6,97	0,78
		Male	41	22,85	4,99	
	Secondary-(Physics+ Chemistry+Biology)	Female	29	23,45	6,03	0,23
		Male	19	25,37	4,88	
General of study skills	Primary-Science	Female	46	76,76	15,09	0,57
		Male	41	75,10	11,58	
	Secondary-(Physics+ Chemistry+Biology)	Female	29	73,38	11,27	0,03
		Male	19	81,95	14,05	

According the t test outputs on gender, there isn't statistically significant difference (p>0, 05) for the student teachers from the Science and Technology Education Program at Department of Primary Science Education. But for Department of Secondary Science and Math Education (Physics, Chemistry and Biology Education Programs), there is statistically significant difference on time management dimension and general of study skills on gender.

Table 4 The Mean Scores and Standard Deviations Values for Departments

Dimensions	Department-Discipline	N	Mean	Std. Deviation
Motivation	Primary-Science	87	34,08	7,01
	Secondary-(Physics+ Chemistry+Biology)	48	33,67	6,88
Time management	Primary-Science	87	19,24	4,38
	Secondary-(Physics+ Chemistry+Biology)	48	18,90	4,36
Preparation for the exam- exam anxiety	Primary-Science	87	22,66	6,09
	Secondary-(Physics+ Chemistry+Biology)	48	24,21	5,63
General of study skills	Primary-Science	87	75,98	13,50
	Secondary-(Physics+ Chemistry+Biology)	48	76,77	13,01

As it is seen in Table 4, mean scores are nearly same about all of the dimensions for student teachers of Department of Primary Science Education and for Department of Secondary Science and Math Education (Physics, Chemistry and Biology Education Programs)

Table 5 The Analysis Of Variance Values of Study Skills According the Departments

Dimensions		Sum of squares	Df (degree of freedom)	Mean Square	F	p
Motivation	Between groups	5,30	1	5,30	0,11	0,74
	Within groups	6457,10	133	48,55		
	Total	6462,40	134			
Time management	Between groups	3,70	1	3,69	0,19	0,66
	Within groups	2546,41	133	19,15		
	Total	2550,10	134			
Preparation for the exam- exam anxiety	Between groups	74,62	1	74,62	2,12	0,15
	Within groups	4675,57	133	35,16		
	Total	4750,19	134			
General of study skills	Between groups	19,49	1	19,50	0,11	0,74
	Within groups	23618,43	133	177,58		
	Total	23637,93	134			

According the analysis of variance value, there isn't statistically significant difference according the departments (p>0, 05).

4. CONCLUSIONS

The results of the questionnaire about study skills showed that study skills of student teachers student teachers from the Science and Technology Education Program at Department of Primary Science Education and from Department of Secondary Science and Math Education (Physics, Chemistry and Biology Education Programs) are at the average level.

There isn't statistically significant difference related to gender regarding to the study skills for the student teachers from the Science and Technology Education Program at Department of Primary Science Education. However, for student teachers from Department of Secondary Science and Math Education (Physics, Chemistry and Biology Education Programs), the dimension of time management and general of study skills are significant according the gender. The mean scores of male students on time management and general study skills are higher than female students' mean scores. The students answered for the items of "I am not able to study for a long time without break" and "I feel so tired before starting to study" regarding to motivation dimension are 'agree' level. Also their answers for the items "I start to study one day before an exam" and "I do not study on a definite plan" regarding to time management dimensions are similar to the items above.

It is known that the factors, motivation and time management, are very important for students' success (Anthony, 2000; Hulick and Higginson, 1989). The student teachers' answers toward 'agree level' about items of "I study for my exams, but I can not remember anything about the subject during the exam" and "I think I studied very well for the exam. However, I can not remember many things in the exam" regarding to preparation for the exam-exam anxiety dimension can be resulted from their deficiencies about motivation and time management dimensions.

It is concluded that student teachers have deficiencies about motivation, time management and preparation for an exam. This result is coherent with the study of Bay et al. (2005).

All of the dimensions as motivation, time management and exam anxiety, have influence on the student teachers' academic achievement. Conclusion, it is very important to overcome the defined disabilities for student teachers to develop study skills. There can be some seminars or motivating implications to orientate the student teachers for more productive studying manner.

5. REFERENCES

Agnew, N.C, Slate, J.R, Jones, C.H, Agnew, D.M (1993). "Academic behaviors as a function of academic achievement, locus of control, and motivational orientation", *NACTA Journal*, Vol. 37, 24–7.

Anthony, G. (2000). Factors influencing first-year students' success in mathematics. International Journal for Math Education, Science and Technology, 31(1), 3–14.

Atılgan, M., (1998). 'Üniversite Öğrencilerinin Ders Çalışma Alışkanlıklarıyla Akademik Başarılarının Karşılaştırılması'. (Yayınlanmamış Yüksek Lisans Tezi). Gaziantep Üniversitesi Sosyal Bilimler Enstitüsü.

Bay, E., Tuğluk, M. N., Gençdoğan, B., (2005). Analysis of undergraduate student's study skills. Electronic journal of social sciences, 4, (94–105).

Bomia, L., Beluzo, L., Demeester, D., Elander, K., Johnson, M., & Sheldon, B., (1997). The impact of teaching strategies on intrinsic motivation. Champaign, IL: ERIC Clearinghouse on Elementary and Early Childhood Education. (ERIC Document Reproduction Service No. ED 418925).

Carter, D.D.G. (1999). The Relationship of Study Habits, Attitude, and Motivation to Academic Achievement in a Selected Course of Study at an Historically Black University, Morgan State University, The Faculty of The School of Graduate Studies and Research, The Degree of Doctor of Education, UMI Number: 9945902.

Elliot, T.R, Godshall, F., Shrout, J.R., Witty, T.E (1990), "Problem-solving appraisal, self-reported study habits, and performance of academically at-risk college students", *Journal of Counseling Psychology*, Vol. 37 No.2, 203–7.

Hill, K. T., Wigfield, A. (1984). Test anxiety: Elementary School Journal, 85, 105–126.

Hulick, C., Higginson, B. (1989). The use of learning and study strategies by college freshman. Paper presented at the Annual Metting of the Mid-South Educational Research Association, Little Rock, AR.

Lammers, W.J.; Onwuegbuzıe, A.J. ve Slate, J.R. (2001). Academic Success as a Function of the Gender, Class, Age, Study Habits and Employment of College Students, *Research in the Schools,* 8(2).

Lawler-Prince, D, Slate, J.R, Jones, C.H (1993), "Academic behaviors of preservice elementary and/or special education teachers: a preliminary study", *Louisiana Education Research Journal*, Vol. 18, 109–18.

Jones, C.H, Slate, J.R, Perez, E., Marini, I (1996). "Graduate students' study skills as a function of academic achievement, sex, conceptions of intelligence, and locus of control", *New Directions for Education Reform*, Vol. 3, 61–78.

Kleijn, W.C, Van der Ploeg, H.M, Topman, R.M (1994), "Cognition, study habits, test anxiety, and academic performance", *Psychological Reports*, Vol. 75, 1219–26.

Schultz, R. A. (1989). Differences Between Academically Successfull and Unsuccessfull Students in an Intrusive Academic Advising Program, The Graduate College of the Oklahoma State University, The Degree of Doctor of Philosophy, Umi Number: 9019517

Telman, N. (1996). Etkin Ögrenme Yöntemleri, İstanbul: Epsilon Yayıncılık.

Yip, M., Chung, O., (2002). Relation of Study Strategies to the Academic Performance of Hong Kong University Students. Psychological Reports, Vol. 90, Issue 1,p. 338.

A SCIENTIST ENTREPRENEURIAL APPROACH IN SECONDARY SCIENCE CURRICULUM IN PROMOTING SUSTAINABLE DEVELOPMENT

Lilia Halim
Faculty of Education, Universiti Kebangsaan Malaysia
lilia@ukm.my

Nor Aishah Buang
Faculty of Education, Universiti Kebangsaan Malaysia
norais@ukm.my

T. Subahan Mohd. Meerah
Faculty of Education, Universiti Kebangsaan Malaysia
subhan@ukm.my

Kamisah Osman
Faculty of Education, Universiti Kebangsaan Malaysia
kamisah@ukm.my

▼ Abstract

This paper proposes a model of science curriculum that adopts the scientists' entrepreneurial approach as a mean of promoting sustainable development. We propose that the integration of science process skills and entrepreneurial thinking will enable Malaysia to realize her dream as a contributor to scientific and technological culture, as stipulated in Vision 2020. Malaysia as any developing country believes that science and technology is the building blocks for a nation's development and closing the economic gap between a developed country and developing country has always been a focus of one of the goals of sustainable development. This paper first outlines the concept of an entrepreneurial science thinking skills. This is followed by presenting the needs analysis study relating to the usefulness of the concept in science education. It was found that certain stake holders (namely the scientists and science teachers) view that science should be taught and learned for its own sake. On the other hand, technologists and certain policy makers agreed that there is need to inculcate the entrepreneurial science thinking skills in the science curriculum. This difference of view should be the basis of the policy makers in mapping the Malaysian science education and training that supports both the learning of science for its own sake and preparing youths to be able to invent products or technologies.

Key Words Science curriculum, Entrepreneurial science thinking, Need assessment

1. INTRODUCTION

Various efforts have been taken by the Ministry of Education (MOE) to instill Malaysian secondary students' interest in science subjects at all levels. The purpose is to increase the number of students who will choose science disciplines at the university level (Mohd Najib, 1997) which in turn will help to create the critical mass of scientists needed to advance the nation's science and technological development. Aligned with the era of globalization and knowledge based economy, it is the aim of a developing country such as Malaysia to work towards being the creator and producer of scientific and technological knowledge and innovation rather than being only the user of the knowledge. This vision serves as a roadmap to ensure Malaysia is able to sustain the country's economic growth in this ever changing world.

Thus, one of the main agendas in the Malaysian Second National Science and Technology Policy and Plan of Action (SNSTP) is to promote a culture for science, innovation and techno-entrepreneurship. The fulfilment of the objective of encouraging "techno-entrepreneurship' demands a shift from the culture of examination and rote learning teaching and learning approach to hands-on and innovation oriented approach (Ministry of Science, Technology and Innovation, p. 18). This move also depends on the orientation of the science education and training that one envision. According to Lewin (2000), a curriculum that upholds the orthodox views of science education that stresses the importance of understanding the natural world will not be helpful in preparing young people to generate new technologies or invent new products. Thus, we argue that the culture of innovation and techno-entrepreneurship could be promoted through the inculcation of entrepreneurial science thinking skills.

The concept of Entrepreneurial Science has been introduced in courses and programs which are currently offered in countries such as the USA and UK at the tertiary level. They are MSc Science Entrepreneurship offered by University of London, UK, http://www.cass.city.ac.uk/masters/courses/mscse), Physics Entrepreneurship Programs offered by Western Reserve University, USA (http://www.cwru.edu/pubaff/univcomm/2003), and Entrepreneurial Studies in Natural Science Program by Carthage College, USA; MIT and Entrepreneurial Science at MIT, USA (Etzkowitz, 2002). These courses or programs, however, only focus on the skills of how to be entrepreneurial scientists rather than on developing the entrepreneurial science thinking skills.

In the case of Malaysia, the connection between entrepreneurship and advances in applied science has been slowly recognized in Malaysian education system. The common approach in promoting science and technological innovation involves rewarding awards to science-based designed products created through science and technology competitions and thorough the introduction of *Design-Technology* subject at the secondary schools. The concept and implementation of the subject 'Design and Technology' at the upper school secondary levels (age 16-17) serve to introduce the spirit of innovation to students. However, this subject focuses on general application of creative problem-solving method in creating products rather than specifically applying scientific knowledge in designing products or services

At the tertiary level, effort such as government funding for schemes of university-industry co-operation in all public universities had been fostered. In addition, Tech-

nology Park Malaysia was also built to enhance this entrepreneurial science development through out the country.

This study proposes that the inculcation of entrepreneurial science thinking (EST) skills can be done systematically and formally in the school science teaching through valid and effective teaching and learning module rather than implementing it in a "bolt on" and "ad hoc" fashions as necessitate in many previous embedded educational programmes.

2. CONCEPTUAL FRAMEWORK OF THE STUDY

This EST skills model (Table 1) was initially developed based on the comprehensive search of the related literature review and in various pioneer researches on similar concepts (Lilia, Nor Aishah & Khalijah, 2003 and Abu Bakar, T. Subahan & Omar, 1995). This model was further refined and confirmed based on the empirical evidences in the study of Lilia et al. (2003). Several scientist entrepreneurs were interviewed with regard to their experiences in the entrepreneurial enterprise. One of the significant differences found between the proposed model of EST skills with any *Design or Problem Solving Model* is that the EST skills starts with a scientist discovering the benefit of a scientific knowledge and its scientific properties on human beings through continuous observation either in formal research or daily life experiences. This discovery encouraged them to invest in the business development of a new product as a way of distributing the 'goodness' quality of the product to the people or society. In contrast, the *Design or Problem Solving Model* begins with identifying the problem needed to be solved.

The EST skills model takes into consideration the integration or combination between the two thinking processes which are the science process skills and the entrepreneurial design thinking process. The combination of two disciplines leads to the development of innovative and creative thinking process that leads to producing science based products or ideas that are new and innovative which are presently nonexistent in the markets (Peter& Anne 2000 & Lilia et al. 2003).

Table 1 Desing Thinking Processes involved in Various Disciplines and Contexts

General model of Problem Solving	Technology/Design process	Science process skills	Entrepreneurial thinking process	Entrepreneurial Science Thinking
• **Understand the problem** • **Describe the problem** • **Consider alternative solution** • **Choose one solution** • **Take action** • **Evaluate the product**	• **Determine the need** • **Describe the need** • **Formulate ideas** • **Select one idea** • **Make product** • **Test product**	• Questioning and observing • Defining the problem • Investigating the known-(use of books, journals and experts) • Articulating the expectation- (involve making a prediction or hypothesizing) • Carrying out the study-(choose a methodology) • Examining the results-(to address the validity of the results) • Reflecting on the findings-(what conclusions can be reached) • Communicating with others	• **Purposely observe the environment** • **Discover the need** • **Formulate ideas** • **Select one idea** • **Make product** • **Test product** • **Adapt to the environment based on cost, marketability and usage**	• **Take initiatives to observe purposefully, deliberately and continuously** • **Keep thinking to find uniqueness of the observed phenomena in the form of new ideas/system/product/model/technology design.** • **Generate and select ideas that might be successful for innovation and evaluate them.** • **Purposeful enhancement and improvement of ideas (design and redesign)** • **Create valued added to the ideas/products in terms of value creation to the society /community**

3. AIM OF THE STUDY

The main aim of the study was to develop a teaching and learning (T&L) module inculcating the proposed EST skills among secondary students. The steps involved in developing the T&L module begins with a need analysis with relevant stake holders (such as the curriculum developers, science teachers, scientists and policy makers) on developing EST skills among Malaysian secondary school science students, followed by developing the teaching and learning module based on the EST model and finally to test the usability of the module on the different age groups and levels of achievement of secondary school students in terms of its readability, comprehensibility and achieving the EST skills. This paper presents the findings of the needs analysis with the stake holders and its implication.

4. METHODOLOGY

The needs study involved the following steps: a) A review of the Science Curriculum, b) An assessment of the views of policy makers and prominent scientists, c) An assessment of the practicing teachers views and perceptions and d) A focus group discussion with the curriculum developers. A total of 20 respondents comprising of various stakeholders were interviewed. All groups were subjected to semi-structured interview questions and below are examples of questions asked:

1. How do you feel the about the science and technology advancement in Malaysia?
2. What do you think of the accomplishment of S&T so far in Malaysia?
3. How do you think science and technology advancement can be achieved or accomplished?
4. One of the agenda of Ministry of Science, Technology and Innovation (MOSTI) policy is to develop techno-entrepreneurship, what do you understand by techno-entrepreneurship? Or What is your concept of techno-entrepreneurship?
5. Who do you think should become techno-entrepreneurship? Or What would be the background of a techno-entrepreneurship?
6. It is written in the policy that one of the ways to develop techno-entrepreneurs is to offer techno-entrepreneurship courses to undergraduate students, however these courses are not being offered?
   - ❖ Why do you think this is not being done yet?
   - ❖ If it is offered, what the content of the course should be?
7. With regard to the same situation but at the secondary school level, do you think the current science curriculum is helping to address that policy (to develop techno-entrepreneurship)?
8. If yes, in what manner the curriculum is helping? If No, can you suggest how the curriculum should be?

The interview data was transcribed and common themes were extracted from the data.

5. MAIN FINDINGS

All of the respondents namely the policy makers, teachers, curriculum developers and scientists agree the need for acquiring entrepreneurial skills for among students studying science, irrespective whether they could be working in entrepreneurial or in research setting.

Some view that the elements of these skills be introduced as early as possible in the primary level. However, some view that secondary level students are considered more readiy to acquire the skills.

Policy maker 1: ' I think primary students should see simple examples of the application of biology knowledge (for instance) in everyday situation. Primary students should be facilitated in their learning and not providing answers to them'

Science teacher 1: ' The skills can be acquired in some Chemistry topics in Form 4 and 5 such as the production of soap, of perfume and so..'

Not all of the respondents agree on the mode of teaching the skills. Some stress the need for student to experience the business culture through activities outside the classroom. But others feel that it should be more formal, and to be accommodated within the present school curriculum. And students will be evaluated on it.

Science curriculum developer 2 'Knowledge of science and technology is not enough; students need to have knowledge of business'

Science curriculum developer 4 'If the Entrepreneurial science thinking skills are to be inculcated in the curriculum, then it should be evaluated on it. Then only the skills will be inculcated explicitly'

On the question of the integrating within the present science syllabuses, teachers particularly disagree as they feel the curriculum has already been overloaded and time is too short even to teach the present curriculum. They prefer a separate subject is introduced to teach the EST skills. The view, however, was not purported by the curriculum developers, for they feel, it is still possible to reduce the content of the syllabuses in place for the extra time required. This will provide the relevancy of the skills in the subject taught.

Those who prefer to inculcate the skills in out-of-class activities, stress the need to plan the activities and create the atmosphere to change the mind set of the students.

School teacher 3 'I think the thinking skills are best inculcated while doing a project based activities. It should be done during co-curricular activities'

With regard to the concept of entrepreneurial scientific thinking skills, there is a contrasting view of it by the stakeholders. Some feel that the concept is about teaching students how to run a business-sort of skills. Others adopt the idea that as the need to innovate and be creative in entrepreneurial thinking. Another category of stakeholders believe that science and business should not be mix.

Policy maker 3 'Entrepreneurial thinking skills are about finding alternatives…the thinking process is important and not the end answer. It is totally different from learning or doing business. It is about being creative, willing to take risk and doing things in a different way'

Policy maker 1 'To me entrepreneurial thinking skills are about being innovative, creative, finding original solutions and to think differently. It is about encouraging people to think in an alternative manner'

Scientist 1' Science undergraduates should be exposed to business modules or programs'

Scientist 2 'Students who do not want to become scientists can audit the business courses or management'

Similarly, these were differences of opinions on who should teach these skills. There is obviously a need for in-service courses, both in terms knowledge and skills as well as on the pedagogical practices involved.

6. CONCLUSION

The needs analysis findings suggest that some of the respondents understanding of entrepreneurial thinking are limited to ways of doing business hence the suggestion of taking business courses in developing the thinking. However, as argued earlier entrepreneurial thinking processes is more of towards the development of design thinking process and that can be applied in any situation. In this study, the entrepreneurial thinking is applied to a science discipline leading to creative and innovative product based on scientific principles and knowledge.

The need of developing EST skills is also viewed in two different perspectives. On one hand, teachers and policy makers think that learning and doing science should be for knowledge sake. They further argue that the product development should be dealt at the tertiary level. However, the study found that the scientists argue that science education and training should be focussing on understanding of the natural world. It appears that the majority view about science education is to learn science for knowledge sake. If this view persists then the nation's agenda to be involved in technology development might be realised slowly. On the other hand, some of the respondents such as the technologists realised that EST skills are necessary for the advancement of science and technology of the country and it might be necessary to inculcate such an orientation or thinking at the school level. The second phase of this study (i.e. the inculcation of EST skills among students through a developed teaching and learning module) would perhaps shed some light to the feasibility of inculcating the EST skills and acceptance of the EST skills among the most important stakeholders, namely the students themselves.

The current trend of science education curriculum reform such as the UK argues that science beyond 2000 should be suitable for all young people today. Thus, as a result of the rapid changes of technological advancement and globalisation of the marketplace, there is a need for an individual to have a broad general education, good communication skills, adaptability and a commitment to lifelong learning. One of the recommendations of the report is the need of the students to explore the impact of the products of science and technology on their lives, and more knowledgeable about how they work.

We would further suggest that knowing how a common technology in a society (e.g. carbonless copy paper) works leads the students to consider/question the scientific knowledge/principles that are utilized in the technology. Even though knowing the 'technical know how' do not start with an observation with an entrepreneurial purpose, but knowing the scientific principles behind the technology might propel further innovation of the technology which then leads to patenting and suggest the moulding/making/development/ of a scientists to being research technical entrepreneur.

7. REFERENCES

Abu Bakar Nordin, T. Subahan Mohd Meerah & Omar Ibrahim. (1995). The thinking of Malaysian scientists, Research Report Intensified Research of Priority Areas. Malaysia: Ministry of Science and Technology,

Keith, L. (2000). *Mapping Science Education Policy in Developing Cou*ntries. World Bank Human Development Network, Secondary Education Series. Washington, DC: The World Bank.

Lilia Halim, Nor Aishah Buang & Khalijah Mohd. Salleh. (2003). The level of entrepreneurial science orientation among Malay science secondary students. Research Report 2/2004. Universiti Kebangsaan Malaysia: Malay World Research Institute.

Mohd Najib Abdul Ghafar.(1997). Paradox in Science in Education. *Proceedings of Science and Mathematics Seminar, 20-21 November 1996.* Universiti Kebangsaan Malaysia: Faculty of Education.

Peter, A. & Anne, T. (2000). Entrepreneurship in Science: Case Studies from Liquid Crystal Applications. *Prometheus.* Vol. 18 Issue 2. p133-148.

8. ACKNOWLEDGEMENTS

We would like to express our thanks to the Ministry of Science, Technology and Innovation, Malaysia for awarding us the grant (07-07-10047-EAR) that made this research possible.

KNOWLEDGE AND VALUES IN SCIENCE TEXTBOOKS CONCERNING COMPLEXITY IN ECOLOGICAL SYSTEMS AND ENVIRONMENTAL PROBLEMS. A CROSS-CULTURAL STUDY ON SECONDARY SCHOOL MANUALS

Silvia Caravita
ISTC-CNR
Via s, Martino d. Battaglia 44
00185 Rome, Italy
silvia.caravita@istc.cnr.it
Boujemaa Agorram
ENS, Marrakesh, Morocco
bagorram@gmail.com
Adriana Valente,
IRPPS-CNR. Rome, Italy
Daniela Luzi
IRPPS-CNR. Rome, Italy
Nicola Margnelli,
ISTC-CNR, Roma, Italia

▼ Abstract

The study was carried out within the European research project "Biology, Health and Environmental Education for Better Citizenship" that joined 18 european and North-african countries. We report here the methodology and some of the conclusions drawnn from an analysis of science textbooks that considered the topics Ecology and Environmental Education (EEE). Grids were conceived with the aim of revealing value systems conveyed by the exposition of the content and by images. We concentrate on the explicit/ implicit presence of two of the four conceptions that have been investigated: *complex vs linear* and *relation of humans respect to nature* in relation to the sub-topics *ecosystems and ecological cycles* and *pollution*. Dogmatism, scientism, non-historical approach were also checked. The findings from the analysis of the sample of seven Italian textbooks for Lower and Higher Secondary School are illustrated and compared with those obtained in Morocco.The outcomes of the analyses show that Ecology is not oversimplified, but structural descriptions appear more articulate than the relational and the dynamical ones. The view of ecology communicated by most of the textbooks is rather superficial and incomplete under many respects that we specify. The topic Pollution is treated in a fragmentary way, as a "call of attention" added to the description of the environmental components or in Cards

included in the chapters concerning the human body. The Higher Secondary School manuals do not contain more and more articulate information nor they more deeply account concrete cases, familiar to students' experience. Regardless to cultural differences and the diversity in the environmental contexts, the examined topics are treated in a very similar way in the Italian and Moroccan textbooks, as if a globalized approach to EE prevails on the attention for the construction of students' environmental identity.

Key Words Environmental Education, Textbooks, Complexity

1. INTRODUCTION

1.1. Ecology and Environmental Education

A solid base of knowledge is necessary for understanding the scientific ways of modeling the interdependence of ecological relationships and processes that shape any environment, particularly when humans and their activities are included in the system. This aim can hardly be achieved by the students if the information that they receive deals with ideal, de-contextualized scenarios and it does not examine specific cases of altered ecological relationships and the multiple consequences arising from these conditions. Ethical reflection engaging personal beliefs and agency is the other important component of the cultural transmission. The relationship between values and environmental attitudes has been pointed out by several studies (e.g., Schultz & Zelenzy, 1999) and the clarification of values has proven to be a crucial element in the construction of scientific knowledge (Thelen, 1987).

Teachers' competences are seriously challenged by EE for sustainability therefore they often they rely on the collaboration with other partners for engaging their students in educational programs. EE is not a subject matter, didactical aids and documents have to be retrieved from a variety of sources but not all teachers take the their time to do so. Very likely, the textbooks are still the most at hands resource and the main reference for the majority of the school classes. In fact, they represent the actual curriculum since they may determine the selection and sequencing of topics to be taught, besides influencing even the teaching approach. It is important to underline that textbooks convey *ideological* and *epistemological* values either in explicit or implicit ways and incorporate a lot of obvious or hidden messages in the textual exposition and in the images (Jacob, 1988).

1.2. The construct of *conception*

The theoretical construct of *conception* elaborated by Clemént and Hovart (2000) has been applied to ecology to investigate teachers and student-teachers representations (Clément et Forissier, 2001; Clément et alt, in press). The challenging aspect of this construct lies in its endeavor of non-disentangling the informational from the emotional and the practical content of social representations. Actually, *conceptions* originate from the mutual interaction of scientific knowledge, values and social practices that instantiate the specific knowledge in cultural contexts. Multidisciplinary and un-stabilized knowledge, such as EE implies, is particularly object of debate in con-

texts that are characterized by ideologies, when the search of practical solutions and decisions to be taken is carried out in associations, political and professional groups . Beliefs and knowledge work together and their separation can only be the eventual outcome of a metacognitive process.

1.3. The presuppositions that justify a cross-cultural study

EE ought to be grounded on the awareness of the environment where the students live, it should coach the comprehension of the complexity that emerges from exploring and interpreting specific contexts and cases. On the other hand, we witness a deep change in the relationship that the individuals entertain with the environment, the "natural" one in particular, because of the growing rigidity of the routines in everyday life, because of the transformations produced by the industrialization and urbanization of territories that tend to delete their environmental identity in a process of globalization. Moreover, media communication promotes the globalization of representations. An understated consequence of these phenomena is that the social rather than the individual construction prevails and people risk to loose that part of their cultural identity that has its roots in the specific environmental identity (geographic, historical, social) where they grow up and in the multiple forms of interaction in which specific environmental features engage the people (Sauvé, 2005; Giuliani, 1995; Schultz and Tabanico, 2007).

The comparison among countries offers the opportunity to verify these presuppositions and to strengthen the conclusions that can be drawn from more limited observations. Italy and Morocco differ under many respects, presumably relevant for the development of ecological culture. Geographic, historical, economic, cultural features, including religion, characterize each country. It may be debatable how the religious beliefs in an increasingly secularized world may influence the "official" culture of a country, but there is no doubt that the authors of textbooks are situated within a culture from which they absorb values on fundamental issues, such as the attitude towards the natural world.

2. OBJECTIVES OF THE STUDY

The group of BIOHEAD partners designed grids for the analysis of text and images of the textbooks to find out to which extent:

- the textbooks support the development of a systemic approach to and a dynamic interpretation of local and global cases dealing with polluting agents and related environmental problems
- the implicit *conceptions* are instantiated in the images that illustrate the environments and in the exposition of emblematic examples of environmental issues
- the authors are sensitive to environmental identity, promote reflexive thinking on the specific nature of the human relationship with the environment
- the approach to the complexity of environmental issues is dogmatic, non-historical, scientist and relies on linear causality

3. TOOLS AND METHODS FOR THE ANALYSIS

The design and construction of the grids for the analysis of textbooks has been a collaborative endeavor of the BIOHEAD partners and it is illustrated in a separate paper (Caravita, in press on Science Education International Journal). This presentation focuses on **ecosystems and cycles** (**EC**) and **pollution** (**Po**) and it will report only the data about the presence of two out of four *conceptions* that have been targetted by the entire analyses, that is: **Complex *vs* linear** and **relationship of humans in respect to nature**.

The **complex *vs* linear** view was characterized as follows when instantiated in **EC** or in **Po**:

- Webs ***vs*** chains of ecological components
- High number and diversity of components of the ecological webs ***vs*** stereotyped simplification of their components
- Functional ***vs*** structural description. A functional perspective highlights factors, variables, constraints.
- Inter-dependence among the components ***vs*** one-way relationships
- Presence ***vs*** absence of feedbacks, retroactions, cycles.
- Time scales consideration, reversibililty of processes ***vs*** "here and now" descriptions
- Interpretation of events from systems as emergent from co-factors, from parallel processing ***vs*** description/explanation of events deterministically caused
- Interpretation of events as emergent from systems of co-factors, from parallel processing ***vs*** description/explanation of events deterministically caused, results of linear chains of causes

The conception of the **relationship of humans in respect to nature** was characterized in terms of viewing humans as owners of nature and environment in opposition with humans as guests of the Earth together with other living beings. We outlined it as follows:

- Humans as part of nature ***vs*** humans as observers
- Planet as a resource for humankind ***vs*** planet as a resource shared with other living beings
- Emphasis on the attainment of economical aims ***vs*** social, cultural, ethical, aesthetical aims
- Humans only considered to be an external source of pressures, pollution and destruction ***vs*** humans as users and responsible managers of resources
- Human benefits ***vs*** ecological benefits considered in the evaluation of the impact, costs, priorities
- Emphasis on risks, catastrophes, problems ***vs*** balanced information about problems and about possible solutions

- Unlimited trust in science and technology solutions ***vs*** principle of precaution, on one side, and citizen's participation, on another side

The grids were composed of several forms each one having lists of items to be checked. The whole set of grids had to be applied to each examined volume of textbook. One set of grids was common to all the topics, another set was specific for each topic and sub-topic and it was differentiated for each *conception*. The items included in these grids were checklists of ***indicators***, that is of concepts that were considered pertinent for each sub-topic and adequate for revealing the explicit or, to some extent, implicit presence of a *conception*.

Subjective interpretation is certainly the main drawback of this kind of qualitative analysis. This problem was partially controlled by having two analysts separately applying the grids and crosschecking their findings afterwards.

4. RESULTS

4.1. Space of the sub-topics EC and Po in the examined textbooks.

The number of pages and of images (and their ratio) found in the textbooks examined in Italy and in Morocco are reported in Tables 1 – 2. In the Italian textbooks, the number of pages dedicated to the two sub-topics and the ratio images/ text varies across the textbooks. The smaller space that **Po** has in the books appears as a common trend. Textbook 1 for Technical Higher Secondary School deviates from this tendency.

Comparing Lower and Higher Secondary School Italian textbooks we do not find great differences in the average number of pages dedicated to **EC**. The ratio images/ text is higher in the Lower Secondary School textbooks. As average, they assign more space to **Po**.Comparing Italian and Moroccan textbooks, we do not notice great differences in Lower Secondary School, except for the ratio images/text that is higher than in the Italian books. The science manual for Higher Secondary School has almost double number of pages dedicated to **EC**. The History and Geography textbook (T. 2 in Table 3) dedicates to **Po** a number of pages higher than any of the Italian science textbook.

Table 1 Number of pages, number of images (and their ratio) dedicated to the topics Ecosystems and cycles, Pollution in the sample of examined textbooks for Lower Secondary School

	EC	EC	EC	Po	Po	Po
	N° p.	N° Img.	Ratio	N° p.	N° Img.	Ratio
Textb Morocco	15	84	5.6	2	3	1.5
Textb 1 Italy	32	82	2,6	16.7	32	1.9
Textb 2 Italy	32	107	1,7	20,5	37	1,8
Textb 3 Italy	15,5	30	1.9	12.5	15	1,2

4.2. Main types of images in the textbooks

We classified the images that we found in the examined textbooks in 8 categories; the most frequent ones and meaningful for the aims of our analysis belonged to figurative images from macroscopic observations, figurative images communicating conceptualizations, figures reporting empirical data (e.g., measures, statistic distributions, diagrams). Tables 3 and 4 report the frequency as percentages on the total number of images and the distribution of these categories in relation to the sub-topics **EC** and **Po**.

Figurative images (photos and drawings) make the largest percentage of the images found in the Italian textbooks, with the exception of one textbook for Higher Secondary School (TB 2). Images showing conceptualizations follow in the ranking. The images that report empirical data are very few or absent.

Some variation for sub-topics and across the examined textbooks can be observed: the images of conceptualizations are less in relation to **Po** than to **EC**, the percentage of figurative images is higher in Lower than in Higher Secondary School textbooks.

The comparison with Moroccan textbooks mainly highlights that the percentage of images reporting empirical data is much higher than in the Italian textbooks.

Table 2 Number of pages, number of images (and their ratio) dedicated to the topics Ecosystems and cycles, Pollution in the sample of examined textbooks for Higher Secondary School

	EC	EC	EC	Po	Po	Po
	N° p.	N° Img.	Ratio	N° p.	N° Img.	Ratio
Textb1Morocco	64	147	2,3	5	16	3,2
Textb2Morocco	22	50	2,7	37	45	1,2
Textb1 Italy	39	65	1,7	20,5	37	1,8
Textb2 Italy	16,5	29	1,8	3	5	1,7
Textb3 Italy	31	45	1,5	6,5	7	1,1
Textb4 Italy	34	65	1,9	4	8	2

4.3 CONCEPTION "COMPLEX VS LINEAR"

Sub-Topic Ecosystem and cycles (EC)

We cannot claim that the descriptions of ecosystems is presented in an oversimplified way in the exposition of textbooks, either in the Italian either in the Moroccan books, though the structural aspects appear more articulated than the relational and the dynamical ones, either in the text and in the images.

We can state that the textbooks' view of ecology is rather superficial and incomplete. What we did not find in the content treated by the manuals is a long list that mainly highlights the absence of detailed illustration of concrete, contextualized examples of ecological phenomena. Very rarely mentioned or described: processes of regulation that take place at the ecosystems or at micro-ecosystems level as a consequence of natural (even cyclic) perturbing factors a; ecosystems at life limits that

can well illustrate the interplay between ecological and biological factors; variables and conditions that modify and modulate the ecological events. Consideration of the role that ecosystems' size and their degree of complexity may have is lacking, and also reference to time-scales, severity and persistence of perturbing factors. The concepts of resilience, of robustness of ecosystems are not defined. Most importantly, the "balance of natural system" should be treated as a metaphor, a model rather than a fact (Zimmerman and Cuddington, 2007).

Table 3 Percentages of the main categories of images found in the sample of examined textbooks for Lower Secondary School: figurative images, images containing empirical data, images illustrating conceptualizations in a figurative way

	EC	EC	EC	Po	Po	Po
	Fig. Im	Emp. data	Fig. Concept.	Fig. Im.	Emp. data	Fig. Concept.
Textb1Morocco	46.4	3.6	20.2	100	0	0
Textb1 Italy	70	1.2	30.5	81.3	0	9.4
Textb2 Italy	90.7	0	9.3	75	5	10
Textb3 Italy	56.7	0	30	75	6.3	18.7

Table 4 Percentages of the main categories of images found in the sample of examined textbooks for Lower Secondary School: figurative images, images containing empirical data, images illustrating conceptualizations in a figurative way.

	EC	EC	EC	Po	Po	Po
	Fig. Im.	Emp. data	Fig. Concept	Fig. Im.	Emp. data	Fig. Concept.
Textb1Morocco	57.8	15.6	6.8	43.8	0	37.8
Textb2Morocco	30	30	22	28.9	15,6	22.2
Textb1Italy	52.3	7.7	33.8	83.8	5.4	2.7
Textb2Italy	10.3	13.8	37.9	80	0	20
Textb3Italy	71,1	0	24.4	42.9	0	29.6
Textb4Italy	52.3	10.8	27.7	62.5	37.5	0

The illustration of emblematic concrete (successful and unsuccessful) cases of management of ecosystems, of wildlife conservation might improve the comprehension of the controversial control of anthropic factors. Different kinds of empirical data produced by scientific studies, the use and meaning of statistical analysis, the possibilities offered by the application of new methodologies like simulation, should be essential components of the information conveyed by the manuals to make more intelligible the role of ecology as science in the interpretation of ecosystems' changes and in the management of the environment.

Sub-topic Pollution (Po)

In the majority of the examined textbooks, the issue of pollution is treated in a fragmentary way, as an added "call of attention to …", often in relation to the description of the environmental components or to the risks for the human body affected by dangerous agents. An organic exposition including definitions of the concepts that are relevant for a deeper understanding of the phenomena and are needed for facilitating transfer of information, is lacking. Surprisingly, in Higher respect to Lower Secondary School the exposition of the environmental issues does not attain higher levels of information and does not consider their complexity in a more articulated way. Analyses of the factors, the drawbacks that influence the success of concrete interventions for controlling or preventing pollution are lacking. The relation between potential solutions and contextual features is never highlighted. The participation of people, the role of local expertise are never mentioned. The limits of available knowledge, the new fronteers of research, the arguments raised in the scientific debate are never or rarely considered. Actually manuals do not offer models of those epistemological values that are crucial in EE to prevent dogmatic attitudes and to make citizens more aware of what Herbert Simon calls "procedural rationality" opposed to "substantive rationality", that is citizens more acceptant of the approximation to satisfying solutions when many trade-offs have to be evaluated in the complex problems that characterize most of the ecological issues.

The conclusions that we have illustrated are consistent with the outcomes reported by the French team who took into account the Life and Earth sciences manuals for Secondary School on which the teachers who presently start their professional career have studied (Berthou-Gueydan, Clément and Clément, 2008).

4.4 Conception "Relation of humans respect to nature"

The conflict of interests between humankind and nature takes the shades of a philosophical dilemma. The difficulty of finding a compromise between the protection/ preservation of environmental "integrity" and the demands of the development of human economy is stated in terms of a stereotyped complaint about the destructive presence of humans on Earth. The attitudes conveyed by the Italian textbooks might be classified into the following types: fatalistic, blaming ("man is guilty"!), responsibilizing, objectivizing ("interest of environment are also the interest of the human species"), optimistic and mainly based on trust in the progress of science and technology. Thus, the appeal to a generic responsibility of humans substitutes the identification of real cases, the pointing out of specific responsibilities of agents, the highlighting of concrete policies that might be explored at economic, social and political level.

In Higher Secondary School textbooks the role that individuals can take in limiting pollution is almost disregarded or it is treated in the same way as in Lower Secondary, that is ignoring that the students have hopefully developed higher competences, have more autonomy of decision and action as consumers, as customers of services, as people who are planning their life as adults.The neutral informative style of the exposition buries any emotional implication under a veil of neutral, reassuring, pretended rationality

5. CONCLUSIONS ABOUT THE COMPARISON BETWEEN ITALY AND MOROCCO

What can we gain from the comparison between the outcomes of the textbooks'analysis in these two countries? Slight differences can be pointed out. The most outstanding conclusion is that regardless the obvious cultural differences and differences in the environmental contexts, the topics of ecology and pollution are treated in a very similar way! We have also observed that the types of pollution, the kind of events that are considered, the accidents that are illustrated are often the same in the Moroccan and in the Italian textbooks. Even images and schematizations tend to be similar. In both countries the majority of the figurative images point out the "bad deeds" of humans. Some of the images that show a less aggressive interaction of humans with their environment concern cases in foreign, and sometimes exotic, countries.

We must conclude that a globalized approach to EE is prevailing on the attention to the construction of students' environmental identity and this approach is in contrast with the aim of EE.

6. REFERENCES

Berthou-Gueydan, G., Clément, C. and Clément, P. (2008). L'éducation à l'énvironnement dans les manuels scolaires de sciences de la vie et de la Terre. ASTER 46. Pp. 155-179.

Caravita Silvia ,Valente Adriana, Luzi Daniela, Pace Paul , Khalil Iman,Valanides Nicos and Nisiforou Olympia, Berthou Guillemette, Kozan-Naumescu Adrienne, Clément Pierre (accepted by *Science Education International Journal* in may 2008). Construction and Validation of Textbook Analysis Grids for Ecology and Environmental Education.

Clément, P. and Hovart, S. (2000). Environmental Education: analysis of the didactic transposition and of the conceptions of teachers. In H. Bayerhuber and J. Mayer (Eds.), *State of the art of empirical research on environmental education* (pp. 77-90). Münster: Waxman Verlag.

Clément, P., Forissier, T. (2001). L'Education à l'Environnement: les systémes de valeurs dans les conceptions sur l'Environnement. L'enseignement des sciences expèrimentales. Proceedings of 2émes Journèes CIFFERSE (pp. 343-347). Dakar: ENS.

Clément, P., Laurent, C., Forissier, T., Carvalho, G. (submitted to *Education et Didactique*, 2007). Trois systémes de conceptions sur l'environnement, chez des enseignant et futurs enseignants en France, en Allemagne et au Portugal.

Giuliani, V. (1995). Il ricordo dei luoghi nella memoria autobiografica. *Ricerche di Psicologia* 19(2). Pp. 35-49.

Jacob, C. (1988). Le manuel scolaireet la construction sociale de la réalité. *Technologies, idéologies et pratiques*, 81(1-4). Pp. 333-341.

Sauvé, L. (2005). Repéres pour la recherche en èducation relative à l'environnement. *Cahiers scientifiques l'Acfas*, n° 104. Pp. 27-47.

Schultz, P.W., & Zelezny, L. (1999). Values as predictors of environmental attitudes: evidence for consistency across 14 countries. *Journal. of Environmental Psychology*, 19. Pp. 255-265.

Schultz, P.W., Tabanico, J. (2007). Self identity and the natural environment. *J. of Applied Social Psychology*, 37. Pp. 1219-1247.

Thelen, L.J. (1987). Values clarification: science or non-science. *Science Education* 71(2). Pp. 201-220.

Zimmerman, C., Cuddington, K. (2007). Ambiguous, circular and polysemous: students' definitions of the "balance of nature" metaphor. *Public Understanding of Science* 16(3). Pp.

7. ACKNOWLEDGEMENTS

This study has been carried out within the "Biology, Health and Environmental Education for Better Citizenship Project" (BIOHEAD-CITIZEN CIT2-CT2004-506015) that joined eighteen countries from Europe and Africa. We thank the coordinators of the project and all our colleagues for the contribution of their ideas.

AN ANALYSIS OF NEW SCIENCE AND TECHNOLOGY PROGRAM IN THE CONTEXT OF ENVIRONMENTAL EDUCATION

Harika Ozge Arslan,
Ceyhan Cigdemoglu,
Kader Bilican,
Yuzuncu Yil University , Atilim University Ataturk University
ccigdemoglu@atilim.edu.tr,
Atilim University,
06836 İncek, Ankara / Turkey,

▼ Abstract

In the light of increased emphasis on environmental education, this study aims to review Turkish National Science and Technology program from grade levels 4th to 8th in terms of environmental dimension. Science Technology Society Environment (STSE) objectives were analyzed to indicate how environmental dimension were incorporated into the objectives of the program regarding to international standards and goals of the environmental education. Findings reveal that although there is sufficient number of objectives related with environmental education. Analysis of STSE objectives indicated that the emphasis is put on environmental knowledge whereas environmental attitude and behavior are less emphasized. Additionally these objectives are seen as consistent with international standards.

Key Words New Science and Technology Program, Environmental Education, Program Analysis

1. INTRODUCTION

School environmental education programs have become increasingly widespread since the awareness of the huge effect of global environmental issues has increased in recent decades. The concept of integration of program with environmental education has immerged as a crucial step to take in action while designing any science, science and technology program. Therefore, many countries; Mexico, England, USA, Chine, Australia and Switzerland considered environmental education as a critical dimension of program (Barraza & Walford 2002; Roch, Wilkening, & Hart, 2007; Ballantyne, Fien, & Packer, 2001; Graber, Hofer, & Wolfensberger, 2006). The evolution (integration) of STS within school science is a complex story of the professional and

intellectual development of science education. Each country has its own story to tell. For instance in Canada and Israel, the environment was emphasized by adding an "E" to STS, producing STSE and STES respectively (Aikenhead, 2003 p.7). Similar to these countries, new national Science and Technology program developers adopted STSE to curricula from grade levels 4 to 8 for Turkey.

Environmental education programs have been viewed as essential elements affecting the knowledge and attitudes needed for an active mobilization for change (Zimmermann, 1996). These attitudes and values are widely recognized as determinant of behavior toward environment (Dillon & Gayford, 1997). Therefore, providing positive attitudes could result in environment friendly behaviors. Although attitudes are not innate, they cannot easily change in short term periods especially in adults thus early childhood level is the key period for the formation of environmental learning and attitudes. Basile (2000) states that effective environmental education should begin in early years "by providing a knowledge base that is developmentally appropriate, occurs in real settings, and involves children's active participation" (p.21). Therefore setting up and applying an environmental education program to specifically at primary schools is important. Last few decades portrayed that incorporating the environmental dimension into primary education begun and has continued. In Turkey, one-third of population is young people and one-sixth of total population is the students in the eight years of obligatory primary education. It is obvious that changing these students' points of views of environmental issues make contribution to change all populations' views in the future. In 2005, the Turkish National Ministry of Education revise primary education program and make radical changes. In the new national program, there have been several attempts to include environmental subjects. However, there is serious need for studies investigating the coherence of these attempts in new program with international environmental objectives and applications.

This study analyzes environmental objectives of new national science and technology program from 4th, 5th, 6th, 7th and 8th grade (aged from 10 to 14) with regard to international standards and goals of environmental education. Main problems of this study are; 1) To what extend the environmental dimension were incorporated into the objectives of new Turkish National Science and Technology program. 2) Is there coherence between international objectives and applications in context of environmental education? 3) How environmental objectives are distributed to knowledge, attitude and behavior dimensions.

2. THEORETICAL FRAMEWORK

In the latter of half of the century, environmental education emerged from the desire of protecting and conserving natural environment from human threat (Smyth, 2006). Although some efforts have undertaken since 70's, it is from the 1990 that environmental education has been recognized as an area of the program (Lee, 2000).Although researchers from various areas have tried to understand and map environmental education, the goal of environmental education was clearly defined

in Tbilisi conference (UNESCO,1977). According to this declaration; environmental education assists people to become environmentally skilled and informed people that willing to make effort individually and collaboratively to perform a dynamic equilibrium between quality of life and quality of the environment (UNESCO,1977).

Basic inter related components of environmental education has been defined as well known mutto: "education about the environment, education in environment, and, education for the environment". (Scoullos & Malotidi, 2004 p. 12).

The Tbilisi Declaration (UNESCO,1977) explained this well known mutto as; education about environment is concerning to acquisition of skills, and knowledge on environment and understanding the environment related issues, dealing mainly with cognitive aspect. Education in environment is focusing on processes of education conducted outside the classroom. It gives opportunities of conducting direct contact with the environment, gaining experiences and arousing interest besides providing relevant context for acquiring knowledge and developing skills. The purpose of education for environment is providing development of informed attitude and behavior toward the environment. It means more than acquisition of skills and knowledge, concerning with values and attitudes that influence behavior and also focuses on formation of attitudes that leads to involving in actions for sound management of environment and the protection of natural sources.

Implementation of environmental education varies among countries; it is integrated into the program or taught as a separate course in different grade levels. For instance, Chatzifotiou (2006), states that environmental education in England developed through primary level as an integration of science, mathematics, arts and English curricula. Similarly, Ballantyne et al (2001) study indicates different environmental education programs in Australia; one conducted in primary school with year 5 and 7 students (aged 9-12), integrated with social studies, English and science; the other in secondary school with year 9 students (aged 13-14) incorporated into society and environment classes. According to Barraza & Walford (2002), environmental education is incorporated into primary levels covering knowledge and the formation of values and attitudes in Mexico. Environmental education program in Taiwan are based on the "knowledge-attitude-behavior" Liang & Tsai (as cited in Shih-Jang Hsu, 2004) and Liu (1996).

In Turkey, objectives related with environmental issues are tried to be achieved through grade levels 1st to 3rd incorporated into life science course in primary level. Through the levels 4th to 8th, Social Science and Science & Technology courses have some environment related objectives; under theme of Science Technology Society Environment (STSE) in new national primary program.

3. ANALYSIS OF PROGRAMS

Many countries have adopted their current program to environmental education. The revision of primary school program in Turkey is a crucial step for adaptation of environmental education to all courses. Science and Technology course program

was incorporated environmental education into school context throughout the grade levels 4th to 8th. Objectives related with environmental issues within science based program for each level were examined deeply to see extend of incorporation with environmental dimension. First, program of 1st, 2nd and 3rd grade levels were reviewed about environmental objectives and results indicated that environmental education component was integrated into selected topics with subject areas such as life sciences. Most of these objectives are at knowledge level for these grades.

The new national science and technology education program of fourth, fifth, sixth, seventh and eighth grades aim to improve scientific literacy for all students. In order to attain this goal, program was organized under 4 main themes that are; "Livings and Life", "Matter and Change", "Physical Events" and "Earth and Universe". The chapters of program were located under these themes. In addition to these four main themes, there are three themes which are Science Process Skills (SPS), Attitude and Values (AV) and Science, Technology, Society and Environment (STSE). These themes were not used in the main organization of program as separate chapters rather these were only used for making relations with objectives of chapters of 4 main themes. There are 24 SPS objectives, 26 AV objectives and 36 STSE objectives for 4th and 5th grade level in the program. In the 6th, 7th, 8th grade levels', there are 32 SPS objectives, 25 AV objectives and 38 STSE objectives in the program.

Since the environment dimension of the curriculum was integrated into STSE objectives, in the present study the STSE objectives are revised. In 4th and 5th grade level program, 19 of 36 and; in 6th, 7th and 8th grade level program, 16 of 38 STSE objectives have environment dimension directly.

All chapters include suggested activities for teachers in attaining goal of the program. Few of these activities have objectives integrated to STSE objectives about environmental issues. Moreover, the STSE objectives are tried to be achieved as a side effect of instructional activities; there is no explicit attention to achieve objectives on environmental education through these instructional activities.

Total numbers of objectives, number of STSE objectives and the number of STSE objectives related with environment are summarized according to chapters and level in the below tables (Table1 and Table 2).

Table 1 STSE Objectives in 4th and 5th Science and Technology Program

Grade Level	Themes	Chapters	Total Number of Objectives	Number of STSE Objectives	Number of STSE Objectives related with Environment	Percentage of STSE Objectives related with Environment
4	Livings and Life	Our Body	23	3	-	-
		World of Livings	16	9	8	50%
	Matter and Change	Matter	46	22	11	24%
	Physical Events	Force and Motion	13	-	-	-
		Light and Sound	43	15	6	16%
		Electricity in Our Life	20	2	1	5%
	Earth and Universe	Our Planet: Earth	17	7	3	17%
5	Livings and Life	Our Body	22	4	4	18%
		World of Livings	33	8	8	24%
	Matter and change	Identifying Matter	46	26	11	24%
	Physical Events	Force and Motion	21	2	1	5%
		Light and Sound	39	10	3	7%
		Electricity in Our Life	16	3	1	
	Earth and Universe	Earth, Sun and Moon	19	6	-	-
Total			374	117	57	15%

Analysis of program indicated that extend of incorporation of environmental dimension into total objectives of new Turkish National Science and Technology program is successful but not adequate for effective environmental education. Although the percentages of STSE objectives to total objectives are 31 %and 20% in 4-5th grades and 6-7-8th grades respectively, actually the percentages of STSE that are directly related with environment are 15 % and 8% for these grades. These percentages show that the earlier is the year, the more is the number of objectives related with environmental education as stated in literature (Basile, 2000).

Table 2 STSE Objectives in 6th, 7th and 8th Science and Technology Program

Grade Level	Themes	Chapters	Total Number of Objectives	Number of STSE Objectives	Number of STSE Objectives related with Environment	Percentage of STSE Objectives related with Environment
6	Livings and Life	Reproduction, Growth and Development	38	2	1	2%
		Systems of Body	26	6	3	11%
	Matter and Change	Particulate Nature of Matter	26	-	-	-
		Matter and Heat	16	5	2	12%
	Physical Events	Force and Motion	27	-	-	-
		Electricity in Our Life	19	3	1	5%
		Light and Sound	26	4	2	7%
	Earth and Universe	Sphere of Earth	21	10	6	28%
7	Livings and Life	Systems of Body	27	7	2	7%
		Human and Environment	12	7	7	58%
	Matter and Change	Structure and Properties of Matter	45	8	1	2%
	Physical Events	Force and Motion	31	5	2	6%
		Electricity in Our Life	33	2	-	-
		Light	31	4	2	6%
	Earth and Universe	Solar System	27	12	2	7%
8	Livings and Life	Cell Division and Heredity	30	7	2	6%
		Energy Relationships of Livings	23	5	4	17%
	Matter and Change	Structure and Properties of Matter	31	6	6	19%
		States of Matter and Heat	29	4	2	7%
	Physical Events	Force and Motion	21	1	1	5%
		Electricity in Our Life	23	2	-	-
		Sound	16	1	-	-
	Earth and Universe	Natural Proceses	26	15	4	15%
Total			604	116	50	8%

According to UNESCO (1977) declaration in Tbilisi, the goals of environmental education are; 1) to foster clear awareness of, and concern about, economic, social, political, and ecological interdependence in urban and rural areas; 2)to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment, and skills needed to protect and improve the environment; 3) to create new patterns of behavior of individuals, groups, and society as a whole towards the environment.

Parallel to international objectives, program developers (MEB, 2006) stated that science and technology have a vital role to play in development of environmental awareness. They also state that applications of science and technology play a major role in environmental education, so it is highly important that science education should lead students to acquire knowledge about environment, attitude toward environment and behavior change for environment.

In Tbilisi Declaration, environmental knowledge, attitude and behavior are equally emphasized, however, in our program the majority of the objectives related with environmental education basically aims to provide environmental knowledge; a few of them emphasize on environmental attitude and behavior. All of them are main components of environmental education to attain the goal of solving environmental problems through environmental education. It could be concluded that it is unlikely to expect students to recognize environmental values, figure out the sources of environmental problems and take action and responsibility to solve and prevent the environmental problems just through the education the focusing on environmental knowledge. National program developers (MEB, 2006) stated that general objectives were not able to achieve behavior and attitude change toward the environment at the moment rather than aim to improve as a process.

In fourth and fifth grade Science and Technology program, only one of the objectives is concerned with developing behavior and two of them are related with developing attitude toward the environmental issues. The remains of the objectives are dealing with attaining knowledge on environmental issues. 14 of 16 STSE objectives are mainly addressing knowledge dimension of environmental education for grade levels 6, 7 and 8. Only one of them is related with developing behavior and one of them is concerned with developing attitude toward the environmental issues.

4. DISCUSSION

Effective environmental education visualized as teaching and learning with interdisciplinary, critical thinking, problem solving and decision-making orientations which provide the ability of transferring specificity of each and every subject or discipline (Zoller, 2000).The main goal of environmental education is to find solutions to environmental problems both locally and globally. In 4^{th}, 5^{th}, 6^{th}, 7^{th} and 8^{th} grade levels awareness about local environment could be more emphasized with behavior oriented objectives. Only one STSE objective is related with this aim thus it indicates insufficiency of objectives about local environmental problems and insufficiency of behavior oriented objectives.

It is reported that children have failed to do enough to protect the environment and seek to influence their parents' behavior (Fuler 1992). Like all education dimen-

sions; environmental education should be started from family and acquired knowledge from family, media and outdoor have importance on students' attitudes and behaviors (Alım, 2006). Therefore, while developing a program, these factors should take into consideration and especially objectives based on student family cooperation should be integrated the program. However, in the present program there is not any objective including the family involvement.

The program could have a separate chapter named as "Environment" in all grade levels; in this chapter teachers should organize field trips to local places in that students could interact with environment. Also, the radical change could be made and a separate environment course can be organized as a must for these levels. There is already an elective environment course for higher levels (9-12th grades) in our national program but it is too late to provide knowledge and awareness.

UNESCO-UNEP International Environmental Education Programme (IEEP) had evolved a regional strategy for developing environmental education curriculum prototypes for primary and secondary schools as well as pre-/in-service training of school teachers, taking into account the physical, biological, social, cultural and economic dimensions of the environment in an integrated manner. Our new developed national program could also offer some local actions according to characteristics of that region.

As stated in results part, the environmental objectives are consistent with the international standards however to evaluate the effectiveness of the program, gap analysis that is an assessment tool to compare its actual performance with its potential performance, could be done. The effectiveness of program depends on teachers implementations of it. In each theme or chapter, objectives and sample activities are given however how teachers use these activities and how they evaluate whether the instruction provides to gain intended goals. Therefore the presence of environmental objectives does not mean that they are integrated to science and technology courses. Thus observation of classrooms, interviews with teachers and students will help to evaluate the effectiveness of the program as a future research.

REFERENCES

Aikenhead, S.G.(2003). STS Education: A Rose by Any Other Name. In R. Cross (Eds.), A Vision for Science Education: Responding to the Work of Peter J. Fensham Retrieved February 15, 2008, from http://www.usask.ca/education/people/aikenhead/stsed.pdf

Alım, M. (2006). Avrupa birliği üyelik sürecinde Türkiye'de çevre ve ilköğretimde çevre eğitimi. Kastamonu Education Journa, 14 (2), 599-616.

Ballantyne, J. R., Fien, J.,& Packer, J. (2001). School environmental education program impacts upon student and family learning: a case study analysis. Environmental Education and Family Learning, 7, 23-37.

Barraza, L., & Walford, R. (2002). Environmental education: a comparison between English and Mexican school children. Environmental Education Research, 8 (2), 171-186.

Basile, C. G. (2000). Environmental education as a catalyst for transfer of learning in young children. The Journal of Environmental Education, 32 (1), 21–27.

Chatzifotiou, A. (2006), Environmental education, national curriculum and primary school teachers. Findings of a research study in England and possible implications upon education for sustainable development. The Curriculum Journal, 17 (4), 367 – 381.

Dillon, P. J., & Gayford C. G., (1997). A psychometric approach to investigating te environmental beliefs, intentions and behaviours of pre-service teachers. Environmental Education Research, 3(3), 283-297.

Fuller, K. S. (1992). Windows on the wild-brings conservation message to children. Focus, 14 (2), 2-6.

Graber, R. K, Hofer, K., & Wolfensberger, B. (2006). Studies on a socio-ecological approach to environmental education: a contribution to a critical position in the education for sustainable development discourse. Environmental Education Research, 12 (1), 101-104.

Hsu, S. (2004). The effects of environmental education on responsible environmental behavior and associated environmental literacy variables in Taiwanese college students. Journal of Environmental Education, 35 (2), 37-48.

Lee, J. C. (2000). Teacher receptivity to curriculum change in the implementation stage: the case of environmental education in Hong Kong. Journal of Curriculum Studies, 32, 95-115.

Liu, C. H. (1996). The effects of an environmental education program on responsible environmental behavior and other associatedfactors of teacher college students in Taiwan. Unpublished doctoral dissertation, University of California, Los Angeles.

M.E.B. (2006). İlköğretim fen ve teknoloji dersi (6, 7 ve 8. sınıflar) öğretim programı. Retrieved February 15, 2008, from http://ttkb.meb.gov.tr/ogretmen/

Roch, M.C., Wilkening, R., & Hart, P. (2007). Global to local: International conferences and environmental education in the people's republic of China. International Research in Geographical and Environmental Education, 16 (1), 44-57.

Scoullos, M., &Malatidi, V. (2004). Handbook on methods used in Environmental Education and Education for Sustainable Development. MIO-ECSDE, Athens.

Smyth, J. C. (2006). Environment and education: a view of a changing scene. Environmental Education Research,12 (3–4), 247–264.

United Nations Educational, Scientific and Cultural Organization, 1977. The world's first Intergovermental Conference on Environmental Education in Tbilisi.

Zimmerman, L. K. (1996). Knowledge, Affect, and the Environment: 15 Years of Research (1979-1993). Journal of Environmental Education, 27 (3).

Zoller, U. (2000). Interdiciplinary systematic HOSC development-the key for meaningful STES oriented chemical education. Chemistry Education: Research & Practice in Europe,1 (2), 189-200.

(Footnotes)

[1] HDI value for United Kingdom.

SCIENCE AND RELIGION: EVOLUTIONISM AND CREATIONISM IN EDUCATION A SURVEY OF TEACHERS' CONCEPTIONS IN 14 COUNTRIES

Pierre Clément (*),
Marie Pierre Quessada (**),
Charline Laurent (*) &
Graça Carvalho (***)

(*) LEPS-LIRDHIST, EA 4148, Université Lyon 1, France

(**) LIRDEF and IUFM, Université Montpellier 2, France

(***) LIBEC-CIFPEC IEC, Universidade do Minho, Braga, Portugal.

PierreClement@univ-lyon1.fr

▼ Abstract

The renewed creationist movements are currently seen as a threat for science teaching in the world What is their impact on teachers' conceptions? We present here the results of a first large survey on this question, analysing teachers' conceptions in 14 countries (5 in Africa, 1 in Middle East and 9 in Europe). The total sample is composed of 5,700 teachers (partly in-service, partly pre-service) of primary and secondary schools; 1,846 of these teachers have biological training, 1,787 have language training and 2,077 have training to teach in primary school. We used a questionnaire including personal information and 15 questions on Evolution. The results show high significant differences between countries and between teachers' level of instruction. This latter effect suggests the need for increasing the level of teachers' training in order to overcome the current increasing creationist movements.

Key Words Teachers' conceptions, Creationism, Evolution, Religion, Teachers' training

INTRODUCTION

A good relation between science and religion in the educational systems is a great challenge for the Peace in the world. The situation is very contrasted from one country to an other, religion being or not officially part of the national curricula and taught or not in the public schools. The growing offensive of fundamentalist religious groups is trying to disturb science teaching, proposing to introduce creationist ideas in the curricula or, at least, to avoid to teach evolutionism in schools. This offensive is par-

ticularly covered by media in USA (Lecourt 1998, Arnould 2007), but is also present in other countries (Picq 2007). To counter-attack, the scientists mainly develop the facts of the Evolution (National Academy of Science, 2008) to help media and teachers.

Nevertheless, we need to know better the present impact of creationist ideas on teachers around the world. That is a first step to try to improve the teachers' training and students' education related to biology including evolution.

In fact, the links between science and religion could be peaceful. The historians of science analysed that the modern science born in a religious context where the laws of the nature, considered as created by God, were possible to analyse and describe, and had to be respected. After some conflicts as the Galileo affair, the three main monotheist religions (Jewish, Christian and Muslim) have accepted the autonomy and respect of science. The pope Jean-Paul 2 clearly recognized in 1996[16] that the theory of evolution is no more to be considered as a hypothesis after the amount of new knowledge in this field. Today, it is quite possible to believe in God (being Jewish, Christian or Muslim) and at the same time to be evolutionist. Nevertheless, inside these three monotheist religions, some fundamentalist groups, as the "*born-again Christians*" (George 2007) are claiming that evolutionism is not compatible with religion and that the educational systems would have to respect their creationism, at least through its new look: the intelligent design.

What is the impact of this renewed creationism movement on the educational system, and mainly on teachers' conceptions? We tried to answer to this question by carrying out a large enquiry in 14 contrasted countries (table 1) where until now no enquiry has been applied to teachers' conceptions on evolution. We present here some of our results, showing that the creationist convictions are much more present that it was expected and are linked to several parameters.

METHODOLOGY

The methodology has been developed in the context of the European FP6 research project Biohead-Citizen (CIT2-CT2004-506015; 2004-2008). We chose 14 contrasted countries inside and outside Europe (table 1). In each country, six samples of approximately 50 persons each, were interviewed: primary school teachers (one sample of pre-service, and one of in-service), secondary school teachers in biology and in national language (pre-service and in-service).

[16] http://www.hominides.com/html/theories/jean_paul_evolution.html

Table 1 Number of teachers (pre-service + in-service) per country, in the 14 countries

	Country	Total sample	including biologist	Main religion(s) (≥8%)
BF	Burkina Faso	296	92	Cath(46%), Prot(19%), Muslim(25%)
CY	Cyprus	322	63	Orthodox (77%), Catholic (9%)
DZ	Algeria	217	57	Muslim (92%)
EE	Estonia	182	60	Agnostic (43%), Protestant (15%)
FI	Finland	306	121	Protestant (66%), Agnostic (15%)
FR	France	732	249	Agnostic (51%), Catholic (38%)
HU	Hungary	334	108	Cath(46%), Prot(16%), Agnost(15%)
IT	Italy	559	119	Catholic (78%), Agnostic 12%)
LB	Lebanon	722	212	Muslim (65%), Christian (30%)
MA	Morocco	330	128	Muslim (97%)
PT	Portugal	350	102	Catholic (76%), Agnostic (9%)
RO	Romania	273	93	Orthodox (71%), Catholic (8%)
SN	Senegal	324	114	Muslim (89%), Catholic (8%)
TN	Tunisia	753	318	Muslim (96%)
Total		5,700	1,846	

For the 14 countries, the total sample comprises 5,700 teachers (about half pre-service and half in-service). The biologists represent about 1/3 of the total sample (1,836). Only few teachers (about 8%) marked they did not want to declare their religion (one of the alternatives to be chosen). In total, 713 teachers (13%) declared to be agnostic or atheist, 1,523 (27%) Catholic, 408 (7%) Protestant, 518 (9%) Orthodox and 2,087 (37%) Muslim.

The questionnaire was built with a lot of guaranties that are described in other works (Clément & Carvalho 2007). The first step was a clear definition of the research goals and of the theoretical background. We mainly used the KVP model (conceptions as interactions between scientific Knowledge, Values and social Practices: Clément 2004, 2006). After some interviews, questionnaire translation and validation of the translations, we did a pilot test to analyse the reliability of each question, in each country, to choose the most discriminating questions, and the most pertinent ways to analyse data.

The questionnaire was dealing with 6 topics, being evolution one of them (15 questions). The answers were analysed by several ways: classical statistical analyses as well as different multivariate analyses that are presented in other publications (Munoz et al 2007 and submitted, Quessada et al, 2007).

3. RESULTS

3.1. Between analysis for countries (figure 1)

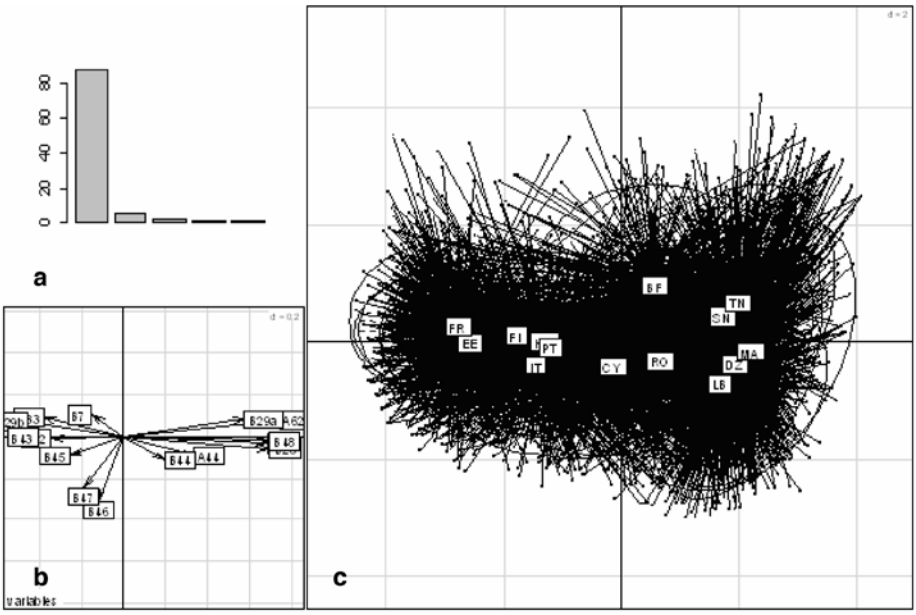


Figure 1 Between analysis comparing the 14 countries from the teachers' answers to the 15 questions related to evolution.

1a) Variance explained by the Principal Components: the component 1 (horizontal axis) is the most important. The component 2 explains a little part of the variance.

1b) Relationship between the 2 Principal Components and the 15 variables. The axis 1 (horizontal) is mainly explained by the creationist conceptions (at right) opposed to the evolutionist conceptions (at left). Two questions related to knowledge on the processes of evolution are explaining the axis 2. The other questions (on finalism, or on other knowledge) are related to the axis 1, showing interactions between knowledge and creationist or evolutionist values.

1c) Repartition of teachers' conceptions (grouped by country) on the plane explained by the axes 1 and 2. Each point corresponds to the conceptions of one teacher, an ellipse surrounding the 2/3 of teachers of the same country. For the meaning of the letters, see the table 1.

The teachers' conceptions very significantly differ among countries. For instance, answering to the questions A64 and B28 (origin of life and of humankind), only 2% of French teachers are anti-evolutionist creationist against 93% in Algeria. At left of the figure 1c, the most evolutionist conceptions correspond to the French and Estonian teachers. Next to them (a little less evolutionist conceptions) are Finland, Italy, Hungary and Portugal. At right are the most creationist conceptions (Tunisia, Morocco, Algeria, Senegal and Lebanon). In the middle position are Cyprus, Romania and Burkina Faso).

3.2. Between analysis for levels of instruction (figure 2)

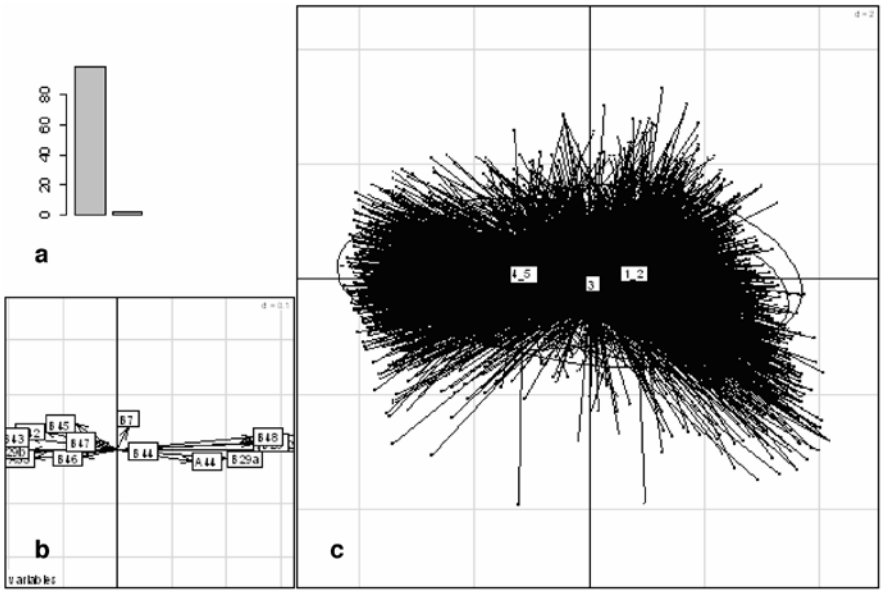


Figure 2 Between analysis comparing the teachers' levels of instruction from the teachers' answers to the 15 questions related to evolution. The captions are the same as those of the figure 1 but, here, only the axis 1 is explaining almost all the variance, opposing the evolutionist conceptions (at left) to the creationist ones (at right). The graph 1c shows that the higher level of instruction (4,5 = 5 years in the University or more) corresponds to the most evolutionist conceptions, and the lowest level of instruction (1, 2 = 2 years in the University or less) corresponds to the most creationist conceptions. In the middle is located the level 3 (= 3 or 4 years in the University).

The effect of the level of instruction is clearly shown in the figure 2. Because it might be a consequence of the effect of countries (the teachers are often more qualified in the European countries), we did a new analysis suppressing the effect of countries (and the effect of religions, very linked to the effect of countries; the resulting graphs are not shown): the effect of the level of instruction is still very significant, as shown by a randomisation test (Monte Carlo): more teachers are instructed, more they are evolutionist, independently of the country and of the religion. We also showed that the effect of the level of instruction is independent of the age and gender effects (that are not presented nor discussed here).

3.3. Different conceptions among the Christian teachers (figure 3)

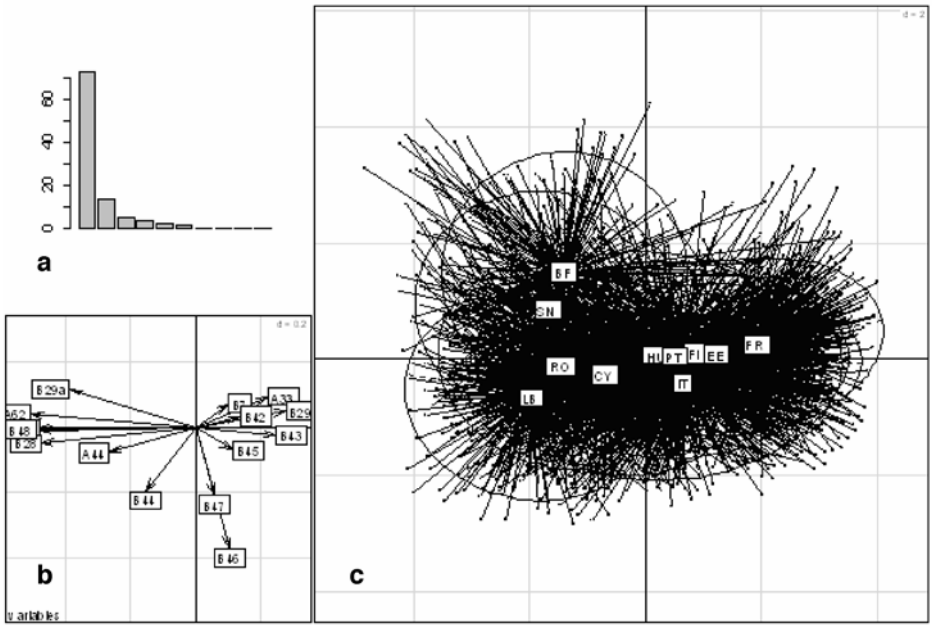


Figure 3 Between Analysis to differentiate countries, from the answers of only the Christian teachers to the 15 questions related to evolution. Only 11 countries are taken into account because there is 0 or 1 Christian teacher in Algeria, Tunisia and Morocco. The legend of this figure is the same as for the figure 1, but the direction of the axis 1 is opposite: here, the creationist conceptions are at left and the evolutionist ones are at right. The weight of the axis 2 is very low and is linked to 2 variables on knowledge.

The results shown in the figure 3 are particularly interesting: the creationist or evolutionist values are very different within the Christian teachers, mostly depending of the country. The French Catholics are mainly evolutionist whereas the Lebanese Catholics are mainly creationist. Other analyses (not presented here) show that inside each country, there is no significant difference between the Catholic, Protestant or Orthodox teachers. Muslim teachers are less creationist than Christian teachers in Burkina Faso, but more creationist in Lebanon.

In consequence, the socio-cultural context of each country and its level of economical development are more important parameters than the religion itself to explain the creationist or evolutionist teachers' conceptions.

4 CONCLUSION

We presented here some of our results, showing that the creationist convictions are much more present that it was expected. Even if they are correlated to the personal degree of believing in God and practising religion, they more differ from a country to an other than from a religion to an other. They also differ with the level of teachers' training.

This last effect is promising for a renewal of the educational systems. More a teacher has studied in the University (primary teachers as well as secondary teachers in languages and in biology) more he/she is evolutionist. From other analyses, we also showed that teachers with university degrees in biology are more evolutionist than the other teachers. These two last conclusions suggest clearly the need for increasing the level of teachers' training in order to struggle against the current increasing creationist / anti-evolutionist movement.

REFERENCES

Arnould J. (2007). *Dieu versus Darwin. Les créationnistes vont-ils triompher de la science ?* Paris : Albin Michel.

Clément P. (2004). Science et idéologie : exemples en didactique et en épistémologie de la biologie. *Actes du colloque Science - Médias – Société*. Lyon : ENS-LSH (http://sciences-medias.ens-lsh.fr)

Clément, P. (2006). Didactic Transposition and KVP Model : Conceptions as Interactions Between Scientific knowledge, Values and Social Practices, *ESERA Summer School*, IEC, Univ Minho, Braga (Portugal), p.9-18.

Clément P. & Carvalho G. (2007). Biology, Health and Environmental Education for better Citizenship: teachers' conceptions and textbook analysis in 19 countries. *XIII World Congress of Comparative Education Societies,& AFEC,* Sarajevo, September 2007, 12 pp.-

George S. (2007). *La pensée enchaînée.* Paris : Fayard (translation from English: *Culture in chains. How the Secular and Religious Right Captured America*).

Munoz F., Bogner F., Clément P., Carvalho G. (submitted). Using multivariate analysis and non-parametric tests to illustrate teachers' conceptions towards the nature and environment (submitted to *Environmental Psychology*).

Munoz F., Quessada M.P., Clément P. (2007). Des analyses statistiques multivariées pour traiter les données issues de questionnaires : Conceptions d'enseignants et futurs enseignants de douze pays sur l'Evolution. *Actes ARDIST*, La Grande Motte, J.M.Dusseau et al ed., CD-Rom, IUFM Montpellier.

Lecourt D. (1998). *L'Amérique entre la Bible et Darwin*. Paris : PUF

National Academy of Science (2008). "*Science, Evolution, and Creationism*": http://www.nap.edu/catalog/11876.html (consulted the 14th February 2008)

Picq P. (2007). *Lucy et l'obscurantisme*. Paris : Odile Jacob

Quessada M.P., Munoz F., Clément P. (2007). Les conceptions sur l'évolution biologique d'enseignants du primaire et du secondaire de douze pays (Afrique, Europe et Moyen Orient) varient selon leur niveau d'étude. *Actes AREF (Actualité de la Recherche en Education et en Formation),* 28 août - 1er sept. 2007, CR-Rom, Strasbourg, 12 pp

ACKNOWLEDGEMENTS

This work had the financial support of the European project FP6 Biohead-Citizen CIT2-CT-2004-506015 (2004-2008). We particularly thank the participants who gathered the answers to the questionnaire in each country: the teams of G.Carvalho in Portugal, P.Clément, M.P. Quessada and D.Favre in France, S.Caravita and A.Valente in Italy, N.Valanides in Cyprus, T.Sarapaju in Estonia, M.Abrougui in Tunisia, I.Khalil in Lebanon, A.L.Rauma in Finland, A.Varga in Hungary, A.Kozan in Romania, F.Khammar and A.Aouar-Métri in Algeria, S.Selmaoui and A.Boudjemaa in Morocco, V.Ndiaye and M.S.Thiaw in Senegal, and I.Béré-Yoda in Burkina Faso.

THE EFFECT OF PROJECT BASED LEARNING ON THE SCIENCE UNDERGRADUATES' BELIEF OF SELF-EFFICACY TOWARDS PHYSICS

Sema ALTUN
Atatürk University / Research Assistant
saltun_11@hotmail.com

▼ Abstract

In this study, it is aimed to investigate the effect of project based learning method on the science teacher training students' belief of self-efficacy towards physics. The sample consisted of total 90 science teacher candidates enrolled Physics I course in 2006-2007 educational year, Bayburt education faculty in Ataturk University. In the research in which pre test post test experimental design with control group was used, while the instruction was based on the lecturing and the discussions in control group, in treatment group the lessons were based on project based learning approach. Data was collected using "Science Teaching Efficacy Belief Inventory for pre-service teachers", a likert type scale of 20 items, developed by Enochs (1990). Quantitative data was analysed statistically (ANCOVA). The results of the analysis indicated that there is a statistically significant difference between control and treatment groups with respect to the belief of self-efficacy towards physics.

Key Words Self-efficacy, Physics Education, Pre-service Teachers

1. INTRODUCTION

Over a quarter century ago, Albert Bandura introduced the concept of self-efficacy or "beliefs in one's capacity to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Since that time, research in many arenas has demonstrated the power of efficacy perceptions in human learning, performance, and motivation. For example, efficacy beliefs are related to smoking cessation, adherence to exercise and diet programs, performance in sports, political participation, and academic achievement (Bandura, 1997). In the past two decades, researchers have found links between student achievement and three kinds of efficacy—the self-efficacy of students, the sense of efficacy of teachers, and the collective efficacy of schools (Goddard, Hoy, & Woolfolk Hoy, 2000; Pajares, 1996; Ross, 1994, 1998; Tschannen-Moran et al., 1998). Teachers' sense of efficacy has been associated with other student outcomes such as motivation (Midgley, Feldlaufer, & Eccles, 1989) and students' own sense of efficacy (Anderson, Greene, & Loewen, 1988). In addition, teachers' efficacy beliefs appear to affect the effort teachers invest in teaching, their level of aspiration,

and the goals they set. Teachers with a strong sense of efficacy tend to exhibit greater levels of planning, organization, and enthusiasm (Allinder, 1994) and spend more time teaching in subject areas where their sense of efficacy is higher (Riggs & Enochs, 1990), whereas teachers tend to avoid subjects when efficacy is lower (Riggs, 1995).

For nearly 30 years, researchers have investigated teacher efficacy and made significant progress in understanding its nature, how it is related to other variables, such as student achievement, and how it can best be measured. Yet, there is still much to learn about this important construct (Utley, Moseley and Bryant 2005). Teacher efficacy is thought to be both context and subject-matter specific (Tschannen-Moran et al., 1998); however, the appropriate level of specificity for measuring teacher efficacy is not clear (Tschannen-Moran & Hoy, 2001). The construct of teacher efficacy has been explored by a number of researchers in recent years. In response to the confusion how to best measure teacher efficacy, Tschannen-Moran and Woolfolk Hoy (2001) proposed an integrated model of efficacy development in the cyclical nature of teacher efficacy that emerged from two interrelated factors of teaching task analysis for the given context and assessment of competence in this context (Gencer and Cakiroglu, 2007).Teachers' sense of efficacy is a construct derived from Bandura's (1997) theory of self-efficacy in which the generalized behaviour of an individual is based upon two factors, (a) a belief about action and outcome; and (b) a personal belief about one's ability to cope with a task. Moran and Hoy (2001) defined teacher efficacy as a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Çakiroğlu, Çakiroğlu and Boone 2005).

Pintrich and Schunk (1996) posited, "Related to this situational specificity, self- efficacy beliefs are assumed to be much more dynamic, fluctuating, and changeable beliefs than the somewhat more static and stable self-concept and self-competence beliefs". If Bandura's theory of self-efficacy is applied to the study of teachers, one might predict that, "…. Teachers who believe student learning can be influenced by effective teaching (outcomes expectancy beliefs) and who also have confidence in their own teaching abilities (self efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning (Enochs, Smith and Huinker, 2000).

Teachers' self-efficacy for teaching behaviours affects, among other things, their choice and structuring of learning activities; their response to students' attempts in learning tasks; their control orientations and control behaviours; their use of classroom discussions and innovative teaching practices; their responses to children who are difficult to teach; their preparedness to include children with disabilities; their level of stress and their satisfaction with the teaching profession (Gordon and Debus, 2002). Research on the efficacy of teachers suggests that behaviours such as persistence at a task, risk taking, and the use of innovations are related to degrees efficacy. For example, highly efficacious teachers are more likely to use open-ended, inquiry, student-directed teaching strategies, while teachers with a low sense of efficacy were more likely to use teacher-directed teaching strategies such as lecture or

reading from the textbook. (Çakiroğlu, Çakiroğlu and Boone, 2005). And personal teaching efficacy has been defined as a belief in one's ability to teach effectively and teaching outcome expectancy as the belief that effective teaching will have a positive effect on student learning (Enochs, Smith and Huinker, 2000).As a consequence of these behavioural differences, teachers' self- efficacy has important formative effects on children's developing conceptions of their own academic self efficacy (Schunk and Zimmerman, 1997; Gordon and Debus, 2002).

Self-efficacy has been shown to be an issue of concern for primary teacher education students - many of them have low self-efficacy and this can negatively affect their future teaching of science. Previous research has identified four factors that may contribute towards self-efficacy: Enactive mastery experiences, vicarious experiences, verbal persuasion and physiological/affective states. It could also be argued that there are additional sources of self-efficacy that apply to primary teacher education students, namely cognitive content mastery, cognitive pedagogical mastery and simulated modelling (Palmer, 2006).

Teachers with high levels of efficacy tend to have a more positive attitude toward implementing innovative teaching methods (Ghaith and Yaghi, 1997). The currently most favoured pedagogical and innovative model for teaching design is project based learning (Dym et al 2005). Project-based learning is a comprehensive approach designed to engage students in the investigation of authentic problems and it is based on teaching and learning within the class environment (Blumenfeld et al, 1991). It is an individual or group activity that lasts for a particular period of time, which results in a product, a demonstration or a performance (Moursund, 2001). Project-based learning arouses interest and desire in students. They become motivated in order to learn the important concepts in an important question or a problem case (Blumenfeld et al., 1991). Provides the opportunity to reflect and involve students' beliefs and values (Mergendoller et al. 2006). Project-based learning requires the use of an interdisciplinary approach in solving problems and understanding subjects thoroughly (Solomon, 2003). Thus, it provides opportunities for interdisciplinary learning. Students establish relationships between the fields of mathematics, social sciences, literature and science in order to get answers to open-ended questions (Curtis, 2002). Considering these definitions, project-based learning can be defined as a learning approach based on students' working for a period of time in order to intensively investigate the real world issues or problems in an interdisciplinary approach so as to produce something concrete through individual efforts or pair-work (Gültekin, 2007). These learning opportunities are necessary for education faculty students to construct meaningful knowledge and skills if they are to be used later on the job (Pelsma and Neufeld, 2002). It is an effective instructional approach that can equip graduates with the necessary value and technical skills to contribute o the workplace from day one. Increasingly, project-based learning is used as an instructional approach to prepare students to succeed in today's dynamic workplaces (Gonzales and Nelson 2005). The most evident results of project-based learning are increasing feeling of pride with regard to achievement and personal development of students (self-confidence, responsibility, self-esteem and etc.), increasing ratio of attendance, and empathy with others (Carr

and Jitendra, 2000). Project-based learning means learning through experience. Projects engage students' attention with learning through serious and authentic experiences. Projects give way to some alternative approaches which take into consideration personal differences, learning styles, intelligence levels, talents and inadequacies of students, and provide students with the opportunity to reveal their personal differences (Solomon, 2003; Grant, 2002; Gültekin, 2007).

Given the importance of a strong sense of self efficacy belief is related to student achievement and is a desirable teacher characteristic, it seems particularly important to examine preservice teachers' efficacy beliefs. Pajares (1996) has considered teacher efficacy, and suggests that it should be used as a motivational paradigm for effective teacher education. So that, the improvement of teacher education programs, it is necessary to examine factors that influence the development of a strong sense of efficacy and competent management strategies among preservice teachers. One group of people for whom science teaching self-efficacy is an issue of concern is teacher education students. Many of these students had negative experiences of science in high school (Jarrett, 1999) and they lack confidence in their ability to teach the subject (Tosun, 2000).Teacher lack of confidence is a serious problem because it impacts on classroom behaviour. Today, most teacher training students have difficulty understanding science concepts, especially physics ones. It is known that the difficulty of the learning and the understanding is reciprocally related to the students' attitudes and beliefs of self efficacy towards this field. So the alternative teaching methods helping students' attitudes and self efficacy to develop, like project based learning, have great potential in this context. Little is known about how PBL affects science teacher candidates' belief of self efficacy towards physics. Therefore, the aim of the present study is to investigate the effect of project based learning on the science teacher training students' belief of self-efficacy towards physics.

2. RESEARCH QUESTION

Is there a difference in the science teacher training students' belief of self-efficacy towards physics according to the treatments of project based learning or traditional instruction?

3. METHODOLOGY OF RESEARCH

3.1 Design

In the research, quasi-experimental nonequivalent groups pretest-posttest design was used. This design is very prevalent and useful in education, since it is often impossible to randomly assign subjects. In the design, the researcher uses intact, already established groups of subjects, gives a pretest, administers the treatment condition to one group, and gives the posttest (McMillan and Schumacher, 2001). Because ANCOVA allowed researchers to adjust for any pretreatment differences that exist between the experimental and control group and was an appropriate and informative technique to make a reliable inference from a pre-test-post-test control group design, it was chosen as statistical analysis technique (Dugard and Todman 1995).

Table 1 Variables and the place in experimental design.

Variable	The role in experimental design
Pre-test scores	Covariate
Posttest scores	Dependent variable
Teaching method (project based vs. traditional)	Independent variable

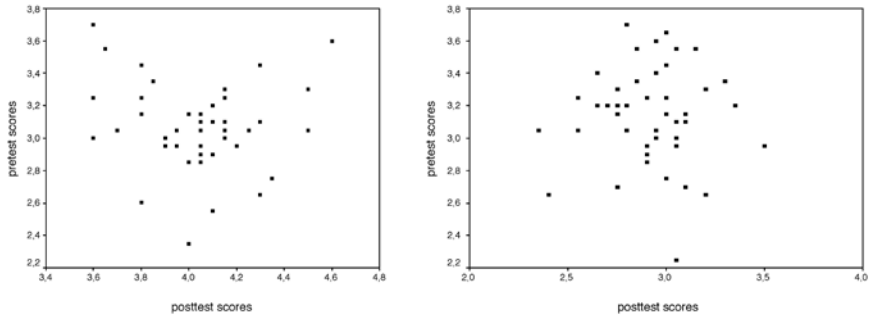
3.2. Participants, instrumentation, analysis of data

The sample was total 90 science teacher candidates (43 students in treatment group and 47 students in control group) enrolled Physics I-II course in 2006-2007 educational year (28 weeks). The research was carried out in department of science teacher training in Bayburt Education Faculty in Ataturk University, a state university. While the instruction was based on the lecturing and the discussions in control group, in treatment group the lessons were based on project based learning approach. Data was collected using "Science Teaching Efficacy Belief Inventory for pre-service teachers", a likert type scale of 20 items developed by originally by Enochs (1990). One week later from the treatment, the test was administered to both control and experimental group as post-test. Covariance analysis was performed to compare post test scores of treatment and control groups by considering pre test scores covariate. Previously, whether the data meet the assumptions of variance analysis was investigated. Then research hypothesis was tested.

4. FINDINGS AND CONCLUSIONS

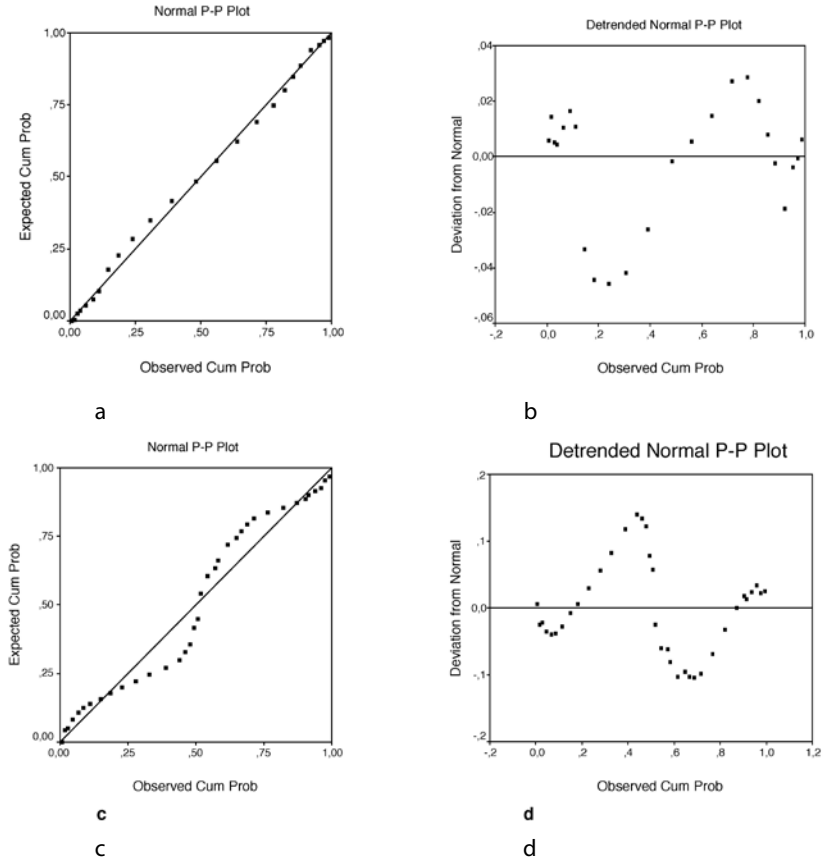
ANCOVA was performed with the science teacher training students' belief of self-efficacy towards physics as dependent variable and pretest scores as covariate. The interaction of treatment with covariate, *one of the assumptions of variance analysis*, that was used to test for homogeneity of regression for dependent variable was not statistically important, $F(1,90) = 0.176$, $p = 0.676$. This showed that the assumptions of parallelism of slopes were met. This situation that supports the result of statistical test given above is also clearly seen in Figure 1a and 1b indicating the graphical distribution of pretest scores across posttest scores. From Figure 1a and 1b, it is clear that there are the similar tends between pretest and posttest scores. Furthermore, Levene's test for homogeneity of variances showed that variances can be assumed as homogeneous, $F(1,88) = 0.046$, $p = 0.830$. By plotting normal P-P graphics and detrended P-P graphics for pretest and posttest scores, normality assumption of raw scores was tested. The linear trends (Figure 2a and 2c) and nearly random (*although some similar sinusoidal trends*) distributions (Figure 2b and 2d) in Figure 2a, 2b, 2c, and 2d indicated that the assumption was also met. ANCOVA was repeated excluding the interactions between treatment and covariate from the model. For the model, Means and standard deviations of scores for the pretest and posttest, as well as the adjusted means for the posttest, are given in Table 2 . Result of ANCOVA (Table 3) showed a statistically significant main effect for treatment, $F(1,90) = 363.622$, $p = 0.000$, (*partial eta squared* = 0.807; it mean that main effect accounts for %89 of variance), favoring project based instruction over traditional instruction. Thus, the null hypothesis concerning the research question was rejected. It was accepted the claim that there is a significant difference between the

participants' belief of self-efficacy towards physics according to treatments of project based instruction or traditional instruction. Furthermore, as seen in Table 3, the covariate (pretest) has not a statistically significant effect, F (1,90) = 0.360, p = 0.550. It means that students' prior belief had not a significant effect on their posttest scores.



a b

Figure 1 The graphical distribution of pretest scores across posttest scores according to treatment (a- experimental group b- control group) for homogeneity of regression test.



a b

c d

Figure 2 Normal P-P and detrended P-P plots for pretest (a and b) and posttest scores (c and d)

Table 2 Observed means, adjusted means and standard deviations for experimental and control groups

		pre-test		post-test	
Groups	**n**	**M**	**SD**	**M**	**SD**
experimental	43	3.079	0.270	4.024 (4.022)*	0.249
control	47	3.130	0.284	2.892 (2.894)	0.302

*Adjusted means are given in parentheses

Table 3 Analysis of Covariance of "student belief of self-efficacy towards physics" test

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
Corrected Model	28,796[a]	2	14,398	185,334	0,000	0,810
Intercept	9,668	1	9,668	124,445	0,000	0,589
covariate	2,797E-02	1	2,797E-02	0,360	0,550	,004
Instruction method	28,249	1	28,249	363,622	0,000	0,807
Error	6,759	87	7,769E-02			
Total	1096,455	90				
Corrected Total	35,555	89				

[a] R Squared = ,810 (Adjusted R Squared = ,806)

It appears from the research finding that thanks to providing them the opportunity of applying what they learn, project based learning may have maden the students' beliefs of physics teaching self efficacy develop. In addition, it was believed that the project based learning method that has the advantages, such as enhancing meaningful learning, promoting experiential learning and developing research skills, is likely to enhance the teacher students' beliefs of physics teaching self efficacy. So, it is suggested that the teaching methods that make the knowledge teacher candidates will use in their forthcoming profession meaningful should be commonly used in the institutions like teacher training institutions. Therefore, because teacher candidates' senses of science teaching efficacy helps enhancing their students' understanding of science concepts, it is imperative to put into effect the teaching methods, such as PBL. Findings of the research are similar to those of the previous studies in this context. In a number of studies investigated how best to enhance the science teaching self-efficacy of teacher education students, it has been found that science methods courses that involve extensive use of hands-on activities, such as PBL, can be very successful in this regard learning. These beliefs may result from their experiences as a student in their schooling period (Tsai, 2002). Similarly, pre-service teachers' experiences in the university through the science classes, laboratory exercises, and relevant activities are also influential to develop their beliefs about science teaching/learning (Uzuntiryaki and

Boz, 2007). Existing beliefs of pre-service teachers should be considered in the teacher education programs since these beliefs interact with their learning. Such beliefs influence pre-service teachers interpretation of pedagogical knowledge, conceptualization of teaching tasks, their teaching decisions and their classroom practice (Utley et al, 2005). Therefore, in teacher education programs it is important to identify prospective teachers' beliefs about teaching and learning (Uzuntiryaki and Boz, 2007).

Since self-efficacy is related to motivational and attitudinal measures, they may be used to promote self-efficacy beliefs of preservice teachers as they progress through teacher education programs in science. (Savran-Gencer & Cakiroglu, 2007; Desouza et al, 2004). The finding of the study supports the findings by Derry and her colleagues (2002) that suggested that preservice teachers' beliefs can be changed through authentic experiences and hands-on activities (Gencer and Cakiroglu, 2007). Such research findings can help researchers, teacher educators, and education programs in assisting preservice teachers to build such beliefs, in revision their program or practicum experiences result in enhancing preservice teachers' sense of efficacy. Teacher education courses in particular should focus on Bandura's four strategies for increasing efficacy providing opportunities for mastery experiences, physiological and emotional arousal, vicarious experience, and social persuasion. As conclusion, it is well known that the present research has some limitations, such as time, size of the sample studied and age range of the students, which reduce the population and environment generalizations of the finding of the study. So, it is proposed that the teacher candidates' belief of self-efficacy towards physics as regarding the effect of project based instruction be explored further in research studies of greater length across the curriculum and grades.

5. REFERENCES

Allinder, R. M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. Teacher Education and Special Education, 17, 86–95.

Anderson, R., Greene, M., & Loewen, P. (1988). Relationships among teachers' and students' thinking skills, sense of efficacy, and student achievement. Alberta Journal of Educational Research, 34(2), 148–165.

Bandura, A. (1997). Self-efficacy: the exercise of control. New York: W.H. Freeman and Company.

Bandura, A. (1997).Self-efficacy: Toward a Unifying Theory Of Behavioural Change. Psychological Review, 84 (2), 199-215.

Blumenfeld, Phyllis C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palinscar, A. (1991). Motivating project-based learning sustaining the doing, supporting the learning. *Educational Psychologist*, 26 (3-4), 369-398,

Carr, T., & Jitendra, A. K. (2000). Using hypermedia and multimedia to promote project-based learning of at-risk high school students. *Intervention in School & Clinic,* 36 (1), 40-44. p Retrieved November 19, 2001 from EBSCO research database.

Curtis, D. (2002). The power of projects. *Educational Leadership,* 60 (1), 50-53. Retrieved May 17,

2004 from EBSCO research database.

Çakiroglu; J.; Çakiroglu; E.and Boone W.J.(2005). Pre-Service Teacher Self-Efficacy Beliefs Regarding Science Teaching: A Comparison Of Pre-Service Teachers In Turkey And The USA. Science Educator; Spring 2005; 14, 1; ProQuest Education Journals pg. 31-40.

Derry, S. J., Siegel, M., Stampen, J, & the STEP Research Group (2002). The STEP system for collaborative casebased teacher education: Design, evaluation and future directions. *Proceedings of computer support for collaborative learning (CSCL) 2002* (pp. 209-216). Mahwah, NJ: Erlbaum.

Desouza, J. M.S; Boone, W.J. and Yılmaz, O. (2004). A Study of Science Teaching Self-Efficacy and Outcome

Expectancy Beliefs of Teachers in India. Wiley Periodicals, Inc. *Sci Ed* 88:837 – 854,

Dugard, P. and Todman, J. (1995). Analysis of pre-test and post-test control group designs in educational research. *Educational Psychology*, 15 (2), 181 - 199.

Dym, C.L.; Agogino, A.M.; Eris, Ö.; Frey, D.D. and Leifer, L.J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education;* 94, 1; ProQuest Education Journals pg. 103- 120.

Enochs, L.G.; Smith, P.L. and Huinker, A. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs Instrument. School Science and Mathematics; 100, 4; Academic Research Librarypg. 194-202.

Gencer, A.S. and Çakiroğlu, J. (2005). Turkish Preservice Science Teachers' Efficacy Beliefs Regarding Science Teaching And Their Beliefs About Classroom Management. Teaching and Teacher Education 23 ,664–675

Ghaith, G. & Yaghi, H. (1997). Relationship among experience, teacher efficacy and attitudes toward the implementation of instructional innovation. *Teaching and Teacher Education, 13*(4), 451-458.

Goddard, R. D., Hoy, W. K., & Woolfolk Hoy, A. (2000). Collective teacher efficacy: its meaning, measure, and effect on student achievement. American Education Research Journal, 37, 479–507.

Gonzales, A. H. and Nelson, L.M. (2005). Learner-Centered Instruction Promotes Student Success. T.H.E. ProQuest Education Journals, 32, 6; pg. 10.

Gordon; C. and Debus; R. (2002). Developing deep learning approaches and personal teaching efficacy within a preservice teacher education context. British Journal of Educational Psychology; Dec; 72, ProQuest Psychology Journals pg. 483- 511.

Grant, M. M. (2002). Getting a grip on project-based learning: theory, cases and recommendations. *Meridian: A Middle School Computer Technologies Journal*, 5 (1). Retrieved May 17, 2004 from
http://www.ncsu.edu/meridian/win2002/514/3.html.

Gültekin, M. (2007). Proje Tabanlı Öğrenmenin Beşinci Sınıf Fen Bilgisi Dersinde Öğrenme Ürünlerine Etkisi. Elementary Education Online, 6(1), 93-112.

Jarrett, O. S. (1999). Science interest and confidence among preservice elementary teachers. Journal of Elementary Science Education, 11, 47-57.

McMillan, J. H. and Schumacher, S. (2001). *Research in education*: A conceptual introduction, p.245 (5th Ed., New York, NY: Longman)

Mergendoller, J.R.; Markham, T.; Ravitz, J. and Larmer, J. (2006). Pervasive Management Of Project Based Learning: Teachers As Guides And Facilitators. Buck Institute For Education. Retrieved October 1, 2008, from http://www.bie.org/index.php/site/RE/pbl_research/29.

Midgley, C., Feldlaufer, H., & Eccles, J. (1989). Change in teacher efficacy and student self- and task-related beliefs in mathematics during the transition to junior high school. Journal of Educational Psychology, 81, 247–258

Moursund, D. G. (2001). *Problem-based learning and project-based learning*. Retrieved October 18, 2007 from http://www.uoregon.edu/~moursund/Math/pbl.htm.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. Review of Educational Research, 66, 533–578.

Palmer, D.H. (2006). Sources of Self-efficacy in a Science Methods Course for Primary Teacher Education Students. Research in Science Education; 36, 337-353.

Pelsma, D. M.; and Neufeld, P. J. (2002).The Teaching Of Leadership, Cooperation, And Communication In A Class Entitle: Management Of Counseling Programs. *TCA Journal;* Spring; 30, 1; ProQuest Education Journals pg. 76

Riggs, I., & Enochs, L. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. Science Education, 74(6), 625–638.

Riggs, I. (1995). The characteristics of high and low efficacy elementary teachers. Paper presented at the Annual Meeting of the National Association of Research in Science Teaching, San Francisco, CA.

Ross, J. A. (1994). Beliefs that make a difference: the origins and impacts of teacher efficacy. Paper presented at the Annual Meeting of the Canadian Association for Curriculum Studies, June.

Ross, J. A. (1998). The antecedents and consequences of teacher efficacy. In J. Bropy (Ed.), Advances in research on teaching, Vol. 7 (pp. 49–73). Greenwich, CT: JAI Press.

Savran-Gencer, A. and Cakiroglu, J. (2007). Turkish preservice science teachers' efficacy beliefs regarding science teaching and their beliefs about classroom management. Teaching and Teacher Education 23, 664–675

Schunk, D., and Zimmerman, B. (1997). Social Origins Of Self-regulatory Competence. Educational Psychologist, 32(4), 195-208.

Solomon, G. (2003). Project-based learning: a primer. *Technology &Learning,* 23 (6), Retrieved May 17, 2004

Thomas, J. W. (2000). A Revıew Of Research On Project-Based Learnıng, *http://www.autodesk.com/foundation.*

Tsai, C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International Journal of Science Education*, 24(8), 771-783.

Tschannen-Moran, M., Woolfolk Hoy, A. & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measurement. *Review of Educational Research, 68*(2), 202- 248.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: its meaning and measure. Review of Educational Research, 68, 202–248.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. Teaching and Teacher Education, 17, 783-805.

Tosun, T. (2000). The beliefs of preservice elementary teachers towards science and science teaching. School Science and Mathematics, 100, 374-379

Utley,J.; Moseley, C.and Bryant,R.(2005). Relationship Between Science and Mathematics Teaching Efficacy of Preservice Elementary Teachers. School Science and Mathematic, 105, no2, 82-87.

Uzuntiryaki, E. and Boz, Y. (2007). Turkish Pre-Service Teachers' Beliefs About The Importance Of Teaching Chemistry. Australian Journal of Teacher Education. Vol 32, 4, 1-16.

FACILITATING STUDENTS' SCIENCE EXPLANATORY WRITING USING WRITING FRAME

Umme Farwah Mansoor & Nelofer Halai
Aga Khan University- Institute for Educational Development
Ummefarwah.mansoor@aku.edu

▼ Abstract

The research study emerged from the background of the present teaching and learning practices of writing in the context of Pakistani science class room. My experience as a science student and teacher informs me that writing is widely used as a recording and collecting of factual information and for the purpose of assessment in science. As a result, students' motivation towards science writing is very low since it is a mechanical process of copying and writing memorized facts. Similarly students find it very challenging to express their own thoughts in science writing, therefore, relying on teachers for the provision of written material. Therefore, a small scale action research was undertaken to develop my own understanding as a teacher and researcher to support students writing with the help of writing frame in science. Writing frame is a support structure providing students a skeleton, with beginning sentences and connectives to scaffold students' explanatory writing. The data was generated through class room observations, focused group interviews, reflections and document analysis.

The evidence gathered from the research study indicated that the writing frame was able to reduce the anxiety level and blank page fear of students while taking on writing. The other findings from the study revealed that the writing process cannot take place in isolation and required continuous teacher support. Writing combined with classroom interaction such as teacher–student and student–student talk helped students in expressing their ideas while writing. The later section of the paper discusses the issues faced by the researcher such as limited understanding of writing frame and her own skills in integrating writing in science class room posed the biggest challenge. The paper concludes with the recommendations to the community of science teacher and teacher educator to jointly work in collaboration with language faculty in developing students' science writing.

Key Words writing frame, action research, scaffolding,

1. INTRODUCTION

Pakistan education system unfortunately encourages rote memorization and duplication of memorized material in assessment tests. This is carried over in science education as well. Explaining science through critical reasoning, problem solving, and

questioning of concepts is seldom part of writing in science education. My experience as a student and teacher informs me that science writing is done in a transmissional way such as asking students to copy the scientific facts from the textbook, black board or prepared notes. The possible reason given by teachers to rely on teacher directed method of writing is students' inability to prepare their own science writing because of low proficiency of language and pressure to complete science syllabus for annual exams. Interestingly, issue of teacher directed writing is also prevalent in developed country where research findings suggest that students have complained about the copying science writing (Osborne & Collins, 2001). According to Parkinson (1994), a lot of time, effort and energy are utilized by teachers in preparing and dictating notes to students in science class. As a result, students are not assessed based on their own thinking and valuable opportunity of learning is lost for the students. Hence students' rote learns the science content with little or no understanding of science concepts.

In science particularly, students usually show high level of motivation and interest in practical activities in science; however, when it comes to writing they consider it boring and a less motivating task in science classroom (Prain and Hand, 2005). Similarly majority of the assessment for science in our existing education system is done in a written format. Considering the existing state of science education in our system, I wanted to understand the ways as a science teacher and teacher educator, who could enhance the students' learning of science by involving students in a writing task which serves purpose of understanding and applying science learning thereby making the process of writing interesting and meaningful. In this paper, I have included a brief theoretical framework which guided my research study. The papers also include the research question, brief description about research design and method for data analysis. The paper give account of the important findings and insights gained from the study. Finally the paper concludes with the recommendations drawn from the research findings.

2. WHAT IS A WRITING FRAME?

A review of literature and exposure to different types writing in science (Wellington & Osborne, 2001; Yore, Bisanz & Hand, 2003; & Warwick, Stephenson & Webster, 2003), suggested that teachers can use *writing frame* to increase the competency of students' writing which might help students to describe, explain, report and argue in science and increase students familiarity with the structures of the text type (Wray,2001). According to Wray and Lewis (1998) *writing frame* serve as a skeleton consisting of different key words, phrases, beginning sentences, connectives and sometimes guiding questions which facilitate students during writing process and help them to communicate their understanding during the process of writing. Staples & Heselden (2001) argue that *writing frame* particularly help students in science writing class who show anxiety while writing and are often ask question 'How do I begin?' Hoyle and Stone (2000) further advocate the use of *writing frame* by saying that it consist of phrases and prompts, which serve as dialogue for the students and takes away the fear of blank piece of paper from the students during the process of writing. Therefore, *writing frame* might be a valuable strategy in science writing for the students in Pakistani

context, to construct their own explanation where they are mostly involved in copying information.

3. PURPOSE AND THE RESEARCH QUESTION

This study is done to understand how science teachers support students during science writing and keep the students actively engaged by making the writing process interesting and meaningful. Therefore, a small scale action research was carried out by a science teacher as a researcher to seek the answers of the following question

1. How do I develop my own understanding of using writing frame in the science classroom to enhance students' ability to explain science concepts in writing?
2. What are the facilitating and hindering factors in introducing the writing frame in science classroom?

4. METHOD

The research study was conducted through action research, as the purpose was to develop researcher's own understanding and bring some change in science writing through intervention by using *writing frames.* The aim of writing *frame* was to facilitate the students in constructing explanatory writing in science. As Kemmis, Mc Taggort and Retallick (2004), points out that through action research one tries out ideas in practice as means of improvement with new and increased knowledge about school leadership, curriculum, teaching and learning process. Thus, by conducting action research, the researcher developed a critical and deeper understanding of the classroom teaching practices during intervention phase and through the constant act of reflection on teaching methodology. In the process of reflection, researcher gained insights into numerous issues and challenges which helped in improving in subsequent lesson plans for the next cycle of action research by overcoming the weakness and challenges faced in the previous cycle.

4.1. Context of the Study

The study was conducted in a community based school that caters to the children of a particular sect. The students come from middle to low socio-economic background. The school system has separate school buildings for boys and girls. The researcher had conducted the research in girls section as she had previously taught in the girls' section. The school has three sections; pre primary, primary and secondary. The research study involved the students of class VII. At present, the school is affiliated with the Karachi Board of Secondary education. However, it is planning to get affiliation with the Aga Khan University- Examination Board in year 2009.

4.2. Research Participants

The research study was conducted mainly, to develop researcher's own understanding of a new strategy in teaching and learning of writing in science. The study involved exploration into science teacher's own teaching methodology and practices during the intervention phase of the study. Thus, researcher had a dual role in the study, both

as a teacher as well as a researcher. The researcher chose to conduct the study with the students of class VII because; the school was opting for AKU Examination Board in 2009. The school was preparing students for AKU Examination board and has already made some changes in the present teaching and assessment practices of class VI and VII, which facilitated the research study of the system. During the teaching sessions, all students were involved, however, for the process of data generation a small group was selected. The small group was formed of six students for the process of data generation. The group was based on mixed ability of the students, in order to get varied findings based on the students' performance ability. Due to time constraints, a small group of students were selected as the scope of the study did not allow gathering data for the entire class. Researcher also involved one school science teacher as a critical friend during the study. Researcher observed science teacher's two teaching session during the reconnaissance stage to find out the present classroom practices for teaching of science writing.

4.3. Plan for conducting study

The study was planned in three stages. In the first stage of reconnaissance, researcher observed the three teaching sessions of the class where the students were given a writing task that required them to construct explanation in their own words. Two Interviews with the teacher and a focus group interview with students were also conducted in order to understand their perspectives about writing for explanation. The purpose of this interview was to find out the perception of students and teacher towards writing in science classrooms. Finally, the students sample writing, teacher's lesson plan and text books were analyzed to better understand the needs of students, so that appropriate lesson plans could be prepared for the next stage of teaching during reconnaissance stage.

During reconnaissance phase, researcher also taught two classes of science writing without introducing writing frame. The teaching sessions provided a reference point for evaluating the students writing. The topics for teaching were selected in mutual consultation by the researcher and a science teacher. The teaching of science concept was during reconnaissance stage was extended to writing. However, writing frame was not used in the session. The teaching at reconnaissance stage served two purposes. First, it gave insights into the issues such as supporting and impeding factors influencing on students writing in science classroom. Then the writing samples produced were used as a reference to see how *writing frame* in the subsequent cycles would facilitate students in constructing explanation during science writing.

The second stage followed by the intervention stage. In this phase lesson plans were revised, taking into consideration the needs of the students, emerging during reconnaissance stage. It was further implemented through class room teaching. Each action cycle had three teaching sessions of around forty five minutes. After each teaching session researcher reflected upon the teaching and made changes based on the reflection. Researcher also conducted a focus group interview with the students after the completion of each cycle in order to inform me their experience of writing frame, in science writing for explanation.

During the post intervention stage, writings of the students from reconnaissance stage and the intervention stage were carefully analyzed to note any differences. The criteria for analyzing students work was based on the explanation of science content based on causal relationship and ability to predict by providing evidences in their writing for explanation. Moreover, students of small group were interviewed

4.4. Data Generation Process and Analysis

For data generation, classroom observations, interviews, reflective journal, students' sample, and analytical memo were used. The multiple sources of data generation allowed the researcher with vivid descriptions and emerging patterns of the change process. The multiple data sources also became a source of validation for any new information obtained during the research study

The data analysis was an ongoing process in action research, due to the participatory nature of research, continuous planning, and acting, observing, reflecting and then re-planning from the findings of previous cycle, required continuous analysis (Koshy, 2005). The analysis was done in two phases. The first phase of analysis was done simultaneously during the process of data generation by maintaining analytical memos. The analytical memos were based on observations, interviews, informal discussions and reflections on the students. The process of analyzing data simultaneously helped me to be focused, and at the same time different themes and patterns emerged during early stage of study (Glesne, 1999).

During various stages of research study, several questions were asked and answered during reflections to develop researcher's own understanding of the purpose and objective involved in the change process. For example, before and during intervention, researcher raised several questions like what was the teaching practice, How did it influence students writing? Why did it happen? What was teacher's role? What other alternatives were there? Answers to these questions from the data helped researcher to understand the process of introducing writing frame, and identify the hindering and supporting factors.

5. FINDINGS

5.1. Students' anxiety level and fear of blank page

The students writing sample and the focus group interview informed that the writing frames helped students in overcoming the fear of blank page. It was found that when students were attempting the writing task, the writing frame served as a dialogue and guided in constructing the explanation. In a focus group interview students mentioned that writing frame provided guidance and the prompts in the frame helped students in thinking the answer. Otherwise, it was found during reconnaissance when the researcher gave the writing task without the writing frame, students were confused and asked several question to the researcher about the task like "Miss, what do we have to write in this question?" or Miss, I don't know what to write despite understanding the question?" This kind of question suggests that students find writing a challenging task which can create unnecessary anxiety and stress and prevent stu-

dents from further doing the task. The frustration of knowing what to do makes the students abandon the task and moving far way from attempting it further. However when writing frame was introduced it was found in the class that students questions for managing and organizing the tasks were reduced and they were trying to answer the question individually. It was felt that writing frame is a useful strategy in overcrowded class where teachers have to address the individual needs when doing writing task because the prompts in the writing frames were actually serving as a dialogue between a teacher and students.

5.2. Writing cannot be done in Isolation

It was found that students in the context, had difficulty in finding the information either from the library or internet. The obvious reason could be that in science classroom students are confined to the information of textbook and are not encouraged to go beyond it. The other reason could be due to the fact that teachers in science rarely provide the students the opportunity to find information. As most of the time teacher and the textbook are the only source of information for the students. It was found that if we want to facilitate the writing as a learning process, it was essential to enhance students other learning areas like group work, information finding skills, reflection, critical thinking and questioning skills which were all intertwined and essential in making writing as a learning process.

5.3. Social interaction like peer-peer talk enhanced writing

It was found that talk generated during small group discussion, influenced students writing and it was evident in the students writing sample (Rivard & Straw, 2000). Students also mentioned in their reflection that they gained immensely from the discussion and shared that: "*writing frame* and partner discussion were very helpful as during group discussions we mix our ideas and then write" (Student's Reflection). From the above finding it is apparent that students benefited from the social interaction as it provided them an outlet to share their ideas which was then communicated in their writing task. Similarly, in a discussion by small group of students had picked the importance of fossil fuel for the transport communication said that when there would be no fossil fuel then how we would communicate from one place to another. Interestingly, I found this point in one of the sample writing. Therefore, I could say that interaction from class talk was helping students in the writing process.

5.4. Inadequate Knowledge and Understanding of Writing Frame

The biggest challenge faced throughout the study was limited understanding of writing frame. This also affected researcher in preparing an appropriate *writing frame* for the students' writing task. Firstly, this difficulty was due to the limited number of research study conducted to see the impact of *writing frame* on students writing. Secondly, researcher had no strong background of language learning and teaching. Thirdly, the *writing frames* available were mostly based on report writing of science investigation. However, the research study focused on explanatory writing and ex-

planations in science are complex type of science writing. The search for model writing frame made the researcher visit the literature time and again. In the process, researcher found the literature on *writing frame* but it did not provide the required understanding of the role of *writing frame* in science writing. To overcome this challenge, one of the language faculty was approached and consulted. Writing frame was shown to her, and found that the purpose of writing frame was to facilitate and scaffold students attempt in writing process by providing some clues which stimulate thinking process during writing task. Based on her valuable feedback, writing frames used in the research study were reviewed and necessary changes were made before using it in the class. Researcher constantly asked questions to herself if she had been going on right path. Researcher did not give up and tried to design and develop her own writing frames.

6. IMPLICATION OF RESEARCH STUDY

Based on the research finding following implications have been drawn. There is a need to shift science learners from heavily relying on the information of text book. The urge of copying from the text book in science might prevent learners to gain maximum learning during science writing. Therefore, teachers should realize that writing has a potential to enhance students learning in science. Therefore, writing activities in science class room which stimulates learner's thinking and reasoning skills might be more valuable then copying from text book and black board. Teaching of writing requires integrated approach and students might benefit more, if science content can be used to design meaningful writing activities in teaching of language and science. Teachers also need to give students variety of writing activities like argumentation, discussion in science writing in order to provide learners an opportunity to construct their own meanings from the science content which is otherwise presented as knowledge of absolute facts. It is important that new writing strategies like *writing frame* which some what facilitated students writing in science could be further explored, therefore, research study is needed to find the potential of *writing frame* in science writing class. It is also time for stakeholders in science teaching to view assessment practices in science classroom which emphasize more on summative assessment; as a result students recall and reproduce scientific facts. It is important that teachers might include the practice of formative assessment during writing so that students learning in science are enhanced.

7. RECCOMENDATIONS

Following recommendations have been made from the findings of the study.

7.1. Teachers' Role in preparing students' writing for explanation

The teachers' role in teaching and leaning of science is crucial. Materials should be designed such that the students' motivational level should be high and students have a strong purpose of learning during writing. Therefore, writing should be viewed as a source of learning and not a tool for assessment or recording knowledge for ex-

amination. Teachers should prepare such activities which centre on students' interest and not confined to copying text from black board and text book. Finally, in science classroom significance of practical activity cannot be denied, but it is essential that learning gained from the practical investigation should be extended to writing so that students' learning is reinforced.

7.2. Interdisciplinary Approach

Syllabus should be made integrated and it is believed that teachers of Science and English can collaborate and design interdisciplinary activity to enhance students' literacy in science, so that they can communicate their message effectively. It would be very helpful in our context, if language teacher and science teacher work collaboratively in order to give support to each other. Mostly, science teachers lack expertise in language and through integrated approach teachers might benefit. It would be valuable if English language teachers could include some writing in an appropriate science context, as part of language study. It might benefit students in our context where students have a low proficiency in English.

8. CONCLUSION/LIMITATION

This study was conducted to understand the process of using writing frame to support students' attempt of explanatory writing. The findings from the study informed that writing frame facilitated the writing process and students overcame the fear of blank page. It was also found that during the process of writing frame several misconceptions were highlighted. Furthermore, it was found that the writing frame proved to be a support mechanism which served as a dialogue between writing task and a student. However it was also observed that science teacher needs to plan and modify teaching activities to meet both science content and the writing objectives. Finally based on the findings, it came out very strongly that science and language faculty has to work in collaboration by working jointly on any project together. It will be not be right to say that the study conducted was a perfect investigation because the study is limited by the small scale investigation and the particular context where the study was undertaken. But by systematically addressing the important questions during the study, researcher has come up with the findings that will certainly influence her future practice as science teacher and teacher educator so as to improve the quality of students learning in science writing.

9. REFERENCES

Glesne, C. (1999). *Becoming qualitative researchers.* New York: Longman.

Hoyle, P. & Stone, C. (2000). Developing the literate scientists. In J. Sears & P. Sorensen (Eds.),*Issues in Science teaching* (pp. 89-90) London: Routledge

Kemmis, S., Mc Taggart, R., & Retallick, J. (2004). *The action research planner*. Karachi: Aga Khan University Institute for Educational Development.

Koshy, V. (2005). *Action research for improving practice.* London: A sage Publications Company.

Osborne, J. & Collins, S. (2001). Pupils views of the role and value of the science curriculum: a focus group study. *International Journal of Science Education, 23* (5), 441-467.

Parkinson, J. (1994). *The effective teaching of secondary science*. NewYork: Longman publishing.

Prain, V., & Hand, B.(2005). Pupil learning through writing in science. In S. Amons, & ABoohan (Eds.). *Aspects of Teaching Secondary Science Perspectives on Practice* (pp. 190-210). London: Open University Press.

Rivard, L. P., & Straw, S. B. (2000). The effect of talk and writing on learning science: An exploratory study, *Science Education*, *84*, 566- 693

Staples, R. & Heselden, R. (2001). Science teaching and literacy part 1: Writing. *School Science Review, 83*(303), 35-46

Warwick, P., Stephenson, P., & Webster, J. (2003). Developing pupil's written expression of procedural understanding through the use of *writing frame*s in science: findings from a case study approach. *International Journal of Science Education, 25*(2), 173-192.

Wellington, J. & Osborne, J. (2001). *Language and literacy in science education*. Philadelphia: Open University Press.

Wray, D. & Lewis, M. (1998). *An approach to factual writing : An invited article*. (Opinion Papers No. CS 217203). DE. Newark, International Reading Association. (ERIC Document Reproduction Service No. ED 44157)

Wray, D. (2001). *Developing factual writing: An approach through scaffolding.* (Report No. CS217600). Dublin, Ireland Paper presented at European Reading Conference (ERIC Document Reproduction Service No. ED 454534)

Yore, D. L., Bisanz, l. G. & Hand, M. B. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research. *International Journal of Science Education, 25*(6), 689-725.

POSTERS

DIAGNOSIS OF SENIOR PRE-SERVICE CHEMISTRY TEACHERS' MISCONCEPTIONS ON PARTICULATE NATURE OF MATTER IN THE CONTEXT OF GASES AND THEIR AWARENESS OF LEARNERS' MISCONCEPTIONS

Sevgi Aydin*, *Yuzuncu Yil University, asevgi@metu.edu.tr*
Yezdan Boz, *Middle East Technical University, yezdan@metu.edu.tr*
** PhD students in Middle East Technical University*
Middle East Technical University, Faculty of Education,
Department of Secondary Science and
Mathematics Education, 06531 Cankaya/Ankara, Turkey

▼ Abstract

Pedagogical content knowledge (PCK) was first offered by Shulman (1987) as knowledge which distinguishes a teacher from a content specialist. It includes several components such as knowledge of instructional strategies, knowledge of curriculum. One of them is the knowledge about students' understanding and difficulties in science topics. Studies on learners' knowledge about particulate nature of matter in context of gas have indicated several difficulties (Gabel, Samuel & Hunn, 1987; Griffiths & Preston, 1992; Kokkotas, Vlachos & Kloudis, 1998, Lee et al,. 1993). To investigate participants' knowledge on this topic and on learners' misconceptions, a class vignette involving open-ended questions was administered to 47 pre-service chemistry teachers. To analyze data, qualitative approach was used. Categories for participants' own answers and for their predictions' for learners' answers were formed. Results revealed that pre-service chemistry teachers had misconceptions related with the topic. 28 % of them gave incorrect answer to the question asked. Although 40 % of participants predicted learners' possible misconceptions detected in the literature, 55 % of them were unaware of learners' possible misconceptions. Implications were suggested for pre-service teacher education.

Key Words Pedagogical Content knowledge, pre-service teacher education, chemistry education

1. INTRODUCTION

Pedagogical content knowledge (PCK) was first offered by Shulman in 1987 as "the special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (p.8). In 1987, Shulman described PCK as knowledge which distinguishes a teacher from a content specialist. There are different models of PCK including different components; however, there

are two parts which are common for all scholars, namely, knowledge of representations of subject matter and knowledge of students' difficulties and conceptions. Another model for PCK was formed by Magnusson et al. (1999). It consists of five components one of which is the knowledge and beliefs about students' understanding of specific science topics. It is related to possessing information about the learners to assist them to learn science. There are two components of this knowledge, namely, knowledge of requirements of learning and knowledge of areas of student difficulty. The latter is related with being aware of students' difficulties and their causes, one of which is misconceptions.

Studies on learners' knowledge about particulate nature of matter in the context of gases have indicated that learners have difficulties in learning the topic (Gabel, Samuel & Hunn, 1987; Griffiths & Preston, 1992; Kokkotas, Vlachos & Kloudis, 1998, Lee et al,. 1993). Even preservice teachers have common misconceptions (Kokkotas et al,. 1998; Novick & Nussbaum, 1981;). These conceptions are resistant to change and despite the many chemistry courses, they may still exist (Gabel et al., 1987).

In this study, PNM in the context of gases were selected because these topics are basic for further learning of others (Gabel et al., 1987; Griffiths & Preston, 1992; Lee et al,. 1993; Harrison & Treagust, 2002). In addition, there are not many research studies to examine teachers' knowledge about specific science topics (Magnusson et al., 1999).

The purpose of the study is to investigate preservice chemistry teachers' knowledge of particular nature of matter in the context of gases and their knowledge of learners' misconceptions on the topic.

Research Questions

1. What is the senior pre-service chemistry teachers' subject matter knowledge about particulate nature of matter in the context of gas?
2. Are senior pre-service chemistry teachers aware of learners' misconceptions related with the topic?

2. METHODOLOGY

2.1 The sample

In the fall semester in 2007-2008, a class vignette was administered to a sample of 47 senior pre-service teachers (34 females and 13 males) who were enrolled at the Department of Secondary Science and Mathematics Education in two universities in Ankara. They took many chemistry courses such as General Chemistry, Analytical chemistry and Physical Chemistry. In addition, they took pedagogical and method courses. Information about the study was given. They were volunteered to take part in it.

2.2 Instrument

To investigate participants' knowledge on Particulate Nature of Matter in the context of gases and on learners' misconceptions related to topic, a class vignette including

six open ended questions was used. They were taken or adapted from the research in literature. For this study, 4th question was analyzed. In the vignette, Mrs.Sevgi with 5-year-experience was introduced. She taught Chemical Reactions chapter and would start to teach Gases unit. There were open-ended questions about prerequisite topics to learn gases meaningfully, and four questions about the PNM in the context of gases. These questions included two parts which were their own answers and their predictions for learners' misconceptions. For this study, 4th question was analyzed.

2.3 Question Analyzed

A football is pumped up hard during the day when it is warm. In the evening when the temperature falls, the football does not feel so hard. How does this happen? (Assume that the football does not leak.) (The question was taken from Lonning, 1993)

2.4 Procedure

Class vignette was administered to the participants. Firstly, they were asked to write their own answer to explain the phenomena. Then, they were asked to predict learners' possible answers to the question. Participants finished answering approximately in 20 minutes.

3. ANALYSIS OF DATA

In order to analyze data, qualitative approach was used. Categories were formed. According to the pre-service teachers' own explanations to 4th question, three categories as correct answers, partially correct answers and incorrect answers were formed. "Correct answer" category includes totally correct responses with all necessary information. For instance, the pressure of the gas in football and atmospheric pressure are equal. In the evening, temperature decreases. Therefore, the pressure of the gas in football decreases because there is a direct proportion between pressure of gas and the temperature (PV= nRT). The volume of the football should decrease to equate the pressure of gas to the atmospheric pressure. If the volume of gas decreases, the pressure of gas increases.

The category of "partially correct answer" is consisted of answers which are true but lacking some part of information. For instance, PV= nRT, if the temperature decrease, pressure of gas decreases. Therefore, volume decreases to increase the pressure of gas.

"Wrong answer" category covers responses which are incorrect and include misconceptions. For example, the volume of the football decreases because gas particles in it compact at the center of the football.

For pre-service teachers' judgments about learners' possible responses given to the question, two categories as "aware of learner's misconceptions" and "unaware of learner's misconceptions" were formed. Answers which included "Students can do it easily", "They do not have problem to solve it", "They give an answer similar to mine" and no answer were put into the "unaware of learner's misconceptions"

category. The "aware of learner's misconceptions category" included two subcategories, which are "likely misconceptions" and "unlikely misconceptions". In likely category, there were answers mentioning learners' misconceptions from the literature, for example, "Air becomes lighter when it is cold." and "When heated the molecules expand, when cooled they shrink." Finally, in unlikely category, there were answers including learners' possible answers but they were not mentioned in the literature, for instance, "football expands" and "when temperature falls, gas in football also falls".

4. FINDINGS

Table 1 Analysis of participants' SMK and their awareness of learners' misconceptions

	Pre-service teachers' incorrect answers	Partially Correct answer	Correct answers	Unaware of students' likely misconceptions	Aware of students' likely misconceptions	
					Likely	Unlikely
Number of participants (Total 47)	13 (27, 66 %)	27 (57 %)	7 (14, 89 %)	26 (55, 32 %)	19 (40, 43%)	2 (4, 26 %)

Although 7 (% 15) of the pre-service teachers gave correct answer to the question, 13 of them answered incorrectly (28 %). Four of participants with wrong answer thought the volume of football as constant (fixed). They attributed the event to a decrease in temperature. They explained that (PV= nRT) if the temperature decreases, the pressure decreases as well (n, V; constant). One of them explained the reason as the larger pressure of the cold air on football than the warm air's pressure. One of them told that on the football there are small and invisible holes. Gas in it diffuses from these holes. Moreover, 5 out of 13 wrong answers included misconceptions detected in the literature. These misconceptions were "when it gets cool, the air contracts to keep warm", "when substances are heated the particles get hotter and colder when substances are cooled" which is a misconception mentioned in Lonning (1993) and Lee et al. (1993).

A similar analysis was done to investigate pre-service chemistry teachers' knowledge of learners' possible misconceptions. First of all, misconceptions detected in the literature were searched. Then the answers were examined and put into the categories. 26 (55 %) of the pre-service teachers were unaware of learners' misconceptions. 19 (40 %) participant predicted learners' possible misconceptions detected in the literature, for instance; "When it gets cool the air contracts", "Air becomes lighter when it is cold.", and "When heated the molecules expand, when cooled they shrink" (Lonning, 1993; Sanger, Phelps & Fienhold, 2000; Lin & Cheng, 2000). Finally, there were 2 (4 %) pre-service teachers whose predictions were not identified in the literature which were "when the temperature falls, gas in the football also falls" and "Learners may think the expansion of the ball".

5. CONCLUSIONS AND IMPLICATIONS

Result of the study revealed that some of pre-service chemistry teachers had some problems in gas unit. 13 out of 47 (28 %) gave wrong answer to the question. 5 of them had specific misconceptions. For example, in this study, 2 of the pre-service teachers answer attributed macroscopic properties to the particles. She mentioned the temperature of the molecule. This finding supports Boz (2006), Kokkotas et al., (1998) and Novick & Nussbaum (1981). In their research, results showed that misconceptions detected in younger learners might be investigated at university level. Gabel et al., (1987) said that these conceptions were resistant to change and despite the many chemistry courses, they might still exist. Although participants have taken many chemistry courses, they have not changed them yet.

Result of both this study and studies in literature indicated some of pre-service teachers' misconceptions and inadequate subject matter knowledge. In preservice education, courses should stress conceptual understanding. In addition, pre-service teachers' misconceptions should be detected and assistance to eradicate them should be provided. Moreover, in courses related with pedagogy, learners' misconceptions and difficulties should be introduced and reasons of them should be discussed since more than half of the pre-service chemistry teachers in the present study were unaware of students' possible misconceptions.

6. REFERENCES

Boz, Y. (2006). Turkish pupil's conceptions of the particulate nature of matter. Journal of Science Education and Technology, 15 (2), 203-213.

Gabel, D. L., Samuel, K. V., & Hunn, D. (1987). Understanding the particulate nature of matter. Journal of Chemical Education, 64, 695-697

Griffiths, A. & Preston, K. (1992). Grade-12 students' misconceptions relating to relating to fundamental characteristics of atoms and molecules. Journal of Research in Science Teaching, 29, 611-628

Harrison, A. G. & Treagust, D. F. (2003). The particulate nature of matter: Challenges in understanding the submicroscopic world. In Gilbert, J. K., Jong, O. D., Justi, R., Treagust, D. F., & Van Driel, J. H. (Eds.), Chemical Education: Towards Research-based Practice (pp189-212). London, Kluwer Academic Publisher.

Kokkotas, P., Vlachos, I., & Koulaidis, V. (1998). Teaching the topic of the particulate nature of matter in prospective teachers training courses. International Journal of Science Education, 20 (3), 291-303.

Lee, O., Eichinger, D. C., Anderson, C. W., Berkheimer, G. D., & Blakeslee, T. D. (1993). Changing middle school students' conceptions of matter and molecules. Journal of Research in Science Teaching, 30 (3), 249-270.

Lin, H. & Cheng, H. (2000). The assessment of students and teachers' understanding of gas laws. Journal of Chemical Education, 77 (2), 235-238.

Lonning, R. A. (1993). Effect of cooperative learning strategies on student verbal interactions and achievement during conceptual change instruction in 10th grade general science. Journal of Research in Science Teaching. 30 (9), 1087-1101

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), Examining pedagogical content knowledge: The construct and its implications for science education (pp. 95-132). Boston: Kluwer.

Novick, S & Nussbaum, J. (1981). Pupil's understanding of the particulate nature of matter: A cross-age study. Science Education, 65, 187-196.

Sanger, M. J., Phelps, A. J. & Fienhold, J. (2000). Using a computer animation to improve students' conceptual understanding of can-crushing demonstration. Journal of Chemical Education, 77 (1), 1517- 1520.

Shulman, L.S. (1987).Knowledge and training: Foundations of the new reform. Hardward Educational Review. 57(1), 1-22.

THE ENVIRONMENT PORTRAYED IN THE FILM AND THE SCIENCE EDUCATION

Glades Miquelina Debei Serra, Agnaldo Arroio
Faculty of Education,
University of São Paulo
Av.da Universidade 308, 05508-040, São Paulo, SP, Brazil,
gladesserra@hotmail.com, agnaldoarroio@yahoo.com

▼ Abstract

Provide access to information is one of the major responsibility of teachers dedicated to the education, teaching to engage their students to be critical and conscious about the environment which they live. Taking care of the planet it is the duty of all, therefore, if students are mobilized and sensitized to reflect about their everyday actions in relation to the environment, certainly better results will appear.

This paper aims to discuss the use of films dealing with environmental issues as a cultural tool in the educational process. It is necessary that teachers make use of many cultural tools awakening interest, curiosity and reasoning skills in the students, to help them to properly discuss that subject. Thus, a comparative analysis was made comparing two genres: fiction and documentary (not fiction). According to the socio-interacionist approach, the public can identify and interact with the characters sharing actions and emotions expressed in the audiovisual language. Using a film is possible to join science, teaching and learning as an opportunity to unveil several aspects hidden, unimaginable.

Key Words environment, science, language audiovisual.

1. INTRODUCTION

Knowledge is one of the ways that human beings can take the world and the reality in their surroundings to adapt it and transform it according to their needs, in order to build a better world where everyone can be held and live fully.

If we accept that some knowledge of science should be part of the education of every child, we need to think how is the best way to provide that education (Lemke, 2005).

Arroio and Giordan (2006) indicate in their research that the problem of educational innovations in science education might be properly treated by analyzing the complexity on the basis of methodology of teaching.

To be successful, science education must count on a rich repertoire of experiences that helps the concept's construction during the learning process. These experiences pave the way to the construction of meaning, which in turn supports learning. Entertainment contributes, creating or re-creating the sense of wonder, questioning and benefiting the concepts and knowledge construction.

It is therefore important to think on an education systemic term, not limiting the student's experiences to what can possibly take place in the classroom. The role of outdoor teaching alternatives shows itself as a prelude, a complement and a follow-up to the school-based learning methodology. Knowledge comes from the environment's interaction experience (Lemke, 1990). In Vigotsky's words, by the cultural learning, part of the elementary basic functions (that belong to all developed animals), become superior's psychological functions as conscience, planning and deliberation, mainly human characteristics, built by his social history and his relation to the world.

Artistic manifestation, as audiovisual language, shows itself as another possibility or easing tool during the knowledge construction. This occurs because of the integration of individual reality with the natural surrounding environment, which develops in the student the sensitivity and perception of the universe. The audiovisual language allows such integration individual-environment, because, it deals with scientific concepts as well shows characters living in a world that can be recognized and identify by the students.

By Vigotsky (1978), the language – the symbolic system of human groups, provides concepts, ways to organize the reality, mediation between the subject and the knowledge object and, by the language, the mental's superior functions are socially formed, mediating the cultural transmission process held by humanity. Without the language, is it almost impossible that teacher's words make sense for students. The vigotskyan historic-cultural theory of psychical (well known as socio-interacionist approach) can show a way if we consider how the ideas are developed, on a broader social plane of the classroom. This comes with a conscience assimilation of the physical world by gradual interiorizing of external acts and its mental actions transformations.

"A film or multimedia program has a strong emotional appeal and therefore motivates the learning of the content presented by the teacher" (Arroio, 2007). In the vigotskian view, as a knowledge subject, man doesn't have direct access to the objects, but it does have mediate access through parts of the real. The knowledge construction doesn't come by the subject's action of reality but it comes from the mediation done by other subjects.

Using a film the student learns sensitively not only by cognition. By presenting a film, not only the content is transmitted, but experiences of all kinds: emotions, feelings, attitudes, actions, knowledge etc., as the cultural acquisition that can give to individual symbolic systems of reality's representation. Films create trends, and have a broader impact on youngsters than any other media, besides it creates more interest in scientific themes.

However, it is important to the teacher to be very clear about his intention and purpose to convey a non-pedagogical tool in a classroom as a film, so that the display

does not become a mere and simple transmission. The audiovisual language gives to the teachers, the possibility to foster the autonomy in the students when he passes from informant to mediator. As a way to illustrate the use of the film's language in teaching sciences it is suggested two films (a fiction and a non-fiction) which address environmental issues for use in the science classroom as a cultural tool in the educational process.

2. METHODOLOGY

Films are very popular for the youngsters (Fish et al., 1997), so here we report a film analysis based on the movie analysis (Jahn, 2003) but considering a vygostkian perspective (Vygotsky, 1978) about contextualizing the scientific contents. First we selected some commercial films looking for what we could take educational advantage of them. Than were selected films that submit the specific topic: global warming. Environmental problems have been strongly discussed in recent decades. Subsequently, we focused on the audiovisual language trying to catch up if those films are able to communicate with the public, especially youngsters. It was chosen a fiction film (The Day After Tomorrow) and a non-fiction (A True Drawback). The analysis methodology has privileged elements of the audiovisual language, contents and classroom contextualization possibilities. The analysis was conveyed to the use of those medias as a pedagogical tool.

3. FINDINGS AND DISCUSSION

In the film "The day after tomorrow" directed by Roland Emmerich and produced in October 2004, a character (the climatologist Jack Hall) warns an authorities group (politicians, leaders) about the risk of a new Ice Age, caused by global warming. The group, apparently sceptic about the possibilities brought by the climatologist, is still insensitive face the complaint because it seems that the announcement changes will not affect them. Meanwhile, political ideals and economic issues are stronger and are built on that mask of skepticism. What the group does not expect is that the events were already establishing and immediately starts a new Ice Age.

The film shows images of the melting glacier in Alaska, tornadoes in Los Angeles, tidal waves in New York, freezing across the northern hemisphere, among other disasters. A sequence of scenes shows the climate imbalance on the planet, such as blocks of ice in Japan, hurricanes in all continents, snow in India, etc. The film also deals with the drama of Jack Hall when the climatologist goes toward New York to rescue his son, in the midst of a major snowstorm and in the opposite direction of the American population that migrates to the south of the country looking for survival.

In the non-fiction film "A True Drawback - A Global Warning," directed by David Guggenheim and produced in 2006, Al Gore gives a lecture that shows the state of the planet and the future that awaits us if no action is made about the global warming. Albert Arnould Gore Jr, former vice president of the United States directly attacks the environmental policy of President George W. Bush.

FILM'S TITLE	THE DAY AFTER TOMORROW	A TRUTH DRAWBACK
FILM	Fiction that portrays reality	Documentary that portrays reality
PLOT	Earth undergoes climate changes because human interference in the environment	Earth undergoes climate changes because human interference in the environment
PLOT DEVELOPMENT	Climate changes alter human life and it starts a new Ice Age. Migrants survivors move to the southern U.S.	Lecture showing that climate changes affects life on Earth and if some actions are not taken we can reach a disaster
IMAGES	Glacier melting in Alaska Torrential rain in New York Hurricanes in Los Angeles and Hurricanes forming on the continent Rain of ice blocks in Japan Snow in India Pollution	Glaciers melting in Alaska Glaciers melting in Nepal Hurricane Katrina in the USA Hurricane Ivan in Florida Hurricane Francis, Dennis Hurricane in the South Atlantic in March 2004 Thaw Ice in Antarctica, in Greenland Tornadoes in the U.S. and Japan
GREENHOUSE EFFECT	Lack of interest to solve the problem of the greenhouse effect	Actions have already been taken to solve the problem
SOCIETY	Shows immigrant working in less valued jobs in the U.S.	Awake awareness for the imminent extinction of the human race
POLICY	Policy ideals interfere in possible environmental solutions	"If an issue is not at the tip of the tongue, it is easy to ignore it" (Al Gore)
SCIENCE	Scientific development influences at environment issues	Scientific development influences at environment issues
ECONOMY	Economic interests limits investment in environmental preservation	It presents a balance with bars of gold on one side and the other side the Earth planet
U.S.A.	It presents a mea culpa from the United States in response to environmental issues	Data presented graphically indicating the U.S.A. as biggest polluter on the planet
HERO	Climatologist Jack Hall recovers his son in New York across the USA in the midst of a snowstorm	Al Gore former vice president of the United States promotes lectures around the world, visiting various locations on the planet to monitor and learn proposing solutions on environmental issues. It shows a personal journey of Al Gore, overcoming family obstacles and barriers during the competition to the presidency of the U.S.A.
CHARACTER'S IDENTIFICATION	It occurs by the living drama between the climatologist, his son and other people confined in a public library	It occurs by the charisma of the presenter and the humor; by the satire and the impact of the scenes shown in various drowns images and animations presented in the lecture
FORECAST	Climate imbalance expected to be around 21st century is something that is already happening	Climate imbalance and environmental changes are already occurring
THE END OF THE FILM	Message of hope: the atmosphere seen from space shows up clean	Message of hope: It is still possible to reverse the situation

The broad agreement among climate scientists that global temperatures will continue to increase has led some nations, states, corporations and individuals to implement actions to try to curtail global warming or adjust to it. Many environmental groups encourage individual action against global warming, often by the consumer, but also by community and regional organizations. Others have suggested a quota on worldwide fossil fuel production, citing a direct link between fossil fuel production and CO_2 emissions.

There also has been business action on climate change, including efforts at increased energy efficiency and limited moves towards use of alternative fuels. One important innovation is the development of greenhouse gas emissions trading through which companies, in conjunction with government, agree to cap their emissions or to purchase credits from those below their allowances.

The world's main international agreement is the Kyoto's Protocol. It was discussed and negotiated in Japan in 1987, opened to signatures in 1988, but effectively started in 2005. The international agreement proposes that industrialized countries reduce in, at least, 5,2% their greenhouse gas emissions (based on 1990 emission numbers), between 2008 and 2012. The greenhouse effect is the process by which absorption and emission of infrared radiation by atmospheric gases warms a planet's lower and surface.

Observe that the films are very similar, differing only in the aspects: greenhouse effect, society (but by the fact of not being the focus of the second film (non-fiction)), besides the aspects context in which the film is presented and identification with the characters. The borders between science and fiction can be discussed to show what science presented on these films corresponds to reality and what fiction is. The genre "fiction" is the using term to describe films based on imagination. In turn, they end up opposing to non-fiction that claims being based in reality facts. The fiction films can be entirely or partially based in real facts, but they always will present an imaginary component. The fiction definition is based in the act or effect of simulating, pretending, imaginary's creation, that which belongs to the imagination, to unreal, fantasy, invention.

Documentary is a film characterized by the compromise with the realities exploration. But it is impossible to infer that it represents reality as it is, because it is a determined vision about a determined subject. The documentary's definition is a relation with the example, model, lesson, teaching, demonstration and test.

Both the documentary and fiction are partial and subjective realities representation. However, by watching these films the spectator does not assume this presumption. The spectator's perception generally is based on a common sense definition of each genre. This perception dimensions a distorted vision between fiction and reality.

The professor, when choosing an audiovisual material to be used in a classroom, most of the times ends up optioning by the documentary, because he understands that the science retreated on it is "real", opposing to the fiction.

It is important to emphasize that most popular fiction films themes, the blockbusters, generally show yearns and fears of a specifically generation about new technologies or scientific discoveries.

The cinema is known as a representation vehicle of the society in which it belongs. In fact, it is in the capacity of the cinema to reproduce systems of representations or socials articulations that it is possible to say that it replaces the major mystic narratives. Then, the typology of a character can be considered as a representative period not only of the cinema but also of the society.

In Kracauer words (1960), a film tells us a human history surpassing the exterior world forms (space, time and casually); and adjusting the events to the interior world forms (attention, memory and emotion).

The first film presents a story. Maybe, that is why it mobilizes more the spectators than the Al Gore's film, which presents a lecture given all around the world. In both films science is presented in a social context not only as applications but as well by the implications of its relations (Zoller, 1974). However, either one or another can be used in a classroom for presenting many scientific concepts, while contributes to make students distinguish between the science and "pseudo-science" presented in the films.

It is necessary to use different resources for students to mobilize and awake theire interest and curiosity about various subjects, as well as the ability to develop logical discussion to any issue with property (today, above all, issues related to the environment).

Using films as a pedagogical tool can promote the educational process, because, based on the socio-interacionist approach of Vygostsky the public can identify and interact with the characters sharing actions and emotions expressed in the audiovisual language. By Vigostky, is in the interchange between the other subjects and himself that the subject intern acts and social functions, allowing the knowledge construction and his own conscience.

By using audiovisual language it is possible to join science, teaching and learning in a way that the communication becomes more efficient and learning more effective, besides raising interest and motivation of science in the youngsters.

Another important aspect to be detached is the resources education. The films are an information font, as other medias, that directly influence the perceptions and conceptions of the students. So than, a lecture's way helps in the acquisition of information process, contributing to the development of students critical sense.

4. CONCLUSIONS

A film can be used in the science education in different ways, taking advantage of this media that is very popular among youngsters. However, regardless of the chosen method, it is observed that the teaching of science appears much more effective when it uses this methodology compared to the traditional.

Whatever being fiction or not fiction, the environment portrayed in both of them is very similar. Perhaps the non-fiction preference is because, for teachers imaginary, the non-fiction is more realist than the fiction. What is not true. Once both presents the author's voice and pass through the same edition process. But this is not a discussion that will take place here.

Using films awakes the spectator's imagination and also facilitates the internalization of scientific concepts while working with the interdisciplinarity. It serves to illus-

trate scientific concepts and analyzing their scientific content from different subjects taught at school.

Using audiovisual film's language has some advantages:

- is a more accessible language than the scientific language thus more easily understood by the non-experts;
- serves to mediate new concepts, aiming to stimulate interest in science;
- dispels misconceptions that arise from films;

Another advantage is that on this way, we are preparing students to read the film, because read is more than just watch. Read is to get information and able them to have a critic view about mass media used by the audiovisual language.

Students use to spend many hours in front television which is one of their source of information. Reading is not only the basic tool of learning, but it also has a practical role in everyday's life.

The audiovisual language presents itself as a potential pedagogical tool. This because it can deal with scientific matters, show science on society, being a mediator between science and education, besides showing the public how to learn values, information and knowledge presented in the film.

5. REFERENCES

ARROIO, Agnaldo (2007). **The role of cinema into science education**. In: *Science Education in a Changing Society*. Lamanauskas, V. (Ed.). Siauliai: Scientia Educologica.

ARROIO, A., & GIORDAN, M. (2006) **Methodology of teaching: integrating video analysis into the preservice training of chemistry teachers**. In: *Research in Didactics of Science*. Pasko, J. R., Nodzynskiej, M. (Eds.). Krakow: Akademia Pedagogczna.

FISCH, S.M., Yotive, W., McCann, S. K., Scott, M. & Chen, L. (1997). Science in Saturday morning: children´s perceptions of science in educational and non-educational cartoons. *Journal Educational Media*, 23, 157-167.

JAHN,M. (2003) *A Guide to Narratological Film Analysis*. Cologne: University of Cologne.

KRACAUER, S. **Theory of film**. Oxford: Oxford University Press. 1960.

LEMKE, J. L. (1990). *Talking Science: Language, learning and Values*. Norwood, NJ: Ablex Publishing.

LEMKE, J. L. (2005). *Research for the Future of Science Education: New Ways of Learning, New Ways of Living*. Retrieved April 30, 2007. from http://www-personal.umich.edu/~jaylemke/sci-ed.html

SANTOS, N.N. & SANTOS, J.M. **A educação científica através do cinema**. Atas do V ENPEC – Encontro Nacional de Pesquisa em Educação em Ciências. 2005

VYGOTSKY, L. S. (1978). **Mind and Society**. Cambridge: Harvard University Press.

ZOLLER, U., & WATTSON, F. G. **Technology education for nonscience students in secondary school.** *Science Education*, 58, 1, 105-115. 1974.

THE TEACHING`S SCIENCE AND CONTRIBUTION TO THE PROCESS OF LEARNING TEACHING-READING AND WRITTEN IN TRAINING OF THE CRITICAL AND AUTONOMOUS CITIZEN

Rosa Azevedo. Amazonas State University-Brazil
Evandro Ghedin. Amazonas State University-Brazil
Amarildo Gonzaga. Amazonas State University-Brazil

1. INTRODUCTION

The Teaching of Science in the elementary levels (last years)and High school have deserved some highlights, which can be found in the works of Delizoicov, Angotti and Pernambuco (2002), Cachapuz (2005), Nardi, Bastos and Diniz (2004), among others. Furthermore, the researches in relation to the Teaching of Science in the early years of elementary school have been decreasing.

Thus we propose to discuss the relevance of the Teaching of Science in the early years of elementary school, focusing particularly its contribution to the process of teaching-learning of reading and writing and the formation of a critical and autonomous citizen. We support this project with a bibliographic research that took two points: the first, selected works that treat the Teaching of Science in general scope, in the second, specific to the early years of elementary school. From the readings, produce reviews and notes that allowed direct the discussions, with the references Cachapuz, Praia and Jorge (2004), Brazil (1997), Delizoicov, Angotti and Pernambuco (2002), (Fumagalli (1998) among others.

The considerations we have developed on the Teaching of Science in the early years of elementary school do not give account of the complexity of this area and education level, represent only an attempt to locate some contributions and suggest ways to furthering studies.

2. OBSERVATIONS ON THE TEACHING OF SCIENCE IN THE EARLY YEARS OF ELEMENTARY SCHOOL

Currently the scientific knowledge and technology that enables it, is present in almost all the activities of daily life, influencing the style of life and the possibility of participation of individuals in society. This can be observed in the current language, in the media, in the children`s play and in many other situations of daily life, bringing consequences, especially for education.

This knowledge "presents, today, as the foundation of human knowledge. A great tool for the transformation of the contemporary world is undoubtedly the ownership and clever use of scientific knowledge "(Moura and VALE, 2003, p. 135).

These questions lead us to reflect on the importance of Teaching Science in the early years of elementary school, since students that level of education (6-10 years) are in a stage in which the logical thinking, objective, acquires preponderance. The child focuses less on himself/herself being able to build a knowledge more compatible with the world that surrounds (DAVIS and OLIVEIRA, 1994).

According to Fracalanza, Amaral and Gouveia (1986), the teaching of Science should help to develop logical thinking, the ability of observation, communication, reflection among others. These skills should be developed, from the elementary level, students giving opportunities to the students to discuss and review the questions dictated by society. Thus, "in a society in which coexists with the overestimating of scientific knowledge and with the increasing intervention of technology in day by day, it is not possible to think in the formation of a critical citizen on the sidelines of scientific knowledge" (BRAZIL, 1997, p. 23).

To refer to such training, Delizoicov and Angotti (1990) stated that to achieve it, at any schooling`s level, there should be a basic training in science to enable the student a better understanding of this society, and a conscious act on it. Such affirmative keeping with the goal proposed by the National Curricular Parameters for the teaching of basic science in school: "show the science as a knowledge that works for the understanding of the world and its transformations, to recognize the man as part of the universe and like individual "(BRAZIL, 1997, p. 23).

To Hurd (apud ROSA, 2006), this science involves issues of daily life of human beings, causing significant changes in society and requiring new behaviors that need of scientific and technological knowledge so that individuals feel members of society, regardless of schooling´s level.

In this way, Rosa (2006), talking with Adorno and Demo, says that the school needs the contribution of knowledge in Science and Technology for to help the, reflection, critical thinking, from the early years of school, so that individuals can get their own opinion in the most varied situations for a scientific text, a story, a environmental or social situation, among others.

In regard to the Teaching of Science in the early years, Signorelli (2001) draws attention to the difficulty pointed out by the majority of teachers on the teaching, with the explanation that students barely know how to write. To Amaral and Gouveia (1986), the Teaching of Science can contribute to the mastery of the techniques of reading and writing and at the same time, allow them to learn the basic concepts of this area of education.

In this point of view, Brazil (1997, p. 62) suggests that the subjects of science, by its nature and by scientific and technical allow different forms of expression, can be a great help, since "it is not only to teach reading and writing so that the students can learn science, but also make use of Sciences to learn to read and write".

In regard to this issue, Brandi and Gurgel (2002) have claimed that the articulation of the teaching of Science with the learning of reading and writing, it is still seen by many teachers as a problem. However, note that such education by enabling the exploration and understanding of social and natural environment can contribute to the insertion of the child to scientific culture. This implies that the teaching of Science as enables the student ownership of the concepts and procedures of Science,

[...] Can contribute to the question of what you will see and hear, for the expansion of the explanations about the phenomena of nature, to the understanding and evaluation of ways to intervene in nature and use its resources, to the understanding of the resources technological that perform these mediations, for reflection on implicit ethical issues in the relations among Science, Technology and Society. (BRAZIL, 1997, p. 24).

When positioning in relation to the teaching of basic science in school, Fumagalli (1998) contains three main points: 1) the right of children to learn science, as subjects that are members of society, and they know how to give meaning to the world that surrounds, 2) the duty of mandatory school social fundamental to spread scientific knowledge in an appropriate manner, 3) the social value of scientific knowledge, which should contribute to the training of critical individuals and aware of their actions.

This position highlights the need of Teaching Science to the formation of autonomous individuals, which does not make the rules imposed by society. Although most individuals make use and live with countless scientific and technological products, rarely reflects on the processes involved in its production and distribution, becoming limited to the commercial and media charges, which prevents making conscious choices (BRAZIL, 1997).

The Teaching of Science has become essential in regard to the citizenship`s practice, constituting in

> [...] Privileged space in which the different explanations of the world, the phenomena of nature and the changes produced by humans can be exposed and compared. Therefore when we consider the elementary school the level of compulsory schooling in Brazil, it can not be thinking in the teaching of science as a teaching propedêutico, turned into an effective learning in timefuture. The child is not citizen of the future, but it is citizen today, and, accordingly, knowing science is expanding its present possibility of social participation and facilitate its full capacity of social participation in the future (BRAZIL, 1997, p. 25).

Such arguments have shown the relevance of Teaching Science and the need of its organized and planned development, from school practices that give priority to this area of education, especially in the early years of elementary school.

3. FINAL CONSIDERATIONS

We have noted the teaching of science in the early years of elementary school, although acknowledged its importance in supporting the formation of the ethical, critical and independent citizen, and for a better understanding, not only of science and its nature, but also of its role in society today, it is still not considered as relevant in the early years of elementary school, and put some obstacle to their implementation, including difficulty in reading and writing of students that level of schooling.

However, the survey revealed that the Teaching of Science from the school can contribute not only vital for the development of reading and writing, but also for developing logical thinking, the ability of observation, communication, among others.

It still need to give opportunities to students of the early years of elementary school the right to learn science, as subjects that are members of society, and they know give meaning to the world that surrounds.

Thus, the Teaching of Science can set up as an area of knowledge and discussion about the world, the nature and the changes produced by man, thus providing the formation of a critical citizen who participate more effectively and with understanding of its action`s context.

4 REFERENCES

BRANDI, A. T. E.; GURGEL, C. M. do A (2002). Alfabetização científica e o processo de ler e escrever em séries iniciais: emergências de um estudo de investigação-ação. *Ciência e Educação,* São Paulo, v. 8, n.1, p. 113-125.

BRASIL. Secretaria da Educação Fundamental (1997). *Parâmetros curriculares nacionais:* ciências naturais. Brasília: MEC/SEF.

CACHAPUZ, A. et al. (Orgs.) (2005). *A necessária renovação do ensino das ciências.* São Paulo: Cortez.

CACHAPUZ, António; PRAIA, João; JORGE Manuela (2004). Da educação em ciência às orientações para o ensino das ciências: um repensar epistemológico. *Ciência e Educação,* São Paulo, v. 10, n.3, p. 363-381.

DAVIS, Claudia; OLIVEIRA, Zilma de. *Psicologia na educação* (1994). São Paulo: Cortez.

DELIZOICOV, Demétrio; ANGOTTI, José André (1990). *Metodologia do ensino de ciências*. São Paulo, Cortez.

DELIZOICOV, Demétrio; ANGOTTI, José André; PERNAMBUCO, Marta Maria (2002). *Ensino de ciências:* fundamentos e métodos. São Paulo: Cortez.

FRACALANZA, Hilário; AMARAL, Ivan Amorosino; GOUVEIA, Mariley S. Floria (1986). *O ensino de ciências no 1º grau***.** São Paulo: Atual.

FUMAGALLI, Laura (1998). O ensino de ciências naturais no nível fundamental da educação formal: argumentos a seu favor. In: WEISSMANN, Hilda (Org). *Didática das ciências naturais: contribuições e reflexões*. Porto Alegre: ArtMed, p. 13-29.

MOURA, Graziella R. Soares; VALE, José M. Ferreira do (2003). O ensino de ciências na 5ª e na 6ª séries da escola fundamental. In: NARDI, Roberto (Org.). *Educação em ciências:* da pesquisa à prática docente. São Paulo: Escrituras, p. 1 35-143.

NARDI, Roberto; BASTOS, Fernando; DINIZ, Roberto E. da Silva (Orgs.) (2004). *Pesquisas em ensino de ciências:* contribuições para a formação de professores. São Paulo: Escrituras.

ROSA, Cleci Werner da. A importância de discutir física nas séries iniciais (2006). Disponível em: <http://www.ciencia.hoje.pt/>. Acesso em: 15 jan. 2006.

SIGNORELLI, Vinícius. Ciências na escola (2007). Um salto para o futuro. Rio de Janeiro: TVE, 2001. Disponível em: < http://www.tvebrasil.com.br/salto/boletins2001>. Acesso em: 10 jan. 2007.

DETERMINATION OF STATE-TRAIT ANXIETY LEVELS OF UNIVERSITY STUDENTS DURING THE LEARNING PROCESS OF GLOBAL ENVIRONMENTAL PROBLEMS

Sami OLUK, Özlem ÖZÜREDİ, Tansel SAKACI
C.B.U. Education Faculty
University Street, 45900 Demirci-Manisa/Turkey
samioluk@gmail.com

▼ Abstract

This descriptive study has been done in order to determine anxiety levels of university students during the learning process of global environmental problems. The scope of the research is composed of 38 students. Data were collected via a State-Trait Anxiety Inventory. Trait Anxiety inventory was applied both before and after the study whereas, state anxiety inventory was conducted once before the study and after each week when the works on each heading was completed. While their levels of state anxiety increase during the learning process, no change was observed in their trait anxiety levels. It can be concluded that the process of learning about global enviromental problems had a significant impact on state anxiety levels of students.

Key Words State-Traıt Anxıety, Global learning, Environmental education.

INTRODUCTION

The fact that global environmental problems have a broad range of issues causes some problems in the process of learning as well. Confronting problems and dangers in the world is becoming an extremely difficult experience for the people. The lives of today's people, who are affected by this experience, are having a confused, fragmented, emotional, rebellious and stressful characteristic (Giddens, 1998). Studies have indicated that although many young people show an interest in and worry about global issues, this worry is often connected with feelings of pessimism, helplessness, and apathy (Connell et all., 1999). For many of the subjects worry was sometimes connected with a feeling of helplessness about the fact that it is very hard to reach concrete results when it comes to global environmental problems because they are so complex and so many diverse actors are involved on a global scale (Ojala, 2007). Recent studies show a decline in general psychological well-being, with increased levels of anxiety and depression, among students (Twenge, 2000). Slaughter (2007) indicated that age-old protective mechanisms of denial, avoidance and repression were in remarkably wide use even—perhaps especially—at the highest levels. Anxiety is the perception of reality of vanishing against existing. The anxiety levels of the students, who consider

global environmental problems as a danger which forces their existence and values to vanishing, will naturally rise. Recent researches have pointed out that mechanisms of learning and recalling are related to relatively permanent changes in the nervous system. Substances emitted in the brain during high level of concern prevent the protein chain, which is essential for learning, to be built, and therefore, increase the concern level and restricts learning partially causing failure (Baltaş 2004). Although a certain level of concern is necessary for learning, it is vitally important to adjust its ratio (Ankay 1990). Studies indicated that academic achievement of students has lessened as a result of increasing the levels of state-trait anxiety (Batumlu & Erden, 2007). At this point it is important an question to answer that which kinds of anxiety incrise during the learning process.

The purpose of the present study was to explore the state-trait anxiety levels of university students during the learning process of global environmental problems

METHOD

Subjects and Procedure

The study was conducted in Celal Bayar University, Faculty Of Education with participation of 39 students of 2006-2007 academic year. Sampling was done randomly. Eight headings of issues accepted global environmental problems such as ozone layer, acid rains, nuclear energy, rain forests, desertification, genetically modified organisms, climate change, green house effect, and global warming were discussed. Students were divided into 8 groups. Each week, one heading was handled and three hours were allocated for each discussion session. Issues of global warming and green house effect were taken under one heading and handled for two weeks. The nine week study plan was given to the students prior to the experiment. In the teaching process, which was generally run according to interactive model and group discussion method, other active learning techniques were also benefited from. Each heading was discussed under sub divisions as; definition of the problem; human factor in the emerging of the problem; effects of the problem on humans and other ecosystems and suggestions for solution respectively. After each heading was discussed in the groups, the groups shared results of their discussions with other groups through short presentations. During discussions, after four stages of sub-divisions, individual opinions of the students were gathered in a final general evaluation session. Group reports were written and attached on the boards, thus, sharing of information was made continuous. During the discussions communication between all groups was allowed. The learning environment was equipped with a board, internet, lap tops, a projection device and other stationary consumables. Prior to each heading started to be discussed, materials prepared by the researcher were handed out to the students.

Gathering the data

The data of the study was gathered through of State-Trait Anxiety inventory. Trait Anxiety inventory was carried out both before and after the study whereas, State

Anxiety inventory was conducted once before the study and after each week when the works on each heading was completed.

Trait Anxiety inventory requires from the individual to describe how he/she generally feels. For the ranking items expressed feelings and/or behaviors are marked according to their frequency as; (1) never, (2) sometimes, (3) often, (4) almost always. State Anxiety inventory requires from the individual to describe student's feelings at a certain moment and under a certain circumstance, in other words, he/she has to describe student's feelings caused by the momentary atmosphere he/she is in. State Anxiety inventory is a self-evaluation questionnaire which consists of short responds. In respond to ranking items, expressed feelings and behaviors are marked according to their intensity as; (1) never, (2) some, (3) much, (4) completely. In trait-state anxiety inventory, there are two types of expressions; direct expressions express negative feelings; reverse expressions express positive feelings. In state anxiety inventory items, 1,2,5,8,10,11,15,16,19 and 20 are reverse expressions. Reverse expressions in trait anxiety inventory are, items 21,26,27,30,33,36 and 39. After calculating total intensity of direct and reverse expressions separately, the total intensity value of the reverse expressions is subtracted from the total intensity value of direct expressions. The State-Trait Anxiety Inventory, developed by Spielberg et al (1970), which measures students' trait anxiety levels. The validity and reliability of the inventory in Turkey was made by Öner & Le Compte (1985). The validity of State anxiety inventory is between 0.83 and 0.87, and test-retest reliability is between 0.71 and 0.86. The validity in the other inventory is 0.94-0.96, and test-retest reability is 0.26-0.68.

Data analysis

Results of state anxiety inventory were analyzed with t test and those of trait anxiety inventory were analyzed using Wilcoxon Signed Ranks and Friedman test. The software SPSS 15 was used in analysis.

RESULT

Descriptive statistical results of the data obtained from state anxiety inventory are given in Table 1.

Table 1 Descriptive statistical results

	pretest	G1p	G2p	G3p	G4p	G5p	G6p	G7p	G8p
N	39	38	37	36	39	39	38	37	37
Mean	35,7	65,2	58,5	62,2	60,6	59,8	58,3	59,0	62,6
Std. Deviation	5,0	15,2	13,0	15,2	11,3	11,4	8,1	10,2	13,8
Minimum	25,00	42,00	31,00	25,00	40,00	41,00	31,00	39,00	27,00
Maximum	46,00	96,00	96,00	100,00	88,00	92,00	75,00	81,00	100,00

G. Global problem, G1. Ozon depletion, G2. Acid rains, G3. Nüclear power, G4.Desertification G5.Rain forest, G6.Genetically modified organism, G7.Green house and global warming, G8. Climate change, p:post-test.

Students received state anxiety points between arithmetic averages of 58-68 in terms of the type of global environmental problems. They also had points between 25 and 43 of minimum values; between 46 and 100 of maximum values; between 42 and 75 of the values that represent the gap between maximum and minimum values (Table 1). Considering the maximum (80) and minimum (20) points which can be received from state anxiety inventory, it can be stated that students generally had higher anxiety levels than the average during the learning process of global environmental problems. State anxiety is defined as an unpleasant emotional arousal in face of threatening demands or dangers (Spielberger, 1970). It could be said that learning about global issues affects the state anxiety levels of students.

To investigate the significance of the difference of the scores between the pre-test and post-test carried out following each week of the study, Wilcoxon Signed Ranks test was applied to the results. The results are given in Table 2.

Table 2 Results of Wilcoxon Signed Ranks test

	G1p - Pr	G2p - Pr	G3p - Pr	G4p - Pr	G5p - Pr	G6p - Pr	G7p - Pr	G8p - Pr
Z	-5,3	-5,0	-5,1	-5,4	-5,4	-5,2	-5,3	-5,2
p	,000	,000	,000	,000	,000	,000	,000	,000

Pr:Pretest

According to Table 2, the difference between the preliminary state anxiety scores and of the state anxiety scores obtained after each week of the study is meaningful. These findings show that state anxiety levels of the students raise during the learning process. Studies supported these results. Rogers & Tough (1996) indicate that Learning about global issues also involves an emotional response. Furthermore, Some students experienced a range of conflicting emotions, such as: elation/depression, hopefulness/hopelessness, fear/courage, sadness/happiness. Hicks, (2002), Hicks and Bord, (2001) stated that some students might get confused, some might have optimistic and some others might have pessimistic feelings, while confronting global environmental problems. Besides these, some students who were introduced with the scales of the future disasters which might occur because of global environmental problems drew a dark future scenario and stated that they wouldn't be able to do anything for the solution of the problems in that particular scenario (Oluk & Sakacı, 2007).

Freidman test was applied to see whether state anxiety scores differ depending on the type of global environmental problem. The results of Freidman test are given in Table 3.

Table 3 Result of Friedman Test

	Mean Rank		Mean Rank		Mean Rank
Gp8	5,07	Gp4	4,61	Gp6	4,06
Gp3	5,03	Gp5	4,39	Gp7	3,85
Gp1	4,92	Gp2	4,08		

(N=36, Chi-Square=9.654, df=7, p=,20)

Results of Freidman analysis show that difference of the student's scores between state anxiety scores according to the type of global environmental problem is insignificant (X^2= 9.654, p> 0.05). These results indicated that all global environmental problems have a similar affect on levels of state anxiety.

The t test was applied in order to investigate the significance of the difference between the preliminary trait anxiety scores and post-trait anxiety scores. The results are given in Table 4.

Table 4 t test results of scores Trait Anxiety

	N	Mean	sd	df	t	p
Pre test	36	55.1	9.4	35	.932	.338
Post test	36	56.1				

t test results show no significant difference between The students' pre-labour and post-labour levels of trait anxiety ($t_{(df=35)}$=. 932, p> 0.05). This result shows that learning process of global environmental problems doesn't change the level of trait anxiety. These results also show students' perceptions of global environmental problems.

CONCLUSION

The study examined the state-trait anxiety levels of university students during the learning process of global environmental problems. These findings indicate that the learning process of global environmental problems doesn't affect the trait anxiety of the students but affects their state anxiety levels. It is clear that the process of learning about global enviromental problems had a significant impact on this group of students. Issues of environmental damage are uncomfortable to deal with and it is this that adds an extra pedagogical dimension to learning about global issues.

REFERENCE

Ankay, A. (1990) İnsan ve Eğitim, Eğitim Psikolojisine Giriş, Ankara.

Baltaş, A. (2004) Üstün Başarı, Remzi Kitapevi, İstanbul.

Batumlu, D.,Z. & Erden, M. (2007). The Relatıonshıp Between Foreıgn Language Anxıety And Englısh Achıevement Of Yıldız Technıcal Unıversıty School Of Foreıgn Languages Preparatory Students. *Journal of Theory and Practice in Education*, 3 (1):24-38

Connell, S., Fien, J., Lee, J., Sykes, H., & Yencken, D. (1999). 'If it doesn't directly affect you, you don't think about it': aqualitative study of young people's environmental attitudes in two Australian cities, *Environmental Education Research,* 5 (1) 95–113.

Giddens, A. (1998). Risk society: The context of British politics. In J. Franklin (Ed.), *The politics of risk society* (pp. 23-34). Cambridge, MA: Polity.

Hicks, D (2002) Teaching about global issues: the need for holistic learning, in: Lessons for the Future: the Missing Dimension in Education, Routledge Falmer, London, (Chapter 10).