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EDITORIAL

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Welcome to the first issue of the third volume of Eurasia Journal of Mathematics, Science, and Technology Education (EJMSTE). Starting with current issue we have prepared and put in effect several changes in the web site and in the journal itself for you. The web site has a simpler interface for you to navigate within the journal issues. We now also have a search feature that utilizes Google's search engine within the journal web site only. You may enter any keyword, author name or phrase to search in the journal articles and web pages. Also, you'll easily notice that we now have a different page format for articles and a different typesetting. Also starting with the current volume we decided to make EJMSTE a quarterly journal in order to be able to allow more papers to be published annually. From now on the journal will be released in February, May, August, and November. We hope with these changes you'll enjoy EJMSTE more. Dr. M. Fatih Taşar, the Associate Editor of EJMSTE, has been very instrumental for making these changes possible. He put in a lot of effort and hard work that should be appreciated by all of us related to EJMSTE in some way.

We are delighted to notice that EJMSTE is becoming more and more popular around the globe since its launch in late 2005. Our aim is to reach more and more educators and researchers around the world and to assist them in fulfilling their self-development. On the other hand, the number of manuscripts submitted to the journal between 5 May 2005 and 31 January 2007 has reached **447**. We consider this number as a huge success for a young journal like ours. We had gone through considerable difficulty to decide and choose articles for publication. We thank the members of the editorial board for doing the hard work in reviewing manuscripts and providing feedback to both authors and the editorial office.

As you'll see there are 8 articles published in this issue. Authors are from 4 continents and 5 different countries. We appreciate their scholarly work and congratulate them for making it to the journal:

Reinders Duit (**Germany**), Serhat Irez (**Turkey**), Neset Demirci (**Turkey**), Effandi Zakaria (**Malaysia**), Zanaton Iskan (**Malaysia**), Erdogan Halat (**Turkey**), William Wanjala Toili (**Kenya**), Orhan Akinoglu (**Turkey**) and Ruhan Ozkardes Tandogan (**Turkey**), Joseph M. Furner (**USA**) and Carol A. Marinas (**USA**). Below you will find a brief description of each paper.

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Science Education Research Internationally: Conceptions, Research Methods, Domains of Research: This overview presents how science education research has played essential roles not only in analyzing the actual state of scientific literacy and the actual practice in schools but also in improving instructional practice and teacher education

Reflection-Oriented Qualitative Approach in Beliefs Research: This paper discusses the need for more reflection-oriented approaches in data collection and analysis in beliefs research. A research project assessing and analyzing beliefs about the nature of science is used as an example of such an approach and each step in data collection and analysis is presented in detail.

University Students' Perceptions of Web-based vs. Paper-based Homework in a General Physics Course: The main aim of this study was to determine students' perceptions toward web-based versus paper-based homework and identify any differences based on homework performance score and grade point average.

Promoting Cooperative Learning in Science and Mathematics Education: A Malaysian Perspective: The purpose of this article is to discuss the current shortcomings in science and mathematics education in Malaysia.

Reform- Based Curriculum & Acquisition of the Levels: The purpose of this study was to compare the acquisition of the van Hiele levels of sixth grade students engaged in instruction using a reform-based curriculum with sixth-grade students engaged in instruction using a traditional curriculum.

Secondary School Students' Participation in Environmental Action: Coercion or Dynamism? In this study focuses particularly on the nature and dynamics of students participation in environmental action within the framework of the established school curriculum.

The effects of Problem-Based Active Learning in Science Education on Students' Academic Achievement, Attitude and Concept Learning: The aim of this study was to determine the effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning.

Geometry Sketching Software for Elementary Children: Easy as 1, 2, 3: This paper discusses insights for using geometry sketching software to teach geometric concepts for kindergarten to grade 4. The authors created hands-on resources that incorporate technology in a user-friendly environment.

There are also two book reviews in this issue. Tolga Güyer has reviewed a report prepared by National Research Council of the National Academies (2006) which is entitled **ICT Fluency and High Schools: a Workshop Summary** published by National Academic Press. Charles Hutchison has reviewed Jack Hassard's (2005) **The Art of Teaching Science: Inquiry and Innovations in Middle and Secondary Schools** published by Oxford University Press. We would like to thank the book reviewers and the section editor. We will continue to publish reviews of books and important reports in the coming issues. Please consider submitting reviews also for publication in EJMSTE. In this way we can contribute to the dissemination of our colleagues' works and be well informed about them.

Please write and let us know what you think about EJMSTE. We will always appreciate your thoughts and comments and be glad to share them with our readers. Now, the time is to go through the pages of the journal. We hope you'll find EJMSTE as a valuable resource for yourself and consider contributing in the future in different capacities.

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Science Education Research Internationally: Conceptions, Research Methods, Domains of Research

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Disappointing results of international monitoring studies such as TIMSS (Third International Mathematics and Science Study) and PISA (Programme for International Student Assessment) have fuelled another general debate on the need for a sufficient level of scientific literacy and the necessity to improve the quality of science instruction in school. Science education research has played essential roles not only in analyzing the actual state of scientific literacy and the actual practice in schools but also in improving instructional practice and teacher education. A conception of science education research that is relevant for improving school practice and teacher education programs will be presented here. This conception is based on a Model of Educational Reconstruction which holds that science subject matter issues and students' learning needs and capabilities have to be given equal attention in quality development attempts. Further, research and development activities have to be intimately linked. It is argued that science education research drawing on this framework is an indispensable prerequisite for improving instructional practice and hence for the further advancement of scientific literacy.

Keywords: Science Education, International Perspectives, Research Conceptions, Research Methods, Research Domains

MULTIPLE REFERENCE DISCIPLINES OF SCIENCE EDUCATION

Science education is a genuinely inter-disciplinary discipline. Clearly, science is a major reference discipline but there are competencies in various other disciplines which are also needed (Figure 1).

Philosophy of science and history of science provide thinking patterns to analyze the nature of science critically, and the particular contribution of science to understand the "world", i.e. nature and technology. Pedagogy and psychology provide competencies to consider whether a certain topic is worth teaching and to carry out empirical studies whether this topic may be understood by the students. There are further reference disciplines that come into play also, such as linguistics

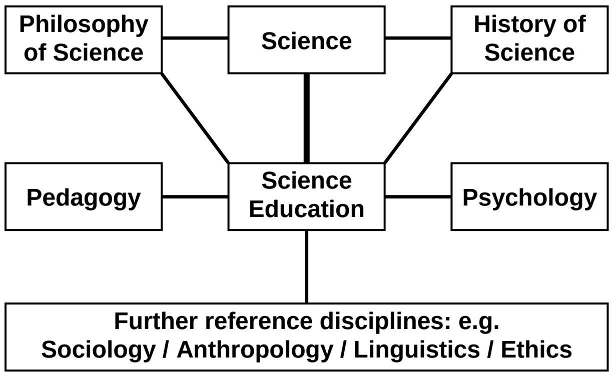

Figure 1. Reference disciplines for science education

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which may provide frameworks for analyzing classroom discourse or conceptualizing learning science as an introduction into a new language or ethics for framing instruction on moral issues.

The interdisciplinary nature of science education is responsible for the particular challenges to carry out science education research and development. Of course, sound competencies in science are necessary but also substantial competencies in a rather large set of additional disciplines. It is noteworthy that in principle, science teachers need the same broad spectrum of competencies as well. Moreover, for teachers to know science well is not sufficient to teach this subject. At least basic knowledge on the nature of science provided by philosophy of science and history of science as well as familiarity with recent views of efficient teaching and learning provided by pedagogy and psychology are necessary.

Shulman (1987) argued that teachers need a large spectrum of rather different competencies. His conception of "*content specific pedagogical knowledge*" (or briefly: PCK - Pedagogical Content Knowledge) has been widely adopted in science education (Gess-Newsome & Lederman, 1999). The idea is the following. Traditionally, in teacher education programs teachers are taught content knowledge and pedagogical knowledge. The link between the two kinds of knowledge, the content specific pedagogical knowledge, is usually missing. Shulman is of the opinion that this kind of knowledge, the PCK, is the major key to successful teaching. The conception of science education outlined in Figure 1 includes Shulman's idea of PCK. Linking competencies provided by the content domain and competencies from various other disciplines (among them especially pedagogy and psychology) is at the heart of the conception of science education discussed here.

A preliminary explication of the interdisciplinary discipline science education addressing these issues may read as follows:[1]

> *Science education is the discipline dealing with teaching and learning science in schools and outside schools. Science education research includes selection, legitimation and educational reconstruction of topics to be learned, selection and justification of general aims of teaching and learning science, as well as instructional sequencing that takes the learners' cognitive, affective and social preconditions into account. A further domain of science education work is research-based development as well as evaluation of teaching and learning approaches and materials.*

Clearly, the focus of this explication is research on actual teaching and learning situations. However, research on the various contexts in which the teaching and learning situation is embedded should also be included as will be more fully argued in a subsequent section.

TRADITIONS OF SCIENCE EDUCATION RESEARCH AND DEVELOPMENT

In a recent review of science education research, Jenkins (2001) distinguishes two different traditions in research within the past thirty years; he calls them *pedagogical* and *empirical*. "*The pedagogical tradition has, at its primary focus, the direct improvement of practice, practice here being understood as the teaching of science*" (p. 20). "*The empirical tradition, always much more evident in the USA than in Europe, has weakened considerably in the last thirty years. It is associated with positivism and seeks the 'objective data' needed to understand and influence an assumed educational reality, close familiarity with which lies at the heart of the pedagogical tradition*" (p. 21). Using chemistry education as his example Jenkins claims that the followers of the pedagogic tradition are those that teach chemistry in schools, colleges and universities, and who publish in journals like *Education in Chemistry* or *Journal of Chemical Education*. These researchers remain close to the academic discipline of chemistry and many of them "*would strongly resist any attempt to classify them as social, rather than natural, scientists*" (p. 21).

There is no doubt that this is a valuable distinction that indicates main "schools" of science education as a research discipline. It appears however that somewhat different emphases of the two schools' characteristics are necessary. Clearly, on the one side, there is a group of science education researchers who are close to the particular science domain. Their attention is not only near to teaching practice but they also put main emphasis on science content issues in designing new teaching and learning sequences. Sadly enough, however, quite frequently a balance between science orientation and orientation on the students' needs, interests and learning processes is missing. Further, research (especially empirical research on teaching and learning) and development are often badly integrated. On the other side, we find an emphasis on the students' needs in various respects and a strong emphasis on improvement of learning environments often accompanied by a neglect of science subject matter issues. A significant number of conceptual change approaches (Schnotz, Vosniadou, & Carretero, 1999) seem to fall into this category. One could summarize the distinction of the two traditions discussed by calling the one *science-oriented*, the other *student-oriented*. Progress in understanding and learning science appears only possible if there is a balance between the two perspectives. Successful design of science teaching and learning sequences needs to merge the two positions.

[1] This explication is based on a statement by a German association for content specific education (KVFF, 1998, 13f).

Peter Fensham (2001) who is well known for his contributions to a student-oriented science education (Fensham, 2000) points to the necessity of research on teaching and learning to rethink science content, to view it also as problematic[2] (and not only the way the content is taught) and to reconstruct it from educational perspectives. His considerations are integrated into a discussion on the continental European Didaktik tradition versus the Curriculum tradition (Hopmann & Riquarts, 1995). Whereas the curriculum tradition has a certain focus on Jenkins' (2001) *empirical* side and on what has been called *student orientation* above the Didaktik tradition tries to bring key features of the science-oriented and student-oriented sides into balance.

Also Dahncke, Duit, Gilbert, Östman, Psillos and Pushkin (2001) argue in favour of such an integrated view. They claim that the science education community so far has been split into the above two groups and that there are considerable clashes between the groups that even seriously hamper the progress that is so much needed. It is also pointed out that there are clashes between science education and the educational sciences, pedagogy and psychology, and between science education and school practice. They argue in favor of emancipation of science education from both the science reference domains *and* the educational sciences with a particular focus on improving school practice. Science education should be seen as an interdisciplinary research domain in its own right as outlined here in Figure 1.

Psillos (2001) also points to the significance of this conception of science education. He distinguishes three "modes" of research. The *practical* mode denoting issues of the actual classroom, the *technological* mode addressing policy makers' attempts to improve science education, and finally the *scientific* mode representing science education as a research domain in its own right. He argues "*that it is necessary to link the major concerns of all three modes in order to meet the various difficulties of improving science teaching and learning*" (Psillos, 2001, 11).

It is common sense among science educators that improving practice is the primary aim of science education research. However, Millar (2003) is of the opinion, drawing also on arguments by Jenkins (2001), that much research is restricted to "what works in practice". He claims: "*The role of research is not only to tell us 'what works'. Some of the most valuable research studies have been ones that made people aware of problems in current practices. Research can inform practice in a range of ways that stop short of providing clear and definite answers: by providing the kinds of insights that enable us to see the familiar in a new way, by sharpening thinking, by directing attention to important issues, by clarifying problems, challenging established views, encouraging debate and stimulating curiosity*" (Millar, 2003, 7-8).

[2] s. also Fensham, Gunstone, and White (1994)

The conception of science education research outlined in the subsequent sections draws on such a more inclusive idea of improving practice.

THE MODEL OF EDUCATIONAL RECONSTRUCTION

The Model of Educational Reconstruction (Duit, Gropengießer, & Kattmann, 2005) presented in Figure 2 may provide a deeper insight into the interdisciplinary nature of science education research as has been outlined so far. The model has been developed as a theoretical framework for studies as to whether it is worthwhile and possible to teach particular areas of science. It draws on the need to bring science content related issues and educational issues into balance when teaching and learning sequences are designed that aim at the improvement of understanding science and hence may foster the development of sufficient levels of scientific literacy.[3] The model can also be used to structure teacher education attempts as teachers may also be viewed as learners. Furthermore, it provides a framework for the conception of science education research outlined above.

The model is based on the German educational tradition of "Bildung" and "Didaktik" (Westbury, Hopmann, & Riquarts, 2000). Both terms are difficult to translate into English properly. A literal translation of *Bildung* is formation. In fact *Bildung* is viewed as a process. *Bildung* stands for the formation of the learner as a whole person, i.e. for the development of the personality of the learner. The meaning of *Didaktik*[4] is based on the conception of *Bildung*. It concerns the analytical process of transposing (or transforming) human knowledge (the cultural heritage) like domain specific knowledge into knowledge for schooling which contributes to the above formation (*Bildung*) of young people. Briefly put, the content structure of a certain domain (e.g. physics) has to be transformed into a

[3] The Model of Educational Reconstruction has been developed in close cooperation of Ulrich Kattman (University of Oldenburg), Harald Gropengießer (University of Hannover) as well as Reinders Duit and Michael Komorek (IPN Kiel) (Kattmann, Duit, Gropengießer, & Komorek, 1995). A brief overview of the model is presented by Duit, Kattmann and Gropengießer (2005). The model has been the frame of various projects at the IPN in Kiel, e.g. on the educational reconstruction of non-linear systems (Komorek & Duit, 2004). At the University of Oldenburg the model serves as theoretical framework of a science education graduate student program: http://www.diz.uni-oldenburg.de/forschung/ProDid/Prodid-Programm-E.htm.

[4] It is essential to take into consideration that the word "didactic" if used in educational concerns in English has a much more narrow meaning than the German "Didaktik". Didactic (or didactical) merely denotes issues of educational technology.

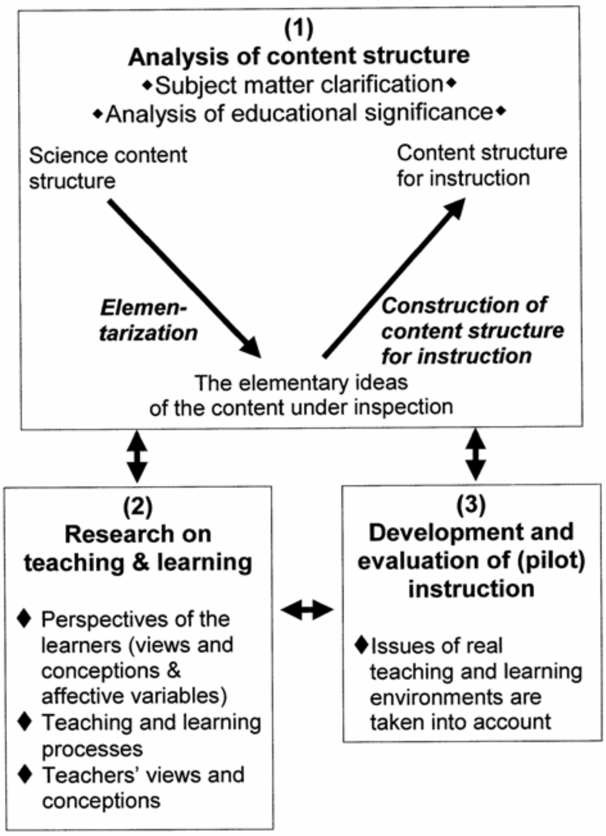

Figure 2. The Model of Educational Reconstruction

content structure *for* instruction. The two structures are substantially different. The science content structure for a certain topic (like the force concept) may not be directly transferred into the content structure for instruction. It has not only to be simplified (in order to make it accessible for students) but also enriched by putting it into contexts that make sense for the learners. Two phases of this process may be differentiated. The first may be called "elementarization". On the basis of this set of elementary ideas the content structure for instruction is constructed. It is a key claim of the *Didaktik* tradition that both processes "elementarization" and "construction of the content structure for instruction" are intimately interrelated to decisions on the aims of teaching the content and the students' cognitive and affective perspectives (Figure 2). These perspectives include students' pre-instructional conceptions and their general cognitive abilities on the one hand and their interests, self-concepts and their attitudes on the other.

Key features of the German *Didaktik* tradition that have been adopted in the Model of Educational Reconstruction will be briefly outlined in the following. A major reference position is the "Educational Analysis" (*Didaktische Analyse*) by Klafki (1969). His ideas rest upon the principle of primateship of the aims and intentions of instruction. They are framing the educational analysis – as is also the case in the model presented in Figure 2. At the heart of the educational analysis are the five questions presented in Table 1. They also play a significant role in our model.

Another significant figure of thought within the German *Didaktik* tradition adopted in the Model of Educational Reconstruction is the idea of a fundamental interplay of all variables determining instruction presented in Figure 3.

The Model of Educational Reconstruction is embedded within a constructivist epistemological framework (Philips, 2000; Duit & Treagust, 1998, 2003; Widodo, 2004). There are two key facets of this epistemological orientation. First, learning is viewed as students constructing their own knowledge on the grounds of the already existing knowledge. The conceptions and beliefs students bring into instruction are not seen primarily as obstacles of learning but as points of departure for guiding them to the science knowledge to be achieved (Driver, & Easley, 1978). Second, also science knowledge is seen as human construction (Abd-El-Khalick, & Lederman, 2000). We presume that there is no "true" content structure of a particular content area. What is commonly called the science content structure (e.g. in Figure 2) is seen as the consensus of a particular science community. Every presentation of this consensus in the leading textbooks, is an idiosyncratic reconstruction of the authors informed by the specific aims they explicitly or implicitly hold (Kattmann, Duit, Gropengießer, & Komorek, 1995). Consequently, also the science content structure for instruction (Figure 2) is not simply "given" by the science content structure. It has to be constructed by the curriculum designer or the teacher on the grounds of the aims affiliated with teaching the particular content. In other words, the science content structure has to be reconstructed from educational perspectives. That is the very essence of the term "educational reconstruction".

Many teachers and also science educators think that the content structure for instruction has to be "simpler" than the science content structure in order to meet students' understanding. Accordingly, they call the process of designing the content structure for instruction "reduction". However, this view misses the point. In a way the content structure for instruction has to be much more complex than the science content structure in order to meet the needs of the learners. It is, namely, necessary to embed the abstract science knowledge into various contexts in order to address learning potentialities and difficulties of the learners.

Table 1. Key questions of Klafki's (1969) Educational Analysis (Didaktische Analyse)

(1) What is the more general idea that is represented by the content of interest? What basic phenomena or basic principles, what general laws, criteria, methods, techniques or attitudes may be addressed in an exemplary way by dealing with the content?
(2) What is the significance of the referring content or the experiences, knowledge, abilities, and skills to be achieved by dealing with the content in students' actual intellectual life? What is the significance the content should have from a pedagogical point of view?
(3) What is the significance of the content for students' future life?
(4) What is the structure of the content if viewed from the pedagogical perspectives outlined in questions 1 to 3?
(5) What are particular cases, phenomena, situations, experiments that allow making the structure of the referring content interesting, worth questioning, accessible, and understandable for the students?

Intentions (aims and objectives)	**Topic of instruction** (content)	**Methods** of instruction	**Media** used in instruction
Why	**What**	**How**	**By What**
Students' intellectual and attitudinal preconditions (e.g., pre-instructional conceptions, state of general thinking processes, interests and attitudes)		**Students' socio-cultural preconditions** (e.g., norms of society, influence of society and life on the student)	

Figure 3. On the fundamental interplay of instructional variables (Heimann, Otto & Schulz, 1969)

There are three intimately linked components of the Model of Educational Reconstruction (Figure 2).

(1) Analysis of content structure[5] includes two processes which are closely linked, *clarification of subject matter* and the *analysis of educational significance.* Clarification of subject matter draws on content analyses of leading textbooks and key publications on the topic under inspection but also may take into account its historical development. Interestingly, also taking students' pre-instructional conceptions into account that have often proven not to be in accordance with the science concepts to be learned (Driver, & Erickson, 1983) contribute to more properly understanding the science content in the process of subject matter clarification. Experiences show that the surprising and seemingly "strange" conceptions students own may provide a new view of science content and hence allows another, deeper, understanding (Kattmann, 2001; Duit, Komorek, & Wilbers, 1997). Traditionally, science content primarily denotes science concepts and principles. However, recent views of scientific literacy (Bybee, 1997) claim that also science processes, views of the nature of science and views of the relevance of science in daily life and society should be given substantial attention in science instruction (Osborne, Ratcliffe, Millar, & Duschl, 2003; McComas, 1998). All these "additional" issues also need to be included in the process of educational reconstruction.

(2) Research on teaching and learning comprise empirical studies on various features of the particular learning setting. Research on students' perspectives including their pre-instructional conceptions and affective variables like interests, self-concepts and attitudes play a particular role in the process of educational reconstruction. But many more studies on teaching and learning processes and the particular role of instructional methods, experiments and other instructional tools are also available. Furthermore, research on teachers' views and conceptions of the science content and students learning are an essential part.

(3) Development and evaluation of instruction concerns the design of instructional materials, learning activities, and teaching and learning sequences. The design of learning supporting environments is at the heart of this component. The design is, first of all, structured by the specific needs and learning capabilities of the students to achieve the goals set. Various empirical methods are employed to evaluate the materials and activities designed, such as interviews with students and teachers, e.g. on their views of the value of the designed items, questionnaires on the development of students' cognitive and affective variables, and also analyses of video-documented instructional practice. Development of instructional materials and activities as well as research on various issues of teaching and learning science are intimately linked (Duit, & Komorek, 2004).

[5] It may be worthwhile to briefly explain the term "content structure". Content denotes science subject matter, structure points to the significance of the internal structure of the content.

The Model of Educational Reconstruction presented here shares major features with other recent models of instructional design that aim at improving practice. First of all, the cyclical process of educational reconstruction, i.e. the process of theoretical reflection, conceptual analysis, small scale curriculum development, and classroom research on the interaction of teaching and learning processes is also a key concern of the conception of "*developmental research*" presented by Lijnse (1995).

In the field of educational psychology there has been an intensive discussion on whether results of research on teaching and learning are suited to improve instructional practice. Kaestle (1993) published an article with the title "*The awful reputation of educational research*". Wright (1993) asked a similar question, namely "*The irrelevancy of science education research: perception or reality?*" The major argument in both cases was that the particular culture of educational research or science education research, respectively, dominating in the scientific communities is responsible for research results that are not relevant for improving instruction. An intensive discussion as a reaction to these statements substantially contributed to a turn from pure towards applied educational research (Gibbons et. al., 1994; Vosniadou, 1996; Cobb, Confrey, di Sessa, Lehrer, & Schauble, 2003). It has been argued that "*Design Research*" (Cobb et al., 2003) is needed to bridge the gap between research on teaching and learning and instructional practice. Design Research intimately links research and development and also explicitly takes instructional practice into account – in much the same way as the Model of Educational Reconstruction.

This model has not only proven to be a fruitful framework for instructional planning and design but also for teacher professional development. Issues comprising "thinking within the framework of the model" are also seen as essential in attempts to improve teachers' thinking and acting in class (West & Staub, 2003; Kattmann, 2004; Duit, Komorek, & Müller, 2004).

DOMAINS OF SCIENCE EDUCATION RESEARCH

The Model of Educational Reconstruction presented in the previous section allows the identification of three major domains of science education research.

(1) Analysis of Content Structure

There are two processes closely linked, namely *subject matter clarification* and *analysis of educational significance*. It has to be taken into account that content is used here in a more inclusive way as it is usually the case. Not only science concepts and principles but also science processes, views of the nature of science, and views of the relevance of science for society are seen as essential parts of science content.

Research methods for subject matter clarification (concerning the above set of content issues) are analytical (or hermeneutical) in nature, and certain methods of content and text analyses prevail. History and philosophy of science issues come into play here.
Analysis of educational significance will also be analytical in nature, i.e. drawing on certain pedagogical norms and goals. However, in projects on educational reconstruction of large domains empirical studies on the educational significance may be also empirical, e.g. by employing questionnaires to investigate the views of experts (cf. Komorek, Wendorf, & Duit, 2003) or variants of Delphi studies (Osborne, Ratcliffe, Millar, & Duschl, 2003).

(2) Research on Teaching and Learning

This is by far the largest research domain in science education. Most studies published in the leading international journals of science education fall into this domain. Major issues researched are: (a) *student learning* (students' pre-instructional conceptions, representations and beliefs, conceptual change; problem solving; affective issues of learning, like attitudes, motivation, interests, self-concepts; gender differences); (b) *teaching* (teaching strategies; classroom situations and social interactions; language and discourse); (c) *teachers' thinking and acting* (teachers' conceptions of science concepts and principles, science processes, the nature of science; their views of the teaching and learning process; teacher professional development); (d) *instructional media and methods* (lab work; multi-media; various further media and methods); (e) *student assessment* (methods to monitor students' achievement and the development of affective variables).

A large spectrum of methods of empirical research are employed ranging from qualitative to quantitative nature, including questionnaires, interviews and learning process studies. Drawing on methods developed in social sciences (like psychology) and close cooperation with social scientists in developing methods that address science education research needs has proven essential.

Various epistemological perspectives have been used with variants of constructivist views (Tobin, 1993; Steffe & Gale, 1995; Duit & Treagust, 1998; Phillips, 2000;) predominating. But also Piagetian views have played significant roles (Bliss, 1995). More recently, variants of social cultural views drawing, e.g., on Vygotsky (Leach & Scott, 2002) or activity theory (Roth, Tobin, Zimmermann, Bryant, & Davis, 2002) have gained considerable attention.

(3) Development and Evaluation of Instruction/ Instructional Design

As mentioned in the above section on traditions of science education research and development, there are still science education development activities that are not well based on research. It appears that much development work still does not take notice of research findings. The position underlying the Model of Educational Reconstruction points to three significant issues. First, development needs to be fundamentally research based and needs serious evaluation employing empirical research methods. Second, development should be viewed also as an opportunity for research studies to be included. Third, improving practice is likely only if development and research are closely linked.

(4) Research on Curricular Issues and Science Education Policies

The Model of Educational Reconstruction provides a framework for instructional design. Basically, features of the teaching and learning situation are addressed. The wider context of the learning environment, however, is not explicitly taken into account. Therefore, a further domain of science education research has to be added.

This domain concerns features of the educational system in which science instruction is embedded. Research here concerns decisions on the curriculum, on aims and contents of science instruction as well as on implementation, evaluation and dissemination of innovations introduced into the school system. Research on scientific literacy, standards, systemic reforms (quality development) and teacher professional development have become much researched sub-domains in science education the past years. Also international monitoring studies like TIMSS (Third International Science and Mathematics Study; Beaton et al., 1996) and PISA (Programme for International Student Assessment; OECD-PISA, 2005) have to be mentioned here. On the one hand, they provide a large set of data that have been also interpreted from science education perspectives. On the other hand these studies have revealed serious deficits of science instruction in many countries and incited various large scale attempts worldwide to improve science teaching and learning (Beeth, et al., 2003) as also outlined in Figure 4.

Figure 4 also displays that science education research is one of many "players" in attempts to improve science instruction. A close cooperation with the other players is absolutely essential. This also concerns cooperation with the reference disciplines pedagogy and psychology in Figure 1. To carry out science education research not only requires drawing on theoretical frameworks and research methods of these reference domains but it also has proven rather fruitful to carry out joint research projects where mutual interests exist. Research on teaching and learning a particular content, for instance, may only foster improvement of practice if the above content specific considerations are taken into account – that also holds for research carried out by educational psychology.

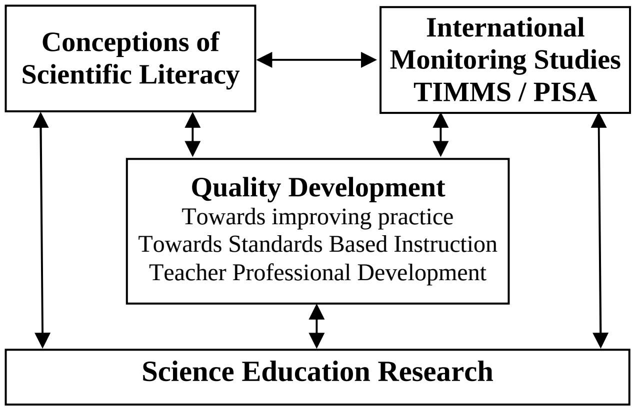

Figure 4. Present large scale attempts to improve science instructional practice

MAJOR FOCUSES OF SCIENCE EDUCATION RESEARCH

It is beyond the scope of the present paper to provide a fine grained picture of the research domains and sub-domains that have been given major emphases. As mentioned above, research on teaching and learning has been given major emphases in science education research for a long time. Students' learning was in the focus in the 1980s, later various issues of teachers' conceptions were also taken into account (Duit, & Treagust, 1998). In the 1980s students' learning of concepts and principles was given by far the most attention. It was only in the 1990s when views of the nature of science really developed to become a significant field of research (McComas, 1998). Constructivist views of teaching and learning have developed towards the dominant epistemological foundation of research on teaching and learning – with certain variants of "radical constructivism" at the outset and more inclusive views of "social constructivist" perspectives later (Duit, & Treagust, 1998).

In general, science education research has developed substantially in the past decades (cf. White, 2001). Science education has grown to a truly international community with the number of researchers still increasing. Interestingly, the percentage of female researchers has also increased substantially (White, 2001, 465). The number of journals is still rising, the number of issues per year of the journal has grown also substantially[6], the same is true for the number of international conferences and books. As a result, it has become rather difficult to maintain an overview of research domains and emphases. It appears, however, that major emphases are now on improving practice, i.e. on the development of powerful teaching and learning environments and teacher professional development as displayed in Figure 4. More recently available video-based studies on actual instructional practice, i.e. on the interplay of teaching and learning processes have provided powerful empirical foundations for both quality development of instruction and teacher professional development (Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999; Roth et al., 2001; Duit et al., 2005). Anderson and Helms (2001) claim that more studies on the actual teaching and learning practice are urgently needed.

This claim is in accordance with the above argument that in order to improve practice, research should not be restricted to studies on what works in practice (Millar, 2003) but should include studies on the actual state of instructional practice that may inform policy makers, curriculum developers and instructional design of more efficient instructional approaches. It appears that the more recent developments outlined allow us to address this issue.

CONCEPTIONS OF SCIENCE EDUCATION RESEARCH

"*As a research domain science education is diverse, methodologically, conceptually and institutionally*"(Jenkins, 2001, 22). The above sections have shown the rich variety of conceptions in the field. In the following major attempts to review the field are briefly discussed. A particular issue will be to point out in which respects the conceptions differ from the conception developed on the grounds of the Model of Educational Reconstruction presented.

The state of the art is marked by handbooks on science education. The "*Handbook of Research on Science Teaching and Learning*" edited by Gabel (1996) and the "*International Handbook of Science Education*" edited by Fraser and Tobin (1998) appeared in the 1990s. Whereas the focus of the handbook by Gabel is research in North America, the handbook by Fraser and Tobin provides a wider international perspective. Interestingly, in both handbooks a conception of science education research is not explicitly developed. The choice of the domains presented in the chapters of the handbooks is justified on pragmatic grounds by claiming that the structure resulted from a brainstorming of the members of the editorial board (Gabel, 1996, ix) or from a consensus of the editors (Fraser & Tobin, 1998).

Jenkins (2001, 23-24), as already mentioned above, is of the opinion that "*the subsequent chapters of the Handbook* (by Fraser and Tobin), *despite their diversity, seem to assume that science education as a field of activity is exclusively concerned with practice of teaching and learning, together with supporting activities such as assessment, evaluation and teacher education. Correspondingly, research in science education is about improving practice, whether this relates to promoting greater equity, making more effective use of educational technology or developing more informative instruments for formative, diagnostic or summative evaluation. This is a view of research in science education with a long history and it is one that is strongly influenced by the empirical tradition that has dominated science education in the USA throughout the twentieth century*".

It appears that this appraisal also holds for the handbook edited by Gabel (1995). At least in both handbooks the major emphasis is on "what works" (in the above sense of Millar, 2003). Other means of improving practice that are addressed in the conception presented here (e.g. in figure 4) are given less attention. The conceptions of the two handbooks differ in another respect from the conception presented here. Issues of research indicated by "Analysis of content structure" above at best play a marginal role in the chapters of the handbooks. The recent "*Handbook of Research on Science Education*" edited by Abell and Lederman (2007a) provides an international perspective of the actual state of research. However, authors from various countries were asked not only to provide a review of what was done in the particular field they are analyzing but also to present a view of major issues that would need further research in future. There are five major sections and 40 chapters in total. Figure 5 provides an overview of the contents of the chapters of this handbook and hence allows a view at the emphases of actual science education research as seen by the editors. The introductory chapter (Abell & Lederman, 2007b) outlines a conception of science education research that appears to be close to the conception presented here on the grounds of the Model of Educational Reconstruction. Drawing on the above mentioned PCK position of Shulman (1987) subject matter issues and pedagogical issues are, for instance, given equal attention. Further, a major concern is improving practice in the above wider sense demanded by Millar (2003). They explicitly claim that the handbook is written for researchers but that it is the duty of the researchers to interpret and transform its contents for other stakeholders, among them teachers.

[6] White (2001, 463) provides data that also the length of articles in the leading journals has increased substantially (from about 7 pages in 1975 to about 15 pages in 1995) due to a change of style of research from experimental towards descriptive studies. Accordingly, the increase of the number of studies published in the journals is only small (about 10%).

Science Learning
- Perspectives of science learning
- Student conceptions and conceptual learning in science
- Language and science learning
- Attitudinal and motivational constructs in science learning
- Classroom learning environments
- Learning science outside of schools

Culture, Gender, Society, and Science Learning
- Science education and student diversity: Race/ethnicity, language, culture, socioeconomic status
- Postcolonialism, indigenous students, and science
- Issues in science learning: An international perspective
- Special needs and talents in science learning
- Gender issues in science education research
- Science learning in urban and rural settings

Science Teaching
- General instructional methods and strategies
- Science laboratories
- Discourse in science classrooms
- Technology and Science classroom inquiry
- Elementary science teaching
- Interdisciplinary science teaching
- Biology / Chemistry / Physics / Earth Science Teaching
- Environmental education

Curriculum and Assessment in Science
- Science Literacy
- History of curriculum reform in science education
- Scientific inquiry and the science curriculum
- Research on the nature of science
- Perspectives in the science curriculum
- Systemic reform in science education
- Science program evaluation
- Classroom assessment of science learning
- Large scale assessment in science education

Science Teacher Education
- Science teacher as learner
- Science teacher attitudes and beliefs
- Research on science teacher knowledge
- Learning to teach science
- Teacher professional development in science
- Science teachers as researchers

Figure 5. Sections and chapters of the "Handbook of Science Education Research" edited by Abell and Lederman (2007a)

As part of the "Handbook on Teaching" edited by the American Educational Research Association (AERA) White (2001) provides a review of the development of science education as a research field in its own right during the past three decades. He points to major changes of research emphases with a particular focus on the "style" of research carried out. Style includes features of epistemological perspectives of teaching and learning and research methods employed. White (2001, 465) claims that *"at the beginning of this period* (1975)*, most studies of teaching were evaluations of predetermined method, developed and controlled by the researcher. Often the method of interest to the researcher was termed "experimental" and was compared with another less favored methods, which was then termed "control". Each was taken to be representative of a class of similar methods. Researchers intended that teachers and curriculum designers would note their conclusions about the methods and apply them. Largely, they were disappointed. Eventually, this disappointment spurred the revolution. Researchers realized that for their studies to influence practice they must take account of the complex nature of teaching and learning. They turned to describing the complexity in order to understand it before trying to manage it"*. Hence, White argues that explicating the complexity of teaching and learning in descriptive manner has become the major research method in science education. But he also points out that this explication is incomplete as education is interventionist, i.e. needs to discover how to intervene effectively. Therefore, *"the next phase of the revolution could see the return of experiments in a more subtle and complex character than those of the earlier period"* (White, 2001, 467). It appears that this kind of research is a major concern of the present large scale attempts to improve science instruction practice outlined in Figure 4 above. An interesting figure of thought is White's (2001, 467) claim for research on research. He argues that it is essential to know the long-term influences of research on curricula, the nature of texts, teaching methods, and also in which way teachers value the role of research for their practice.

Conceptions of science education research from a different vantage point are discussed by Fensham (2004). Based on interviews with about 75 science educators from around the world he provides an overview of the development of the actual rich variety of conceptions for science education research.

His analysis includes the following three perspectives: (1) the identity of science education as a research field, (2) the researcher as person, and (3) trends in research. He also developed a set of categories to interpret the interviews with researchers on the background of a review of the development of science education research during the past decades. These categories (Figure 6) are explicitly justified on the idea of science education as an interdisciplinary field of research as presented by Dahncke et al. (2001) who draw on the conception outlined in Figure 1 above. It is interesting that the only outcome criteria are implications for practice which is also in line with the emphasis of the conception of science education research presented here. As the intention of Fensham's analyses is to investigate the variety of the different conceptions within the research community it is difficult to briefly summarize major features displayed in the book here.

Structural Criteria
- S1: Academic recognition
- S2: Research journals
- S3: Professional associations
- S4: Research conferences

Intra-Research Criteria
- R1: Scientific knowledge
- R2: Asking questions
- R3: Conceptual and theoretical development
- R4: Research methodologies
- R5: Progression
- R6: Model publications
- R7: Seminal publications

Outcome Criteria
- O1: Implications for practice

Figure 6. Criteria for analyzing science education as a research field (Fensham, 2004)

An overview explicitly based on a close cooperation between science educators and cognitive psychologists is the "Framework for Empirical Research on Science Teaching and Learning" in a review article by Fischer, et al. (2005). The review is based on a "Framework Model of the Analysis of Students Performance" developed by Baumert et al. (2002) for the purpose of interpreting the results of the international monitoring study PISA. This model includes issues on the actual teaching and learning situation but also the influence of variables from contexts in which teaching and learning in schools is embedded. Another major framework is the "Basis-Model" theory of Oser and Patry (1994). According to this theory teachers use a limited number of basis models (such as: learning by experience; conceptual change; problem solving; top-down learning; learning to negotiate). Hence this model may be used to describe teachers' classroom behavior adequately. Of course, a comprehensive overview may not be provided in a single review article. However, valuable insights may be gained, especially from issues (like integration and sequencing of content) that are usually not addressed in the handbooks. Concerning the significance of content issues, Fischer et al. (2005, 334) come to the conclusion that purely content driven approaches do not lead to improving instructional practice. This finding may be seen as a support of the assumption of the Model of Educational Reconstruction and hence of the conception of science education research presented here that content issues and educational issues have to be carefully linked.

Finally, the actual state of empirical research on teaching and learning science with a particular emphases on research oriented towards constructivist perspectives is provided by the bibliography STCSE (Students' and Teachers' Conceptions and Science Education; Duit 2006).

SUMMARY

A conception of science education research that is relevant for improving instructional practice has been presented in the previous sections. It turned out that science education research with this aim needs to draw on a rather large spectrum of competencies from various disciplines and demands to bring content issues and issues concerning learning this content into balance. The Model of Educational Reconstruction discussed provides a frame for research that allows us to address the aim of improving practice. Various facets comprise science education with this orientation. Four major domains of science education research are distinguished:

- *Analysis of content structure*
- *Research on teaching and learning*
- *Development and evaluation of instruction / Instructional design*
- *Research on curricular issues and science education policies*

Duit and Tiberghien (2005) suggested a (preliminary) set of key issues of science education research that may provide an additional overview of the various facets to be taken into account in science education research:

1. *Conceptions of science education as a research domain*
2. *Epistemological and ontological views of science*
3. *Epistemological views of teaching and learning science*
4. *Research methods*
5. *Aims of science instruction / Legitimisation*
6. *Gender and equity issues*
7. *Content of science instruction*
8. *Teaching and learning science*
9. *Teacher professional development*
10. *Assessment and evaluation*
11. *Instructional design*
12. *Curricular issues and science education policies*

These 12 issues provide a framework both for planning research in science education and for analysing research presented in the literature. As more fully discussed above, science education as an academic discipline should be characterized by the following facets:

- Scien*ce education is an interdisciplinary discipline (Figure 1) aiming at improving teaching and learning in various practices.*
- *In order to actually facilitate improving practice, research should not be restricted on investigating what works but should also include studies on the major problems and deficits of normal instructional practice.*
- *Science educators need multiple competencies in science and in a substantially large number of reference disciplines (Figure 1).*
- *Science education research has to link science subject matter issues as well as pedagogical and psychological issues.*
- *Research and development are closely linked and are embedded within an elaborated curricular context. Major emphasis is applied research, e.g. in the sense of design research.*

Science education research oriented towards theses characteristics provides prerequisites for actually improving instructional practice. However, an additional issue has to be given serious attention. Improvement of teacher competencies and quality of instruction is always due to an intimate interplay of many variables. Improvement of student achievement may, for instance, not be expected if chiefly one variable is changed, e.g. new experiments or computer simulations are introduced. Such simple actions usually do not work.

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Reflection-Oriented Qualitative Approach in Beliefs Research

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Teacher beliefs have become important constructs in educational research with the recognition that beliefs are the best indicators of teachers' planning, decision-making and subsequent classroom behaviour. In this movement many probes and strategies have been employed by researchers for effective data collection and analysis. This paper discusses the need for more reflection-oriented approaches in data collection and analysis in beliefs research. A research project assessing and analyzing beliefs about the nature of science is used as an example of such an approach and each step in data collection and analysis is presented in detail. In addition, this paper also presents an example of how technology (Internet-Mediated-Interviews) can be used in data collection and discusses strengths and shortcomings of this approach.

Keywords: Educational Research, Nature of Science, Qualitative Research, Reflection, Teacher Beliefs, Technology

INTRODUCTION

Since the mid-1980s, research on teaching and teacher education has shifted dramatically from a focus on behaviours to an interest in cognition (Richardson, 1996) with the recognition that teachers' ways of thinking and understanding are vital components of their practice (Clark & Peterson, 1986; Nespor, 1987). With this shift, attitudes and beliefs have become important concepts in understanding teachers' thought processes, classroom practices, change, and learning to teach (Richardson, 1996). Although attitudes received considerable attention in the mid-century, teacher beliefs has only gained prominence in the education literature in the last three decades (Richardson, 1996). It is now accepted that research into teachers' beliefs can inform educational practice in ways that prevailing research agendas have not and cannot (Pajares, 1992). This view is based on the assumption that beliefs are the best indicators of the decisions individuals make throughout their lives, or more specifically, teachers' beliefs affect their planning, decision-making, and subsequent classroom behaviour.

Dewey (1933) was amongst the first to realise the importance of beliefs in education. He described belief as the third meaning of thought, 'something beyond itself by which its value is tested; it makes an assertion about some matter of fact or some principle of law' (p.6). According to him beliefs are crucial, for 'it covers all the matters of which we have no sure knowledge and yet which we are sufficiently confident of to act upon and also the matter that we now accept as certainly true, as knowledge, but which nevertheless may be questioned in the future' (p.6).

Since then, many researchers and theorists have contributed to the efforts to define the nature of beliefs (e.g. Clark & Peterson, 1986; Nespor, 1987; Kagan, 1992; Pajares, 1992; Richardson, 1996). The contributions of such researchers and many others helped to reach a consensus on the nature of beliefs. Accordingly, beliefs are psychological constructs that: (a) include understandings, assumptions, images, or propositions that are felt to be true; (b) drive a person's actions and support decisions and judgements; (c) have highly variable and uncertain linkages to personal, episodic, and emotional experiences; and, (d) although undeniably related to knowledge, differ from knowledge

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in that beliefs do not require a condition of truth (Bryan, 2003).

The difficulty with beliefs research is that beliefs cannot be directly observed or measured; understanding beliefs requires making inferences about individuals' underlying states (Pajares, 1992; Rokeach, 1968). Therefore, researchers need effective probes and strategies to unearth deep and complex beliefs. Throughout the history of research on teacher beliefs, researchers have used different approaches and methods of assessment. The literature indicates that the measurement of attitudes and beliefs in teaching and teacher education have undergone considerable change reflecting the paradigm shift from positivist research strategies to a more qualitative approach. The general trend in mid-century research was to develop predictive understandings of the relationship between teacher attitudes/beliefs and behaviours by developing various inventories (which were usually in the form of paper-and-pencil, multiple-choice surveys) to be used in the selection of teachers (Richardson, 1996).

Current thinking in the assessment of teachers' beliefs is that multiple-choice measures are too constraining in that they are derived from scholarly literature and are predetermined by the researcher (Munby, 1984; Richardson, 1996). With the shift from a focus on behaviours to an interest in cognition in the 1980s, the methodologies and approaches employed by researchers have also gradually shifted toward more qualitative methodologies. The goal of these studies is not to develop predictive indicators of teacher effectiveness but to understand the nature of teachers' thinking and their world-views (Richardson, 1996). In recent years a variety of qualitative methods for eliciting teacher belief has emerged; including semi-structured interviews, during which teachers are asked to recall specific classroom events and decisions; concept maps that teachers are asked to draw to depict their understandings of pedagogical terms; and a close analysis of the language teachers use to describe their thoughts and actions (Kagan, 1992).

As in many disciplines in social sciences, assessing beliefs on various dimensions of science education has become an important research topic in the field of science education. Amongst these dimensions, the assessment of teachers' beliefs regarding the nature of science (NOS) has been the focus of attention in the last two decades with the assumption that teachers' beliefs about the subject matter they teach exert a powerful influence on their instructional practice (Brickhouse, 1991; Shulman, 1986). The NOS has been defined in many ways throughout the decades dating back to its earliest inception in the 1907 report of the Central Association of Science and Mathematics Teachers which emphasized the scientific method and the processes of science (Hammrich, 1997; Lederman, 1992). The most cited definition of the NOS is that by Lederman and Zeidler (1987) in which they refer to the values and beliefs inherent in scientific knowledge and its development. More specifically, McComas, Clough and Almazroa (1998) define the NOS as;

> …a fertile hybrid arena which blends aspects of various social studies of science including the history, sociology, and philosophy of science combined with research from the cognitive sciences such as psychology into a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors. (p.4)

The history of the assessment of the beliefs about the NOS mirrors the evolution that has occurred in teacher thinking research. Traditionally, the dominant strategies employed with regard to the assessment of individuals' beliefs regarding the NOS have been those associated with quantitative methodology. Lederman, Wade and Bell (1998) report that the majority of researchers tended to develop instruments that allowed for easily "graded" and quantified measures of individuals' understandings. Some of these instruments involved some open-ended questioning; however, little emphasis was placed on providing an expanded view of an individual's beliefs regarding the NOS (Lederman, Wade, & Bell, 1998). Especially during the last 10 years, qualitative approaches have been more widely employed by researchers to assess NOS understandings. In this movement, interviews are considered to be crucial in yielding the essential data (Lederman, 1992) and, the use of such qualitative probes is considered to be important for generating profiles of the meanings individuals ascribe to various aspects of teaching and learning (Hogan, 2000).

Arguably, beliefs about science and its nature represent one of the most highly complex belief systems and as such it is not easy for individuals to express their beliefs completely and accurately without some form of careful reflection. The main argument guiding this paper is that the research probe and analytical approach to be used in any study assessing individuals' beliefs about science should also include means and opportunities to promote reflection in order to achieve a complete understanding of individuals' beliefs. Reflection-oriented approaches and strategies to foster pre-service science teachers' understandings of the NOS have been used by many researchers (e.g. Hammrich, 1997; Meichtry, 1999; Nichols, Tippins, & Wieseman, 1997, Nott & Wellington, 1998; Trumbull & Slack, 1991) in science teacher education. These approaches have been based on the constructivist view of teaching and learning and argue that prospective teachers should be given opportunities to explore, discuss and reflect on their beliefs on the various aspects of the NOS across various contexts in order to achieve desired conceptual change. However, such approaches have been rarely used in researching beliefs about science. Towards this end, this paper describes and discusses a reflection-oriented qualitative approach employed in a research project assessing and analysing beliefs about science. Further, this paper also presents an example of how technology can be used in data collection and discusses strengths and shortcomings of this approach.

THE STUDY

The participants of this study were a group of science teacher educators who, at the time of the study, were studying abroad as a part of the Turkish government's strategy to improve the quality of teacher education. The study assessed the beliefs of these teacher educators regarding the NOS in order to trace how these beliefs may shape the profile of science education in Turkey (Irez, 2006). 15 participants involved in the study. Nine of them were conducting their doctorate level studies in England whereas six of them were in the USA. In order to keep the individuals anonymous, codes were used to represent them (for example; "TE1" stands for Teacher Educator One). In this paper, one of the participants (TE1) of the study will be used as a case in order to explain the data collection and analysis procedure in some detail.

DATA COLLECTION

The data collection process involved two interviews with each of the participants. All interviews with the participants who were conducting their studies in England involved face-to-face interviews. All face-to-face interviews were audio-taped for analysis. The interviews with the participants in the USA were conducted through the Internet using MSN Messenger software.

The use of new and effective technologies in data collection and analysis is not new for researchers. Various strategies such as telephone interviewing and computer-assisted interviewing have been used by social researchers as data gathering tools for many years (Couper & Hansen, 2002; Shuy, 2002). The Internet as a medium for interviewing has also been used in many studies (Mann & Steward, 2000; 2002). Researchers in these studies have usually interacted with the participants using text messages, either synchronously or asynchronously. Synchronous communication has involved an interchange of messages between two or more users simultaneously logged on at different computers or computer terminals and asynchronous communication has involved typing extended messages that are then electronically transmitted to recipients who can read, print, forward, and file them at any time they choose (Ibid.).

However, recent developments have presented opportunities for computer users to simulate face-to-face interviews by communicating synchronously by talking and seeing each other. This is achieved through the use of web cameras and a microphone.

There has been no published research, as far as I have been able to trace, that has used these technologies. An influential factor in making the decision to use synchronous web cameras to conduct the interviews with the participants in the USA was the fact that all the participants had access to Internet connected computers with the necessary hardware (microphone and web camera). All the participants welcomed this initiative. Usually the Internet connection was quite good and we experienced only one or two minor technical problems in the interviews. The interviews were, in one sense, very similar to face-to-face interviews as even facial expressions were clearly visible. All the interviews were saved on to the hard disc drive of the researcher's computer for analysis as the software used, MSN Messenger, also allowed the user to do this.

The first round of interviews

The first interviews lasted about 1 hour. These interviews were devoted to questions aimed at assessing the participants' conceptions about science and scientific processes. The questions of the VNOS-C (Views on the Nature of Science Questionnaire, form C) developed by Abd-El-Khalick in 1998 were used as the interview guide. The original form of the VNOS questionnaire was developed by Lederman and O'Malley (1990) and consisted of seven open-ended questions. It was used in conjunction with follow-up individual interviews to assess high school students' views of the tentative nature of science (Abd-El-Khalick, Lederman, Bell, & Schwartz, 2001). In 1998, the questionnaire was modified twice and the final form (Form C) based on ten questions was developed by Abd-El-Khalick (Abd-El-Khalick et al., 2001). The VNOS-C questionnaire was designed to elicit the participants' beliefs about several aspects of the NOS. These aspects included the empirical and tentative nature of scientific knowledge, the nature of scientific method and scientific theories, the creative and imaginative nature of science, the subjective nature of scientific knowledge and social and cultural influences on scientific knowledge. Although the original questionnaire was developed as a paper and pencil instrument, it was thought that the questions were also appropriate for use in interviews since they were open-ended.

The analysis procedure for the data obtained in the first interviews

The procedure for analysis of the data obtained in the first interviews concerning the participants' understandings of the NOS was quite similar to that suggested by Hewson and Hewson (1989) except for the generation of cognitive maps. The analysis involved four steps.

The first step involved the coding of the data. First, the transcriptions were read. In coding, each question was assigned with a number. Then, each sentence implying a unit of information in the participant's answer was also given a number. The following is an example of such coding taken from TE1's transcription.

> Question (21), Interviewer: After scientists have developed a scientific theory, for example atomic theory or the theory of evolution, does the theory ever change?
>
> TE1: 1 (If we still call it a "theory", yes, I believe that it changes.) 2 (If a theory has not been not accepted by everyone, what I mean by everyone is 'scientists' or the "scientific community"), 3 (because it has not been proven) 4 (due to insufficient technology or lack of knowledge in that field,) then it changes. 5 (For example, we did not know the structure of the DNA until Watson and Crick developed that model in 1956, with that model they explained that genes located on the DNA are the key for our lives and "the information" is transferred to next generation through the DNA.) 6 (Today technology is so developed that we are able to change the locations of genes on the DNA.) 7 (We do not call it the theory of DNA or the theory of Watson-Crick, I mean it is apparently proven.) 8 (There were different theories regarding this issue until 1956, but now…)

The second step of the data analysis involved theme (or category) generation (Hewson & Hewson, 1989). The participant's interview transcript was carefully analysed and the statements regarding the NOS aspects (or themes) that were of interest in this study were grouped together. For example, a participant's statements that informed his/her understanding of the tentative NOS were grouped together. At the end of this process, each participant's statements were grouped under nine themes (or aspects of the NOS) regarding the NOS; which were; *description of science, the empirical NOS, scientific method, the tentative NOS, the nature of scientific theories and laws, inference and theoretical entities in science, the subjective and theory-laden NOS, social and cultural embeddedness of science, imagination and creativity in science.*

The themes were not independent of one another as they represent components of a conception of the NOS. Therefore, some of the statements were placed within more than one theme as they applied to all these themes. Furthermore, some of the themes were broad, for that reason, they consisted of several sub-themes. For example, four sub-themes were detected under the theme "The nature of scientific theories and laws", which were: *theories: well-supported explanations vs. guesses, theory change, the relationship between theories and laws, and the status of laws.*

This theme generation process helped the researcher to check the consistency, or lack thereof, between the participants' statements regarding an aspect of the NOS that were made in response to different questions. Any inconsistency identified as a result of this analysis was noted and was followed up with the participant in the second interview for clarification.

The third step was *statement generation*. This involved summarising the participant's detailed explanations in a single sentence or phrasal statements. An example of this process is shown in Box 1.

The last step of the analysis was *the generation of cognitive maps* regarding the NOS for each participant. These cognitive maps were generated by employing a technique that is analogous to that developed and used by Novak and Gowin (1984) for concept maps. The concept mapping technique was invented and developed by Novak and his graduate students at Cornell University in the early 1970s (Wandersee, 2000). Concept maps are intended to represent meaningful relationships between concepts in the form of propositions (Novak & Gowin, 1984).

The potential of concept mapping as a cognitive learning and assessment tool has long been recognised and its validity has been established in many studies (Anderson-Inman & Ditson, 1999; Jonassen, Reeves, Hong, Harvey, & Peters, 1997; Mellado, 1997). Concept maps have also been used in research on science teachers (Hoz, Tomer, & Tamir, 1990; Mellado, 1997; Shymansky, Woodworth, Norman, Dunkhase, Matthews, & Liu, 1993).

The difference between a cognitive map and a concept map is that a cognitive map is drawn from a particular piece of text, such as an interview transcription, and the reader analysing the text is interrogating, rather than the person (Miles & Huberman, 1994). Furthermore, cognitive maps relate, in a partially hierarchical manner, units of information in a broader sense than the concepts used in conceptual maps (Mellado, 1997). In this sense, the cognitive maps generated and presented in this study display an overall picture of the participants' beliefs concerning the NOS.

Box 1. An example of statement generation process. (Taken from the analysis of TE1's first interview)

…
Science represents systematically collected knowledge (7.1,2)
Science relies on evidence (11.4)
A discipline should follow the scientific method to be called 'scientific' (11.2,3)
Scientific knowledge is clear, commonly accepted, and collected without any interpretation (11.5; 12,3,4; 18)
Scientists use their imagination in developing theories (34)
Scientists should not use their imagination unwisely in attempting to explain unscientific phenomena (34.6,7)
One of the main aspects of the scientific knowledge is that it is repeatable and clear (18)
Scientists should not make claims without direct evidence (31.1)
Scientific method is the same in all scientific disciplines (13; 14; 15)
Scientific method: theory – systematic data collection by experiment and observation – evidence – conclusion (13.2,3)
Theories are unproven proposals (20; 21)
Due to insufficient technology and lack of knowledge (21.4)
Theories have not been accepted by all scientists (20.4; 21.2)
Theories change (21)
Theories become laws if they are proven (22; 23)
Example: The DNA model (21)
Laws do not change (22.3)
…

The sentences and phrases (units of information) obtained in Step 3 (statement generation) were used to construct cognitive maps. The construction of cognitive maps involved careful analysis of these units of information, classification of these units into categories, and identifying the relationship between them. The critical point in this phase was to turn back to the full interview transcriptions and check the participant's statements in order to avoid misrepresentations concerning the relationships between the concepts. After being confident about these relationships, the concepts and the relationships between them were represented graphically in the form of a cognitive map. Figure 1 shows TE1's cognitive map on science constructed as a result of this data analysis procedure. These cognitive maps were constructed for each one of the participants.

The codes located above each box on the cognitive maps indicate from which part(s) of the interview that specific information is obtained. For example, 27.1 indicate that the information in this box was obtained from the first sentence of the 27th question asked in the first interview.

It needs to be recognised that the propositional networks in the mind are far more complex than anything that can be represented in cognitive maps. The links between the concepts in cognitive maps are illustrated as one way, in reality, concepts are often linked in multiple ways depending upon the particular meaning of each concept, which is contextually dependent (Jonassen *et al.*, 1997). Therefore, the cognitive maps should be presented and viewed as conceptual summaries of the participants' accounts which provide a partial view of their more complete internalised conceptual frameworks. So as not to loose the rich descriptions provided in the interviews, quotes from the transcriptions should also be referred in order to explain the participant's conceptual maps more fully.

The second round of interviews

Upon completion of the analysis of the first interviews, the transcriptions and the cognitive maps constructed concerning the NOS were sent to the participants by e-mail at least two weeks before the second interviews. The aim was to give the participants an opportunity to think about and reflect on their responses as well as ensuring the authenticity and validity of the cognitive maps constructed from the analysis of the first interviews.

As in the first interviews, the second interviews with the participants in England were carried out face-to-face whereas those in the USA were conducted synchronously using MSN Messenger over the Internet. The difference between the first and the second interviews was that the latter were clinical in nature (Tall, 1979) in that the questions for each participant in the second interview were developed during the analysis of the first interviews and so were different for each individual participant. The second interviews lasted between 30 minutes to one and half-hours depending on the number of the questions asked and the length of the explanations made by the participants. All second interviews were recorded as in the first interviews.

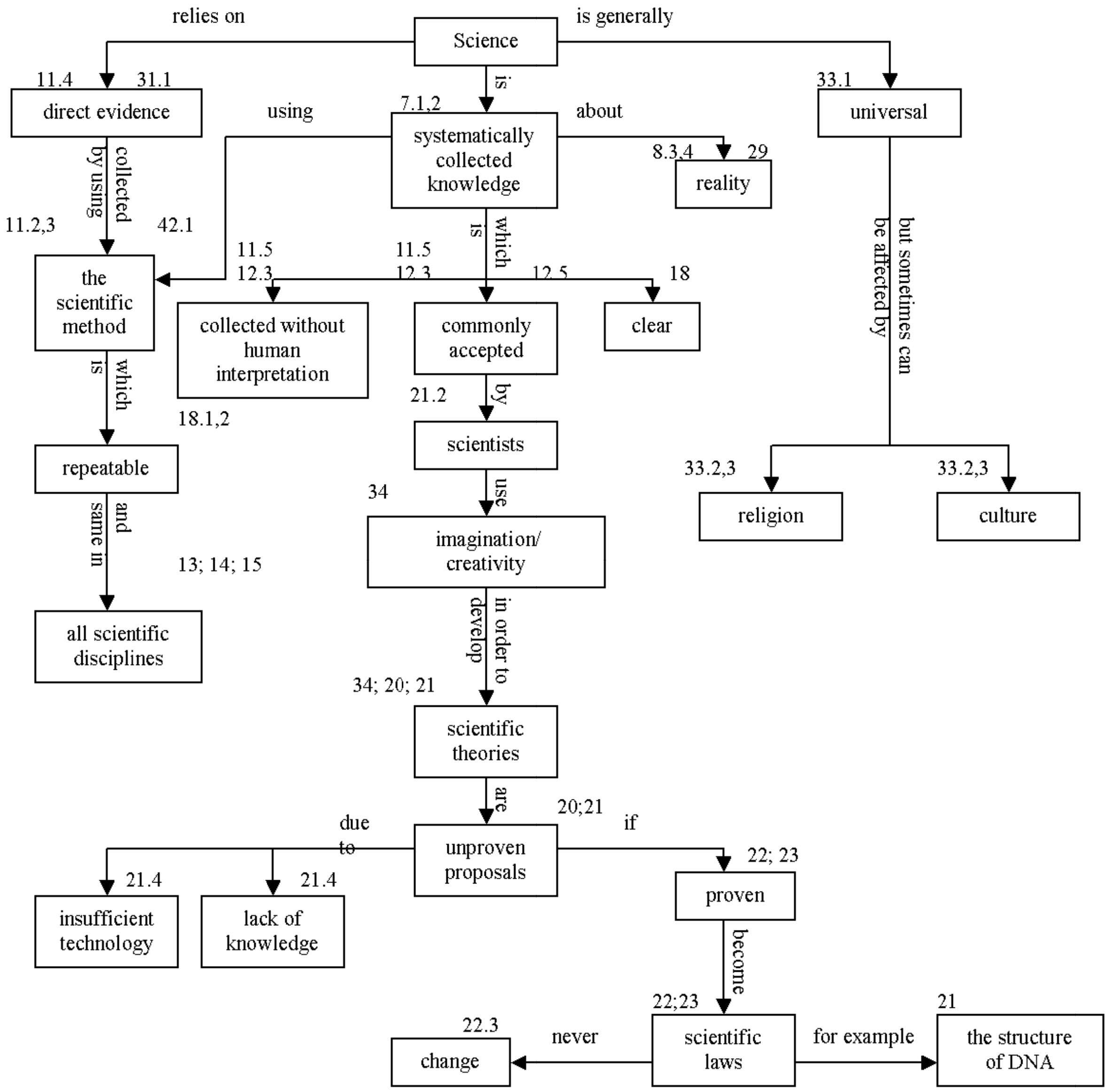

Figure 1. TE1's cognitive map on science generated on the basis of the first interview

The second interviews started with conversations about the cognitive maps. The participants were mainly asked whether they felt that the cognitive maps reflected their beliefs about science and its nature. These conversations led to further discussions and questions about contradictions and inconsistencies in their beliefs detected in the analysis of the first interviews and illustrated in their cognitive maps. For example, one of the questions asked of TE1 in the second interview was:

> Interviewer: As I illustrated in your cognitive map, in some parts of the first interview you mentioned that scientists use imagination and creativity in their work and that culture and religion affect the scientific process. However, in some other parts earlier in the first interview, you also mentioned that one of the important aspects of scientific knowledge is that it is collected without human interpretation using the scientific method and that it is accepted by everyone. Do you think that these two statements contradict each other? Can you elaborate?
>
> TE1: [Pause] … Well … If you reach a truth in the light of scientific investigations it is the truth. Culture and religion affects people's interpretation and use of that reality. I mean, culture and religion might be decisive on whether or not to use that reality or knowledge but this does not affect a scientist in reaching a conclusion.

As can be seen in TE1's cognitive map (Figure 1), his ideas in the first interview led the researcher think that he believed that science is generally universal but can be affected by society and culture. However, TE1's answer to the above question in the second interview revealed that he actually believed that scientific processes are independent from cultural influences. However, he thought that society has the authority on how and in what ways the products and knowledge that science presents will be used.

There were many other examples of such instances where, with the help of cognitive map generation process, participants' inconsistent ideas were detected and asked in the second interviews. Combined with cognitive maps, asking for further explanations about such inconsistencies forced the participants reflect on their beliefs. This process provided rich descriptions of the participants' belief systems about the NOS. Following is two other examples of this taken from the interviews with two other participants (TE4 and TE13).

> Interviewer: In the 22nd and 23rd questions of the first interview you claimed that subjectivity is a necessity for the development of science. On the other hand, in the following questions you expressed that science should be universal. Are these views contradictory? What you think?
>
> TE4: Let me ask; is there an agreement amongst scientists about the theory of evolution? These are specific things, I generalised when we were talking about these things in the first interview. Science generally deals with certain realities independent of everything, but sometimes culture and society may affect science in certain issues. It depends on the subject. Gravity, for example, is truth. Subjects such as the theory of evolution constitute 3-5% of science, the remaining 95% are the truths and not affected by society and culture.
>
> --------------------------
>
> Interviewer: In some questions at our first meeting you expressed your doubts about the investigation methods and findings of some disciplines and their theories, such as the theory of evolution and the theories about the extinction of dinosaurs…
>
> TE13: Right, I said that we could not reach the truth about the beginning of life, because it happened a long time ago, we cannot see, therefore it is difficult to prove.
>
> Interviewer: Yes, on the other hand, you claimed that atomic theory is a well-sustained theory. But, both theories are about unobservable things and in your words at the first interview 'estimations' of scientists relying on indirect evidence…
>
> TE13: But, for example you mentioned about volcanoes, meteors and the extinction of the dinosaurs. There is no evidence… no, of course some evidence exists, but… they are different… I think it is possible to develop and support atomic theory; it is easy to believe it. Because one theory is about a thing that happened millions of years ago, I could not be sure that the fossils that I have are from that period of time. In contrast, in the case of atomic theory you might find new evidence with the development of technology. I mean, I don't know…

Responses to such questions helped the researcher have a clear understanding about the participants' beliefs and the rationale they put behind these. In this process, the participants were given an opportunity to make changes to their cognitive maps and to provide the reasons for that change.

The analysis procedure for the data obtained in the second interviews

All the second interviews were transcribed in verbatim and coded. The process for analysis for the second interviews was more straightforward than that of the first interviews. The participants' cognitive maps were modified in the light of their explanations. The cognitive maps illustrated in the final report would be these final versions that were created after the second interviews, since they represent a comprehensive and "validated" picture of participants' beliefs.

To give one instance, TE1's cognitive map for science which was modified in the light of his explanations in the second interview is illustrated in Figure 2. The shaded areas in the figure show the modifications that were made after the second interview with TE1 in accordance with his explanations.

It is important to note that this second cognitive map was constructed in the light of the analysis of two interviews with TE1. In order to avoid any confusion regarding the codes placed above each box in the map, any information unit obtained from the second interviews is coded with the '*' sign whereas the codes showing the units of information obtained from the first interviews do not carry any symbols (For example, 8.2,3* indicates that this information was obtained from the second and third sentences of the 8th question asked in the second interview whereas 27.1 indicates that the information in this box was obtained from the first sentence of the 27th question asked in the first interview.).

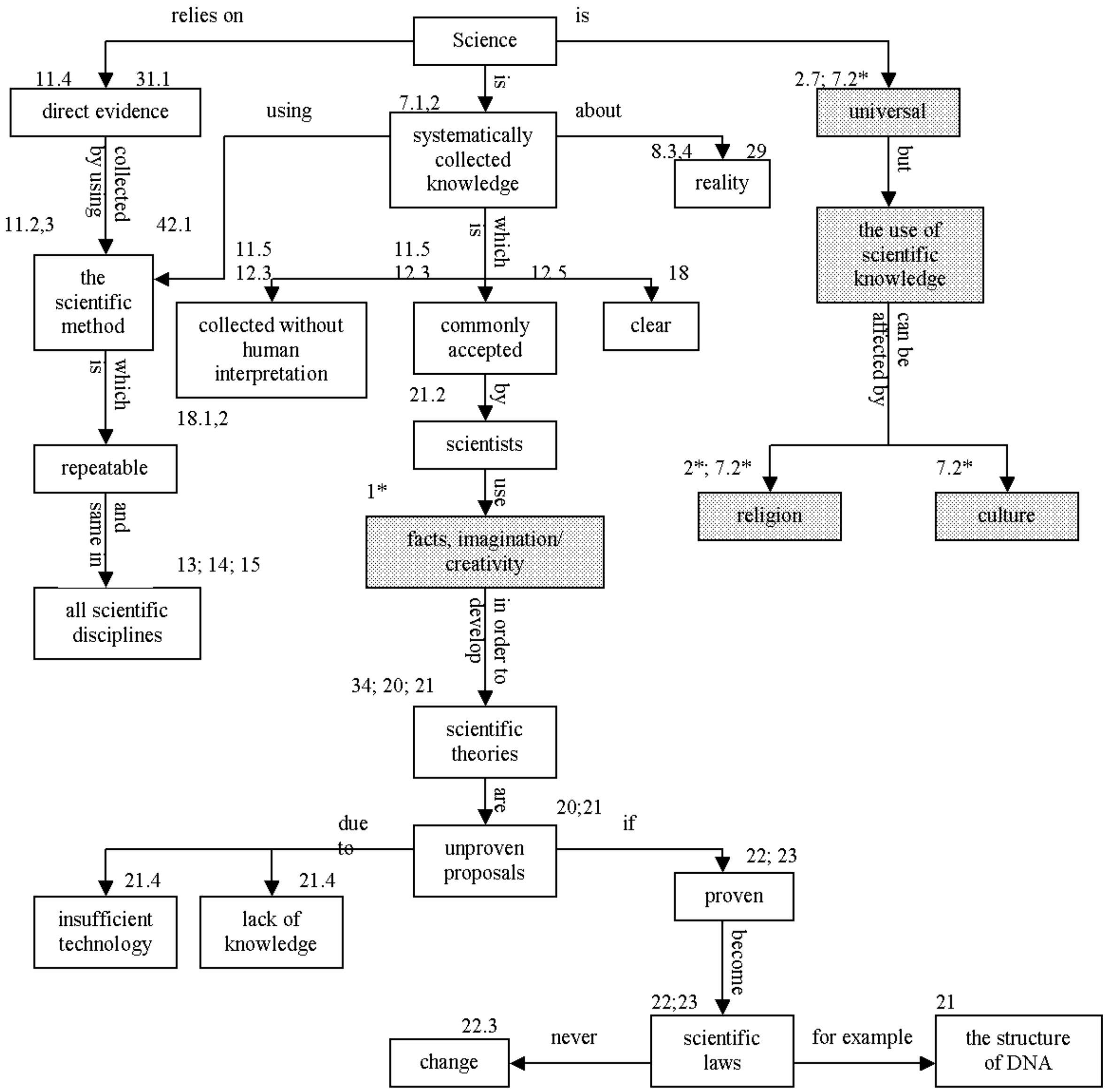

Figure 2. TE1's cognitive map on science after the second interview

It is worth noting that not all participants requested changes and modifications regarding their cognitive maps. Indeed most of the participants were happy with their cognitive maps and commented positively on them. Some of the remarks were:

> … I could easily say that this map precisely reflects my thoughts. (TE3)
>
> It was very interesting to see the map of my thoughts… I felt like somebody had taken a picture of my mind. (TE9)
>
> I really liked it; it reflects what I believe about the nature of science. (TE11)
>
> … In short, it is a summary of my thoughts. (TE14)

Furthermore, additional cognitive maps (on scientific methodology and scientific change) were constructed for some participants in the light of the first and second interviews in order to present a more detailed graphical summary of their understandings of some aspects of the NOS.

DISCUSSION AND IMPLICATIONS

This study argued that in order to achieve a complete understanding of individuals' thinking processes successfully, reflection-oriented probes and strategies are needed. The reason behind this rationale is the idea that any individual is likely to have a series of beliefs which will probably be incoherent and contradictory (Zeichner, 1986). Individuals are often not aware of these beliefs until such time as they are overtly challenged (Tann, 1993) since most of these beliefs usually exist at an implicit or a "common sense" level (Calderhead, 1987).

Therefore, a highly reflective probe (VNOS-C questionnaire) and cognitive mapping technique were utilized in this study in order to unearth the participants' beliefs about the NOS and conceptualisations of science education. This approach provided the participants with opportunities to explore and reflect on their thinking. Feedback and comments from the participants showed that cognitive maps were very effective in starting the process of reflection. Therefore, researchers are encouraged to employ similar techniques and strategies that encourage participants to reflect on their thinking. Such techniques and strategies can be utilized from a growing body of activities and approaches suggested by researchers in order to achieve desired conceptual change by engaging prospective teachers with exploring and reflecting on their beliefs. Examples of these activities are co-operative controversy strategy (Hammrich, 1997), journal writing (Holly, 1989; Nichols et al., 1997), the use of metaphors and proverbs (Nichols et al., 1997) and, critical incidents (Nott & Wellington, 1998).

The use of cognitive maps has also proved to be effective in data analysis. Generating cognitive maps is a labour-intensive procedure. But when they are completed, they provide a graphical summary of each participant's belief system. This summary supports the researcher in locating elements in an individual's belief system and reveals consistencies and inconsistencies between beliefs. The important thing to remember is that cognitive maps have a way of looking more organised and systematic than they probably are in the person's mind (Miles & Huberman, 1994). It was important for the researcher to constantly check with the actual transcriptions when making interpretations.

An important contribution of this study is, perhaps, pointing out the potential of the Internet as a research medium. Although this potential has been explored and exploited by a few researchers in recent years (Mann & Steward, 2000; 2002), this has been limited to obtaining and exchanging textual data via e-mails or online chatting. This study moved a step further and, using available hardware and software, simulated face-to-face interviews by communicating synchronously with the participants by using web cams. The result was more than satisfying as the interviews via the Internet were almost like face-to-face interviews. In the light of this experience, I believe that the practical benefits of incorporating Internet mediated interviews (IMI) into research design could be substantial.

The obvious advantage of conducting IMI is that the researcher crosses the time and space barriers which might limit face–to-face interview research (Mann & Steward, 2000). Besides, IMI minimizes the cost by saving the researcher and participants from travel expenses. This also minimizes the time input of participants and increases the flexibility in the timing of the interviews. Indeed, the use of IMI in this study did not only offer a means of minimizing the constraints of time and cost but also allowed me to include participants from another continent.

The fact that IMI allows the researcher to sent and receive files from participants during the interview might also be potentially important for research projects requiring or involving textual data presentation. The researcher can present the necessary information to participants in various ways such as using Microsoft PowerPoint.

There are, of course, challenges involved in including IMI into research design. Clearly, there are some basic requirements in order for a research design using IMI to be conducted successfully. Obviously, the potential participants and the researcher need to have (or have access to) the appropriate technology, such as a computer system, internet connection and, necessary hardware and software. Furthermore, some degree of technical expertise both on the parts of the researcher and participants is required.

Qualitative research relies on the development of rapport, a mutual respect arising between researcher and participants (Mann and Stewart, 2000). In face-to-face interviews, rapport is developed through verbal and non-verbal paralinguistic cues (Ibid). However, despite its similarity to face-to-face interviews, IMI limits non-verbal communication to a certain degree. This may create problems in the development of rapport as it may hold back researchers and participants who primarily express themselves in different ways such as body language or facial expression. This situation may result in difficulties in attracting participants or may threaten the quality of data obtained from interviews. Arguably, this study did not suffer from such difficulties due to the fact that the participants were in the same position as the researcher and thus they could relate to their position. They showed a willingness to cooperate and tried to overcome the difficulties mentioned above. However, researchers may experience problems in other contexts. One way that researchers may ensure the development of rapport in qualitative studies involving IMI is by getting in touch with potential participants at an early stage in the research in order to increase familiarity with them and gain their trust. As a result, researchers and participants may find IMI less threatening as a good research relationship is built beforehand.

There are also some challenges arising from shortcomings of available technology. A key challenge is to sustain electronic connection with participants during the interviews. Although this study did not suffer from connection cuts, the researcher was aware of the possibility. Such disconnections might have resulted in losing concentration and motivation during the interviews which would have severely affected the research process. The reason for these connection cuts is usually poor and slow internet connection. However, this problem can be overcome by the use of more advanced technologies, such as broadband internet connection, as they are faster and more reliable.

Unfortunately, the available software only allows for voice conversation between two users, therefore, for now, it is not possible to conduct interviews involving more than one participant, such as focus group interviews.

Despite these challenges, this study proved that the Internet presents enormous potential for research projects and researchers are encouraged to further explore and exploit this potential.

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University Students' Perceptions of Web-based vs. Paper-based Homework in a General Physics Course

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The main aim of this study was to determine students' perceptions toward web-based versus paper-based homework and identify any differences based on homework performance score and grade point average. A 21-item perception of online vs. paper-based homework survey was administered to 103 students (54 were male and 49 were female) in general physics-1 classes. Results of the study indicated that there was not a statistically significant difference in physics grade point average scores; however, there was a statistically significant difference in homework performance (average) scores based on assigned homework groups. Overall, students' perception of web-based homework testing was positive. Finally, some tentative recommendations are posed.

Keywords: Web-Based Homework, Paper-Based Homework, Physics Course, Student' Perception

INTRODUCTION

Homework is an important component of introductory physics instruction at the university level. An effective method of student assessment is necessary in physics as well as all areas and levels of education. In the traditional formal classroom, assessment has been conducted with paper and pencil using questioning techniques such as multiple choice, constructed response, fill-in-the blank, and essay items. This type of testing has been used to assess the skills and knowledge of students since the early 1930s (Hatfield & Gorman, 2000). Advancements in technology have led to new methods of student assessment. With the evolution of web-based technologies and the broad availability of computers, student assessment can now include computer-based forms.

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Bonham et al. (2003) indicated their study that nineteen of the 25 journals or conference papers in physics described a system and/or included student responses on surveys. Two papers compared students in a typical classroom to ones using programmed learning CAI to supplement or replace the standard course (Marr, 1999; Weiss, 1971), and one evaluated tutorials using two-way coaching between students and computers (Reif & Scott, 1999). All three reported improved student performance for those using computers, but they also involved differences in pedagogy, significant effort in development of the computer-based materials. One of the remaining three papers found that student performance improved in a course after Web-based homework was introduced (Woolf et al., 2000). Bonham et al. (2003) compared student performance over several years in large introductory physics courses, including both calculus-based and algebra-based courses, and four different instructors who had taught courses with both paper-based and Web-based homework system. Comparison of their performances on regular exams, conceptual exams, quizzes, laboratory, and homework showed no significant differences between groups.

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Alexander, Bartlett, Truell, and Ouwenga (2001) has examined the impact of computer-based forms of testing outcomes, and their research findings provided support that the two forms were equivalent. The current literature does not really answer questions being raised about computerized homework, web-based or otherwise. However, web-based homework system has some benefits. These benefits include obtaining students' results faster, having the ability to place grades into electronic format, measuring learning accurately, focusing on a student-centered environment, and costing less compared to paper-based exams (Bartlett, Reynolds, & Alexander, 2000; Dash, 2000; Oregon to Administer, 2001).

Purpose

The purpose of the study was to determine university students' perceptions toward web-based versus paper-based homework testing. To address this purpose, answers to the following research questions were sought:

1. What are students' perceptions on each of the 21 items composing the students' perceptions of web-based and paper-based homework testing survey instruments?
2. Are there statistically significant differences in students' homework performance scores and physics grade point average scores?

METHODOLOGY

Participants

The participants for this study consisted of all computer education department' students (of the 103; 54 were male, and 49 were female) enrolled in general physics-1 course offered at Balıkesir University, Necatibey Faculty of Education during the fall semester of 2005.

Instrumentation

The researcher has developed the students' perceptions of web-based and paper-based homework preference survey. 56 students [26 were female (46.4%), and 30 were male (53.6%)] had completed web-based homework preference survey questionnaire and 47 students [23 were female (48.9%), and 24 were male (51.1%)] had completed paper based homework preference survey questionnaire via online. The 21 items were arranged to form a Likert-type scale with a five-point spread. Participant scoring options were (1) strongly agree, (2) agree, (3) no opinion, (4) disagree, and (5) strongly disagree. To estimate instrument internal consistency, Cronbach's alpha was calculated and determined to be .87 for web-based survey, and .85 for paper-based survey.

Data Collection

During the last second week of the fall semester of 2005 for each section, participants were asked to complete the students' perceptions of web-based and paper-based homework preference instrument. Both groups, during the fall semester of 2005 students had taken eight homework tests. Students were registered for the two different sections through standard course registration system and were unaware of the homework method until it was announced the first week of physics-1 class. The physics-1 course has two main exams, one of which is mid-term and the other is final exam. The homework performance scores in both groups were added to include the 20 % of the final grade of the course. One is received their homework via online quiz system where it was graded by computer. The other wrote out solutions to homework exercises on paper with working as four or five groups of students. These exercises were turned in and graded by the instructor. Through the semester after each unit of physics-1 course is completed; students were administered homework questions according to their assigned groups. Most of the homework exercises on which the two groups worked was the same or similar problems from the physics textbook (Turkish translation of Principals of Physics by Bueche and Jerde, sixth edition, 1995) with addition of some conceptual questions by the instructor. There were total eight-homework exercises and they all in both groups graded in percent scores and calculated average scores to be their homework performance scores. All homework test scores and student's final grade points at the end of the semester were recorded to compare the results.

Data Analysis

Several procedures were used to analyze the data. Specifically, to answer question one and determine the level of students' perceptions on each of the 21 items of the students' perception of online and grouped paper and pencil based homework testing instruments, descriptive statistics were used. Means and percentage were used to determine the level of students' perceptions on each item. The t-test was used to determine where significant differences existed in homework performance scores and final grade point average for both groups.

RESULTS

Research question one sought to determine the level of students' agreement or disagreement on each of the

21 items on the students' perception of online, paper, and pencil-based homework testing instruments.

Level of Students Perceptions on each of the 21-Items for web-based homework testing group

Students' perceptions ranged from a high of 4.61 (indicating agreement) for the item web-based "The online test and its direction were easy to use and read on computer screen and the testing was user friendly" to a low of 2.68 (indicating disagreement) for the item "The way in which evaluation of the online homework scares me." Of the 21 statements, thirteen (61.9 %) had means between 3.31 and 4.61, eight (38.1 %) had means between 2.51 and 3.30. Each item's percentage and mean are presented in Table 1.

Table 1. Students' perceptions of web-based homework

Survey Items	*Strongly Agree*		*Agree*		*No-opinion*		*Disagree*		*Strongly Disagree*		**mean**
	%	N	%	N	%	N	%	N	%	N	
1. I prefer taking physics homework online.	28.6	16	17.9	10	21.4	12	25.0	14	7.1	4	3.36
2. Doing physics homework online is a modern approach than traditional paper and pencil homework.	39.3	22	57.1	32	-	-	-	-	3.6	2	4,29
3. Online homework has to be widespread out to the other courses.	32.1	18	32.1	18	21.4	12	10.7	6	3.6	2	3,79
4. Taking homework online could not be easily controlled*.	17.9	10	28.6	16	25.0	14	21.4	12	7.1	4	2,71
5. Doing homework online has disadvantages for me*.	10.7	6	21.4	12	21.4	12	32.1	18	14.3	8	3,18
6. I spend less time when doing homework online.	10.7	6	17.9	10	28.6	16	28.6	16	14.3	8	2,82
7. I prefer paper-pencil based homework than online homework* .	17.9	10	21.4	12	14.3	8	28.6	16	17.9	10	3,07
8. The technical computer problem reduced my test grade*.	3.6	2	10.7	6	25.0	14	28.6	16	32.1	18	3,75
9. Online homework provides me with more responsibilities in managing my time.	28.6	16	42.9	24	7.1	4	14.3	8	7.1	4	3,71
10. Getting immediate result and feedback from online homework system motivated me.	64.3	36	21.4	12	3.6	2	10.7	6	-	-	4,39
11. Students' progress and results can be easily achieved via online homework system.	46.4	26	28.6	16	-	-	7.1	4	17.9	10	3,79
12. Along with the online homework, the paper-pencil homework should be also given*.	21.4	12	17.9	10	14.3	8	28.6	16	17.9	10	3,04
13. The way in which evaluation of the online homework scares me*.	25.0	14	25.0	14	17.9	10	21.4	12	10.7	6	2,68
14. I want to continue taking homework online for general physics 2 course.	32.1	18	28.6	16	10.7	6	14.3	8	14.3	8	3,50
15. I am more comfortable with taking online homework than paper-pencil based one.	21.4	12	25.0	14	28.6	16	21.4	12	3.6	2	3,39
16. I had some difficulties getting access to computer and/or Internet and taking homework online*.	21.4	12	14.3	8	7.1	4	35.7	20	21.4	12	3,21
17. The online test environment is appropriate for test taking and convenient.	28.6	16	35.7	20	14.3	8	14.3	8	7.1	4	3,64
18. Online homework is a positive experience and I prefer taking some other courses via online.	17.9	10	35.7	20	10.7	6	21.4	12	14.3	8	3,21
19. I do not want to take any homework test via online*.	7.1	4	10.7	6	14.3	8	39.3	22	28.6	16	3,71
20. Preparing physics exams and getting my physics final grade, the online homework tests have helped a lot.	25.0	14	32.1	18	17.9	10	10.7	6	14.3	8	3,43
21. The online test and its direction were easy to use and read on computer screen and the testing was user friendly.	64.3	36	32.1	18	3.6	2	-	-	-	-	4,61

Note:*Negatively worded statements were used in order to avoid response set bias. For analytical purpose, these negatively worded statements were recorded in the positive form. Means and standard deviations are reported as if they were positively worded; participant scoring options were (1) strongly agree, (2) agree, (3) no opinion, (4) disagree, and (5) strongly disagree.

Level of Students Perceptions on each of the 21-Items for paper-pencil -based homework group

Students' perceptions ranged from a high of 4.02 (indicating agreement) for the item of paper and pencil-based homework "The way in which using grouped pencil and paper homework for this course is appropriate" to a low of 2.81 (indicating disagreement) for the item "The way in which evaluation of the paper and pencil homework scares me". Of the 21 statements, fifteen (71.4%) had means between 3.31 and 4.10, six (28.6 %) had means between 2.51 and 3.30. Each item's percentage and mean are presented in Table 2.

Table 2. Students' perceptions paper and pencil-based homework

Survey Items	*Strongly Agree*		*Agree*		*No-opinion*		*Disagree*		*Strongly Disagree*		**Mean**
	%	N	%	N	%	N	%	N	%	N	
1. I prefer taking paper and pencil homework with groups in physics	31.9	15	29.8	14	14.9	7	12.8	6	10.6	5	3,60
2. Doing physics homework online is a modern approach than traditional paper and pencil homework.	25.5	12	38.3	18	19.1	9	10.6	5	6.4	3	3,66
3. Paper and pencil homework with groups has to be widespread out to the other courses.	29.8	14	46.8	22	6.4	3	8.5	4	8.5	4	3,81
4. Taking paper and pencil homework with groups occurs out of controlled.	12.8	6	34.0	16	25.5	12	25.5	12	2.1	1	3,30
5. I spend more time when doing paper pencil homework with groups*.	2.1	1	23.4	11	19.1	9	48.9	23	6.4	3	3,34
6. I prefer paper-pencil based homework with group than online homework	19.1	9	21.3	10	29.8	14	19.1	9	10.6	5	3,19
7. Doing paper and pencil homework with groups has disadvantages for me*.	8.5	4	19.1	9	8.5	4	44.7	21	19.1	9	3,47
8. Gathering with group members to do pencil and paper based homework reduced my grades*.	10.6	5	23.4	11	29.8	14	27.7	13	8.5	4	3,00
9. Pencil and paper homework with groups provides me with more responsibilities.	29.8	14	42.6	20	4.3	2	17.0	8	6.4	3	3,72
10. Getting late result and feedback from paper and pencil homework motivated me negatively.	19.1	9	34.0	16	34.0	16	6.4	3	6.4	3	3,53
11. Students' progress and results cannot be easily achieved via paper and pencil based homework system	21.3	10	31.9	15	19.1	9	25.5	12	2.1	1	3,45
12. Along with the paper-pencil based homework, the online homework should be also given*.	12.8	6	29.8	14	17.0	8	25.5	12	14.9	7	3,00
13. The way in which evaluation of the paper and pencil homework scares me*.	14.9	7	25.5	12	27.7	13	27.7	13	4.3	2	2,81
14. I want to continue taking grouped paper and pencil based homework for general physics 2 course.	42.6	20	23.4	11	12.8	6	2.1	1	19.1	9	3,68
15. I am more comfortable with taking grouped paper-pencil based homework than online.	19.1	9	36.2	17	21.3	10	17.0	8	6.4	3	3,45
16. I had some difficulties gathering and doing pencil and paper homework with groups.	21.3	10	36.2	17	6.4	3	25.5	12	10.6	5	3,32
17. I encounter many problems when doing pencil and paper based homework*.	2.1	1	29.8	14	17.0	8	29.8	14	21.3	10	3,38
18. Grouped pencil and paper based homework is a positive experience and it has to be adopted the other course.	17.0	8	29.8	14	23.4	11	17.0	8	12.8	6	3,21
19. I do not want to take any homework test via online.	14.9	7	27.7	13	8.5	4	23.4	11	25.5	12	2,83
20. Preparing physics exams and getting my physics final grade, the grouped pencil and paper-based homework has helped a lot.	14.9	7	38.3	18	23.4	11	14.9	7	8.5	4	3,36
21. The way in which using grouped pencil and paper homework for this course is appropriate.	46.8	22	29.8	14	8.5	4	8.5	4	6.4	3	4,02

Note:*Negatively worded statements were used in order to avoid response set bias. For analytical purpose, these negatively worded statements were recorded in the positive form. Means and standard deviations are reported as if they were positively worded; participant scoring options were (1) strongly agree, (2) agree, (3) no opinion, (4) disagree, and (5) strongly disagree.

Table 3. T-test summary results

Test differences between groups	$\overline{X}_{web}$, and S.D. $_{web}$	$\overline{X}_{paper}$, and S.D $_{paper}$	$\overline{X}_{difference}$	df	t-test	p
Homework performance differences	71.15 and 15.49	80.30 and 7.24	-9.15	101	-3.29	0.02*
Final grade average differences	62.20 and 15.06	65.13 and 13.93	-2.93	101	-0.78	0.43

*p<0.05

Research question two sought to find out if there exist significant differences in students' homework performance scores and physics grade point average.

Summary t-test results of both groups related to homework performance scores and grade point average scores are given in Table 3.

It can be seen in Table 3 that there were not any statistical differences in physics-1 grade point average scores in terms of assigned groups of being web-based or paper-based (t_{101}= -0.78, p>0.05). However, there was a statistically significant difference in average homework performance scores with respect to assigned two groups (t_{101}= -3.29, p<0.05) in favor of paper-based homework group.

CONCLUSIONS

The main aim of this study was to find out students' perceptions toward web-based versus paper-based homework and seek if any differences exist based on homework performance score and grade point average. A 21-item perception of online vs. paper-based homework survey was administered to 103 students (54 were male and 49 were female) in general physics-1 classes at computer education department in Necatibey Faculty of Education, Balıkesir University. There was a not statistically significant difference in the means for web-based individual homework and grouped paper-based homework system with respect to physics-1 grade point average scores. However, there was a statistically significant difference in homework performance score in terms of assigned groups. The current literature does not really answer questions being raised about computerized homework, web-based or otherwise. Homework is important in technical courses such as introductory physics, where problem solving is a major focus and homework is the main venue for practicing, many students struggle to develop problem-solving skills in physics (Maloney, 1994), although directed instruction and feedback has been shown to be effective (Heller & Reif, 1984; Heller & Hollabaugh, 1992).

While comparison of their performances on regular exams, conceptual exams, quizzes, laboratory, and homework showed no significant differences between groups; other measures were found to be strong predictors of performance(Bonham at al., 2003), however, in this study, there was a statistically significant result between web-based and paper-based homework performance results in favor of paper-based group. Dufresne, Mestre, Hart, and Rath, (2002) compared student performance over several years in large introductory physics courses, including both calculus-based and algebra-based courses, and four different instructors who had taught courses with both paper-based and web-based homework system. Student exam scores generally improved at a significant level after the introduction of web-based homework. Students using web-based homework reported spending significantly more time on assignments than did those using paper homework.

The students participating in the study were enrolled in a required, introductory physics course at computer education department. Since computer use is a major component of their academic studies, students may have higher perceptions toward web-based homework testing than students in non-computer education departments. However, in terms of homework performance score, the paper-based group's homework performance score is found higher than web-based group. Students' perception about web-based and paper-based homework is found to be positive. Students' perceptions ranged from a high of 4.61 (indicating agreement) for the item web-based "The online test and its direction were easy to use and read on computer screen and the testing was user friendly" to a low of 2.68 (indicating disagreement) for the item "The way in which evaluation of the online homework scares me". Of the 21 statements, thirteen (61.9 %) had means between 3.31 and 4.61, eight (38.1 %) had means between 2.51 and 3.30. In addition to this result, also, students' perceptions ranged from a high of 4.02 for the item of paper and pencil-based homework "The way in which using grouped pencil and paper homework for this course is appropriate" to a low of 2.81 (indicating disagreement) for the item "The way in which evaluation of the paper and pencil homework scares me". Of the 21 statements, fifteen (71.4%) had means between 3.31 and 4.10, six (28.6 %) had means between 2.51 and 3.30.

Implications and Discussion

The findings of this study offer physics educators several implications for practice. First, given no practical differences in students' perceptions of web-based testing based on the variables investigated, physics educators who are working with similar groups may find online testing to be a viable alternative to traditional paper and pencil testing. Several studies have reported no differences in student performance when online and paper and pencil test scores have been compared (e.g., Alexander *et al.,* 2001; Bicanich, Slivinski, Hardwicke, & Kapes, 1997; Bonham at al., 2003). Second, while students' perceptions of web-based testing are generally positive, in some areas physics educators may have to adapt the online testing process to better fit the desires of students.

Recommendations for Further Research

Based on a review of the relevant literature and data analysis, the following recommendations for additional research are offered.

1. Further study of students' perceptions toward web-based testing should be conducted in classes where computer use is not a chief component of their academic profession. A study of this type would provide insight into how students perceive web-based testing in courses where the computer is not used as a primary tool of instruction.

2. A study investigating students' perceptions of web-based testing with other variables should be conducted. For example, comparisons of undergraduate and graduate students, face-to-face and distance education students, and instruction (e.g., traditional, peer-based, etc.) would be beneficial.

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Promoting Cooperative Learning in Science and Mathematics Education: A Malaysian Perspective

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The purpose of this article is to discuss the current shortcomings in science and mathematics education in Malaysia. The use of cooperative learning as an alternative to traditional method is emphasized. Cooperative learning is grounded in the belief that learning is most effective when students are actively involved in sharing ideas and work cooperatively to complete academic tasks. This article would also focus on selected studies done locally and their expected educational outcomes. A challenge involved in implementing cooperative learning is also discussed.

Keywords: Mathematics Education, Science Education, Science, Mathematics, Cooperative Learning

INTRODUCTION

The quality of education that teachers provide to student is highly dependent upon what teachers do in the classroom. Thus, in preparing the students of today to become successful individuals of tomorrow, science and mathematics teachers need to ensure that their teaching is effective. Teachers should have the knowledge of how students learn science and mathematics and how best to teach. Changing the way we teach and what we teach in science and mathematics is a continuing professional concern. Efforts should be taken now to direct the presentation of science and mathematics lessons away from the traditional methods to a more student centered approach.

The science curriculum for secondary school has been designed as to provide students with the knowledge and skills in science, develop thinking skills and strategies to enable them to solve problems and make decisions in everyday life (Ministry of Education Malaysia, 2002). In mathematics, the curriculums provide students the mathematical knowledge and skills and develop problem solving and decision making skills for everyday use (Ministry of Education, 2003). The science and mathematics curriculum as well as other subjects in the secondary school curriculum also seek to inculcate noble values and love for the nation. Despite good intentions and directions, teacher centered teaching practices still take centre stage.

Two pedagogical limitations have been identified as the major shortcomings in traditional secondary education: lecture-based instruction and teacher-centred instruction. Lecture-based instruction emphasized the passive acquisition of knowledge. In such an environment, students become passive recipients of knowledge and resort to rote learning. The majority of work involved teacher-talk using either a lecture technique or a simple question and answer that demand basic recall of knowledge from the learners. Lecture-based instruction dominates classroom activity with the teacher delivering well over 80% of the talk in most classrooms. Generally, only correct answers are accepted by the teacher and incorrect answers are simply ignored. Students seldom ask questions or exchange thought with other students in the class. The traditional classroom is also characterized by directed demonstrations and activities to verify previously introduced concepts. Instruction is therefore not for conceptual understanding but rather for memorizing and recalling of facts. It must be noted that students who develop conceptual understanding early perform

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best on procedural knowledge later (Grouws & Cebulla, 2000). Furthermore, students with good conceptual understanding are able to perform successfully on near-transfer tasks and develop procedures and skills they have not been taught.

In the traditional teacher-centered education, the dominance of the teacher take centre stage. The students rely on their teachers to decide what, when, and how to learn. This approach to instruction works relatively well. However, it is not clear that students are learning at higher, conceptual level of thinking.

THE NEED FOR REFORM

The world is increasingly becoming "small". Actions in one part of the world exert powerful influences on other parts of the world. There is more engagement of communities and individuals from different parts of the world. The growth in science and technology is overwhelming. These forces are impossible to avert and they provide challenges and opportunities for people in the science and mathematics education. Education today must enable students to meet the challenges ahead and demands of the work environment and of daily living. Thus, students not only need knowledge but also communication skills, problem solving skills, creative and critical thinking skills in the years ahead. An American Association for the Advancement of Science (1989: 148) report advices that:

> "the collaborative nature of scientific and technological work should be strongly reinforced by frequent group activity in the classroom. Scientists and engineers work mostly in groups and less often isolated investigators. Similarly, students should gain experience sharing responsibility for learning with each other".

Now we look at the performance of Malaysian students in comparisons to students from 44 countries participating in the TIMSS assessment (Mullis et al. 2004). In 2003, Malaysian Form Two students scored 504, on average, in mathematics. Although this average score exceeded the international average but we were out-performed by students from five Asian countries (Singapore, Republic of Korea, Hong Kong, Chinese-Taipei, Japan) and four European countries (Belgium-Flemish, Netherlands, Estonia and Hungary). In science, Malaysian students scored 510, on average, which exceeded the international average of 474 (Martin et al. 2004). In comparison to other countries, we were outperformed by 19 of the 44 participating countries. The top three were Singapore, Chinese-Taipei and Republic of Korea.

The activities that are commonly encountered in science classroom, as reported by science teachers were teacher lecture (25%), teacher-guided student practice (19%) and students working on problems on their own (11%) and homework review (13%) (Martin et al. 2004). In mathematics, 64% of teachers reported that they use textbook as primary basis of their lessons. The three most predominant activities in mathematics classroom were teacher lecture, teacher-guided student practice and students working on problems on their own, accounting for 58% of class time. Other activities were reviewing homework, re-teaching and clarifying content, taking tests and quizzes and participating in classroom management tasks that are not related to the lesson content (Mullis et al. 2004).

COOPERATIVE LEARNING: AN ALTERNATIVE TO TRADITIONAL METHOD

The challenge in education today is to effectively teach students of diverse ability and differing rates of learning. Teachers are expected to teach in a way that enables pupils to learn science and mathematics concepts while acquiring process skills, positive attitudes and values and problem solving skills. A variety of teaching strategies have been advocated for use in science and mathematics classroom, ranging from teacher-centered approach to more students-centered ones. In the last decade, there is a vast amount of research done on cooperative learning in science and mathematics. Cooperative learning is grounded in the belief that learning is most effective when students are actively involved in sharing ideas and work cooperatively to complete academic tasks. Cooperative learning has been used as both an instructional method and as a learning tool at various levels of education and in various subject areas. Johnson, Johnson and Holubec (1994) proposed five essential elements of cooperative learning:

(a) Positive interdependence: The success of one learner is dependent on the success of the other learners.
(b) Promotive interaction : Individual can achieve promotive interaction by helping each other, exchanging resources, challenging each other's conclusions, providing feedback, encouraging and striving for mutual benefits.
(c) Individual accountability: Teachers should assess the amount of effort that each member is contributing. These can be done by giving an individual test to each student and randomly calling students to present their group's work.
(d) Interpersonal and small-group skills : Teachers must provide opportunities for group members to know each other, accept and support each other, communicate accurately and resolve differences constructively.
(e) Group processing: Teachers must also provide opportunities for the class to assess group

progress. Group processing enables group to focus on good working relationship, facilitates the learning of cooperative skills and ensures that members receive feedback.

Essentially, then, cooperative learning, represents a shift in educational paradigm from teacher-centered approach to a more student-centered learning in small group. It creates excellent opportunities for students to engage in problem solving with the help of their group members (Effandi, 2005).

In Malaysia, research on cooperative learning has been carried out since 1990s (Nor Azizah & Chong, 2000). The revised curriculum of the primary and secondary schools emphasized the use of cooperative learning as an alternative to traditional method of teaching. (Kementerian Pendidikan Malaysia, 2001). Cooperative learning is generally understood as learning that takes place in small groups where students share ideas and work collaboratively to complete a given task. There are several models of cooperative learning that vary considerably from each other (Slavin, 1995), for examples in STAD (Student Teams-Achievement Divisions), students are grouped according to mixed ability, sex and ethnicity. The teachers present materials in the same way they always have, and then students work within their groups to make sure all of them mastered the content. Finally, all students take individual quizzes. Students earn team points based on how well they scored on the quiz compared to past performance. Unlike STAD, in TGT (Teams-Games-Tournament) quizzes are replaced by tournaments. Students compete at tournaments table against students from other teams who are equal to them in terms of past performance. Students earn team points based on how well they do at their tournament tables. In JIGSAW, students are responsible for teaching each other the material. Assignment is divided into several expert areas, and each student is assigned with one area. Experts from different groups meet together and discuss their expert areas. Students then return to their groups and take turns teaching. Therefore care must be taken in interpreting cooperative learning research because the term can be used in many different ways.

The effectiveness of cooperative learning in mathematics and science is well established by research. Cooperative learning created many learning opportunities that do not typically occur in traditional classrooms. According to Nor Azizah (1996), cooperative learning has the potential in science classroom because of the following factors: (a) science students always work in group during science experiment in the laboratory therefore what they need is the skill to work in group (b) science laboratory is spacious with intact desk and chairs. (c) science classes are usually two periods with 40 minutes each, enough time for cooperative learning and (d) during experiment many values can be inculcated e.g cleanliness, trustworthy etc. Siti Rahayah (1998) further stated that science teachers need to try cooperative learning in order to enhance scientific skills and to increase achievement in science. Since it is impossible here to summarize the vast literature on cooperative learning, the author would only focus on selected studies done locally.

EXPECTED EDUCATIONAL OUTCOMES OFCOOPERATIVE LEARNING

Central to the goals of cooperative learning in science and mathematics education is the enhancement of achievement, problem solving skills, attitudes and inculcate values. How cooperative learning affects student achievement and problem solving skills was investigated by Effandi (2003). This study of intact groups compares students' mathematics achievement and problem solving skills. The experimental section was instructed using cooperative learning methods and the control section was instructed using the traditional lecture method. Cooperative group instruction showed significantly better results in mathematics achievement and problem solving skills. The effect size was moderate and therefore practically meaningful. He also found that students in the cooperative learning group had a favorable response towards group work. He concluded that the utilization of cooperative learning methods is a preferable alternative to traditional instructional method. Another study by Lee Guak Eam (1999), using TGT and STAD as a model found that students who were taught with a cooperative structure outperformed the students in individualistic goal structure in mathematics problem solving. Other researchers have reported similar findings that point to the achievement benefits of using cooperative learning (Faizah, 1999; Yee, 1995).

Apart from achievement and problem solving, students should also be inculcated with attitudes and values that are appropriate to their life as a student. Nor Azizah et al. (1996), in their study involving 966 pupils and using STAD and Jigsaw II structures, found that cooperative learning can inculcate values such as independent, love and cleanliness. Similar study done by Siti Rahaya (1998) using STAD/Jigsaw as a model which involved 1180 students from 18 schools, concluded that the values of self dependent, rational, love and hard working are prominently inculcated. It was also found that cooperative learning can enhance scientific skills, promote enquiry learning and increase science achievement. The students were found to enjoy learning in groups. According to Nor Azizah and Chong (2000), the result of the two studies varies due to differences in school background and type of students in the respective school.

Attitude has also been the focus of more than one study in cooperative learning. A study conducted by Abdul Halim (2000) found that students in the experimental group held positive attitudes toward science. Zainun (2001) examined the effect of cooperative learning using STAD as a model. Results indicated a positive attitude toward mathematics. Most students also have positive perception towards STAD. Another study conducted by Mazlan (2002) found that students in the experimental group held positive attitudes toward mathematics. However, a study by Meriam Ismail (2000), using TGT (*Teams Game Tournament*) showed that there was no significant difference in attitudes toward mathematics between experimental and control groups. The short treatment period of 3 ½ weeks might be the possible reason for no significant difference between the two groups.

CHALLENGES

Incorporating cooperative learning in science and mathematics classroom is not without challenges. Initially, teachers and students have to face various challenges. The main problems which arise include the followings:

- *Need to prepare extra materials for class use*

The need to prepare materials require a lot of work by the teachers, therefore, it is a burden for them to prepare new materials.

- *Fear of the loss of content coverage*

Cooperative learning methods often take longer than lectures. Teacher conclude that it is a waste of time

- *Do not trust students in acquiring knowledge by themselves*

Teachers think they must tell their students what and how to learn. Only the teachers have the knowledge and expertise.

- *Lacks of familiarity with cooperative learning methods*

Cooperative learning is new to some teachers so they need times to get familiar with the new method. Intensive in-service course can be implemented to overcome the problem.

- *Students lack the skills to work in grou*p

Teachers are often concerned with students' participation in group activities. They think that students lack the necessary skills to work in group. However, according to Ong and Yeam (2000) teachers should teach the missing skills and/or review and reinforce the skills that students need.

CONCLUSION

Changes are needed in science and mathematics teaching. Teachers should give less emphasis on students acquisition of information, presenting scientific and mathematical knowledge through lecture, asking for recitation of acquired knowledge and working alone. More emphasis should be given on students understanding of a particular concept, guiding students in active learning, providing opportunities for discussion and elaboration and encouraging them to work with peers and teachers. In a recent development, the government has introduced the use of English as the medium of instruction in science and mathematics. This move would provide students the opportunities to keep abreast with the rapid development of knowledge in science, mathematics and technology. Collaborative effort with students from other countries is now possible and should be supported.

Findings of cooperative learning study should be disseminated to all schools in Malaysia to encourage other teacher to consider this instructional approach. A staff development program should focus on the needs of the teachers. Needs analysis study should be done before running any courses. The courses should be hands-on and include basic concepts of cooperative learning and the rationale for using cooperative learning in schools setting. Although cooperative learning cannot cure all the problems faced by teachers in teaching and learning science and mathematics, it may serve as an alternative to traditional method of teaching.

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Reform- Based Curriculum & Acquisition of the Levels

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The aim of this study was to compare the acquisition of the van Hiele levels of sixth-grade students engaged in instruction using a reform-based curriculum with sixth-grade students engaged in instruction using a traditional curriculum. There were 273 sixth-grade mathematics students, 123 in the control group and 150 in the treatment group, involved in the study. The researcher administered a multiple-choice geometry test to the students before and after a five - week of instruction. The test was designed to detect students' reasoning stages in geometry. The independent-samples t-test, the paired-samples t-test and ANCOVA with α = .05 were used to analyze the data. The study demonstrated that although both types of instructions had positive impacts on the students' progress, there was no statistical significant difference detected in the acquisition of the levels between the groups.

Keywords: Curriculum, Middle School, Acquisition of Levels, Geometry

INTRODUCTION

Van Hiele Theory Based Curricula & Acquisition of the Levels

Over the past few decades, researchers have found that many students encounter cognitive difficulties in learning geometry in both middle and high schools (e.g., Hoffer, 1981; Usiskin, 1982; Burger & Shaughnessy, 1986; Crowley, 1987; Fuys, Geddes, & Tischler, 1988; Gutierrez, Jaime, & Fortuny, 1991; Mason, 1997). Moreover, results of the Third International Mathematics and Science Study (TIMSS) in both 1995 and 1999 clearly exemplify a general decline in academic performance between fourth and eighth graders. Both TIMSS studies reveal that fourth graders' achievements in the United States in mathematics were at the top level among students from 38 countries that participated in the study. However, US eighth-grade students did not show the same success as fourth-grade students. Their mathematics performances were at the average level. Yet it is clear from the studies that there is a decline in the performance of these students in mathematics between fourth and eighth grade. What causes students' low performances in mathematics at the middle school level? The reasons might be socio-economical, political, environmental, instructional, or other factors.

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Usiskin's study (1982) indicates that many students fail to grasp key concepts in geometry, and leave their geometry classes without learning basic terminology. He says that systematic geometry instruction might help students gain greater geometry knowledge and proof-writing success. Burger & Shaughnessy (1986) claim that sequencing instruction has positive effects on students' success and feelings about self, the topic, and skills. If initial activities are frustrating and not interesting, students might not be motivated to learn, but if the activities are not challenging, they might not attract students' attention to the topic and might fail to generate a sense of success. The tasks in instruction should contain respectable challenges that students can achieve (Hoffer, 1986; Messick & Reynolds, 1992). Moreover, research shows a decline in students' motivation toward mathematics courses (e.g., Gottfried, Fleming, & Gottfried, 2001). Furthermore, according to Billstein & Williamson (2003), "declines in positive attitudes toward mathematics are common among students in the middle school years" (p. 281). In fact, Ryan & Pintrich (1997) and Dev (1998) state that there

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is a positive correlation between students' achievement and motivation in mathematics.

According to Usiskin (1982), Burger & Shaughnessy (1986), Fuys et al. (1988), Messick & Reynolds (1992) and Geddes & Fortunato (1993), Reys, Reys, Lapan, Holliday, & Wasman (2003), and Billstein & Williamson (2003), the quality of instruction strongly influenced by curricula is one of the greatest influences on students' accomplishment in mathematics classes. No one type of instruction can respond to the needs of all students who may be varied in their interests, talents, and learning styles. Nor can one type of instruction be employed 100 percent of the time. This is why other approaches, such as student-centered, cooperative learning, and discovery learning are recommended for the teachers to enhance the effectiveness of their teaching and students' learning. These approaches also should not be utilized 100 percent of the time (Skemp, 1987; Messick & Reynolds, 1992).

Fuys, Geddes, & Tischler (1988) also promote the idea that no one type of instruction can support the needs of students to reach a higher level of reasoning. According to them:

It is possible that certain methods of teaching do not permit the attainment of the higher levels so that students cannot gain the methods of thought at these levels. It is also possible to face some phenomena that would take place between a student and a teacher who are operating at different levels and also between a student and a textbook author (p.76).

As expressed above, it is apparent that the students in any given classes may show variation in interests, capabilities, and intelligences. All of these translate into corresponding variations in learning styles, or preferred modes of learning. In responding to this variation, the instructors show different ways for students to succeed based on their learning styles. Furthermore, it is also important and necessary to give students experience in adapting to other types of learning. These studies suggested that different instructional approaches should be utilized in teaching, and students should be given a degree of freedom to choose activities that enhance their understanding of the subject.

Briefly, the role of instruction is crucial in teaching and learning geometry as expressed by Usiskin (1982), Fuys, Geddes, & Tischler (1988), and Messick & Reynolds (1992). However, the more systematically structured the instruction, the more helpful it will be for middle school students to overcome their difficulties and to increase their understanding of geometry.

Purpose of the Study

The study focused on the comparison of effects of curricula on the students' acquisition of the levels in geometry at the middle school level. This focus was based on concerns expressed by Crowley (1987) as "the need … is for classroom teachers and researchers to refine the phases of learning, develop van Hiele based materials, and implement those materials and philosophies in the classroom setting" (p. 15). While the students in the treatment group were exposed to an instruction using a reform-based curriculum designed on the van Hiele theory, the others in the control group were exposed to an instruction following a traditional one. The following question guided the study:

What differences exist between students who were instructed with a reform-based curriculum and students instructed with a conventional one with reference to the acquisition of the levels in geometry?

The researcher agrees with the recommendation of NCTM (2000) stating that new educational theories and approaches should be used in teaching in order to help students overcome their difficulties in mathematics. In addition, knowing theoretical principles gives teachers an opportunity to devise practices that have a greater possibility of succeeding (e.g., Swafford, Jones, & Thornton, 1997). Furthermore, standard-based curricula have positive impact on students' performance and motivation in mathematics (e.g., Billstein & Williamson, 2003; Chapell, 2003). Based on over twenty years of research it is clear that the van Hiele theory is a well-structured and well-known theory having its own reasoning stages and instructional phases in geometry. Many researchers have studied and confirmed different aspects of the theory since proposed by the van Hieles. The present study adds to the set of studies by examining the validity of the van Hiele theory in terms of curricula.

Theoretical Framework

The National Council of Teachers of Mathematics (2000) suggests that new ideas, theories, research findings and approaches be utilized in teaching and learning mathematics, especially the van Hiele theory in geometry. Knowing theoretical principles provides an opportunity to devise practices that have a greater possibility of succeeding. The van Hiele model of thinking that was structured and developed by Pierre van Hiele and Dina van Hiele-Geldof between 1957 and 1986 focuses on geometry. The van Hieles described five levels of reasoning in geometry. These levels are level-I (Visualization), level-II (Analysis), level-III (Ordering), level-IV (Deduction), and level-V (Rigor). Studies (e.g., Mayberry, 1983; Hoffer, 1986: van Hiele, 1986) have proposed that movement from one level to the next level includes five phases: information, bound (guided) orientation, explicitation, free orientation, and integration. Today, this model is a foundation for curricula implemented in mathematics classrooms.

Research since the early 1980s has helped to confirm the validity of the theory (e.g., Hoffer, 1981; Usiskin, 1982; Mayberry, 1983; Fuys, Geddes, & Tischler, 1988).

Research has been completed on various components of this teaching and learning model. Wirszup (1976) reported the first study of the van Hiele theory, which attracted educators' attention at that time in the United States. In 1981, Hoffer worked on the description of the levels. Usiskin (1982) affirmed the validity of the existence of the first four levels in geometry at the high school level. In 1986, Burger and Shaughnessy focused on the characteristics of the van Hiele levels of development in geometry. Fuys, Geddes, and Tischler (1988) examined the effects of instruction on a student's predominant Van Hiele level. Briefly, some of these researchers, such as Usiskin (1982), Mayberry (1983), and Burger & Shaughnessy (1986) confirmed the validity of levels and investigated students' behavior on tasks. Some of them, such as Usiskin (1982), Senk (1989), Gutierrez, Jaime, & Fortuny (1991), Mason (1997), and Gutierrez & Jaime (1998) evaluated and assessed the geometric ability of students as a function of van Hiele levels.

In this study, the 1-5 scheme was used for the levels. This scheme allows the researcher to use level-0 for students who do not function at what the van Hieles named the ground or basic level. It is also consistent with Pierre van Hiele's numbering of the levels. For this report, all references and all results from research studies using the 0-4 scale have been changed to the 1-5 scheme.

Although the existence of level-0 is the subject of some controversy (e.g., Usiskin, 1982; Burger & Shaughnessy, 1986), Van Hiele (1986) does not talk and acknowledge the existence of such a level. However, Clements and Battista (1990) talked about the existence of a level–0 called prerecognition. Clements and Battista (1990) have described and defined level-0 (Prerecognition) as "Children initially perceive geometric shapes, but attend to only a subset of a shape's visual characteristic. They are unable to identify many common shapes" (p. 354). For example, learners may see the difference between triangles and quadrilaterals by focusing on the number of sides the polygons have but not be able to distinguish among any of the quadrilaterals (Mason, 1997).

METHODOLOGY

Methods of Inquiry

Quasi-experimental statistical design was used in the study. The researcher employed a control group to compare with the experimental group, but participants were not randomly selected and assigned to the groups (Creswell, 1994; McMillan, 2000). According to Creswell (1994), the nonequivalent (Pretest and Posttest) control group design model is a popular approach to quasi-experiments. In this study, while the experimental (treatment) group included students who were instructed with the reform-based curricula, the control group comprised students who were instructed with a curriculum not designed based on the van Hiele theory.

The researcher chose the experimental research method because "it provides the best approach to investigating cause-and-effect relationships" (McMillan, 2000, p. 207). In the study pre-test and post-test were given to the participants before and after the instruction as an independent variable. The researcher investigated the effects of an instruction using a reform-based curriculum on the students' attainment of the levels in geometry. The comparison of students' attainment of levels was made in the study. Therefore, this experimental approach enabled the researcher to evaluate the effectiveness of an instruction using a curriculum based on the van Hiele-theory with the results of the geometry test in mathematics classroom.

Participants

In this study the researcher followed the "convenience" sampling procedure defined by McMillan (2000), where a group of participants is selected because of availability. Participants in the study were sixth-grade students enrolled in twelve mathematics classes at two public middle schools in north Florida. The researcher chose these two schools based on their curriculum practices and permissions of the schools' principals. One of these was following a reform-based curriculum, and the other one was using a traditional curriculum in their geometry teaching. The total number of students involved in the study was 273. The majority of the students were from low socioeconomic income families.

Data Sources

The data collection processes started with giving students a geometry test called *Van Hiele Geometry Test (VHGT)* used as pre-test and post-test in the study. The VHGT was administered to the participants by the researcher before and after the instruction during a single class period. The *Van Hiele Geometry Test (VHGT)* consists of 25 multiple-choice geometry questions to be administered in 35 minutes. The VHGT was taken from the study of Usiskin (1982) with his written permission. The VHGT is designed to measure students' van Hiele levels in geometry. There are some questions or examples found in the (non-Van Hiele based) *Middle School Math Course-I* that are similar to the items in the Van Hiele Geometry Test (VHGT). For example, "Draw an example of each figure… 16.

Trapezoid; 17. Parallelogram; 19. Rectangle; 20. Square; 21.Quadrilateral" (p. 438). Or, "(Problem Solving and Reasoning) Every square is also a rectangle, but every rectangle is not necessarily a square. Explain." (p. 437). This would help to diminish the possibility that the VHGT test being used was biased towards the curricula designed based on the van Hiele theory. In the study, students in both groups met for one hour of geometry instruction a day for five days per week.

Instructional Curricula

The instruction following the van Hiele theory-based materials used curricula designed on the van Hiele theory, based on *Shapes and Designs* (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996) and *Discovering Geometry: An Inductive Approach* (Serra, 1997) in which textbook authors wrote their materials based on the first three van Hiele levels (Level-I: Recognition, Level-II: Analysis, and Level-III: Order). The instruction following the traditional curriculum that was based on *Middle School Math Course I* (Charles, Dossey, Leinwand, Seeley, & Embse, 1998) not designed on the van Hiele theory and addressed the first three van Hiele levels' (Level-I, -II, -III) geometry knowledge. The topics, consisting of polygons such as triangles and quadrilaterals, angle relations, properties, and transformation and tessellation, were taught during the five weeks of instruction. The mathematics teachers using the reform-based curricula implemented the CMP's instructional model, launch, explore and summarize, in their teaching of geometry.

Test Scoring Guide

All students' answer sheets from VHGT were read and scored by the investigators. All students got a score referring to a van Hiele level from the VHGT guided by Usiskin's grading system. "For Van Hiele Geometry Test, a student was given or assigned a weighted sum score in the following manner:

- 1 point for meeting criterion on items 1-5 (level-I)
- 2 points for meeting criterion on items 6-10 (level-II)
- 4 points for meeting criterion on items 11-15 (level-III)
- 8 points for meeting criterion on items 16-20 (level-IV)
- 16 points for meeting criterion on items 21-25 (level-V)" (1982, p. 22)

Analysis of Data

The data were responses from students' answer sheets. In the process of the assessment of students' van Hiele levels, the criterion for success at any given level was three out of five correct responses. First the researcher conducted the independent-samples t-test statistical procedure with $\alpha = .05$ on the students' pretest scores to determine any differences in terms of performance between the two groups. This t-test procedure showed means score differences in terms of levels between the two groups favoring the control group. Then, scores from the VHGT were compared using one-way analysis of covariance (ANCOVA) with $\alpha = .05$, which is a variation of ANOVA, to adjust for pretest differences that existed between control and treatment groups. "For instance, suppose in an experiment that one group has a mean value on the pretest of 15 and the other group has a pretest mean of 18. ANCOVA is used to adjust the posttest scores statistically to compensate for the 3-point difference between the two groups. This adjustment results in more accurate posttest comparisons. The pretest used for the adjustment is called the covariate" (McMillan, 2000, p. 244). In other words, because of the initial differences in regard to students' levels between the two groups, ANCOVA was employed to analyze the quantitative data in the study. The pretest scores from the Van Hiele Geometry Test served as the covariate in the analysis of students' levels by curricula and gender effect. ANCOVA enabled the researcher to compare the VHGT scores of each group.

Furthermore, the paired-samples t-test with $\alpha = .05$ was used to detect the mean differences between pre-test and post-test scores of students in each group separately based on the Van Hiele Geometry Test. The paired-samples t- test procedure compares the means of two variables for a single group. It computes the differences between values of the two variables for each case. This also helped the researcher see the effects of each curriculum on students' attainment of levels for each group. Finally, the researcher constructed frequency tables to get deep information about students' van Hiele levels distributions for both groups.

RESULTS

What differences exist between students who were instructed with a reform - based curriculum and students instructed with a conventional one with reference to the acquisition of the levels in geometry?

Table 1 presents the descriptive statistics and the paired-samples t-test for students' van Hiele levels by the curricula in both the treatment and control groups. According to the paired- samples t-test, the mean score differences between the pre-test and post-test on the VHGT in the treatment group is statistically significant, [$p < .001$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$], and the mean score differences between the pre-test and post-tests on the VHGT in the control group is also statistically significant, [$p < .025$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$]. Based on these statistical test results, one would say that both instructional models either reform-based or traditional have positive effects on the students' acquisition of the levels in geometry.

Although Table 1 indicates that there is a gain in both groups, the gain of the treatment group is relatively higher than that of the control group, [the mean score of the treatment group is 1.050[a], and the mean score of the control group is .930[a]]. However, the analysis of covariance (ANCOVA) (see Table 2) shows there are no statistically significant differences on the van Hiele levels of students who were instructed with a reform-based curriculum designed on the van Hiele theory compared to students instructed with a conventional one not designed on the van Hiele theory in learning geometry [$F(1, 272) = 2.222$; $p > .05$].

According to Burger & Shaughnessy (1986), the progress through the levels is continuous and not discrete. Despite the fact that students generally are assigned to a single van Hiele level, there may be students who cannot be assigned to a single van Hiele level. Gutierrez, Jaime, & Fortuny (1991) used a 100 - point numerical scale to determine the van Hiele levels of students who reason between two levels. This numerical scale is divided into five qualitative scales: "'Values in interval' (0%, 15%) means 'No Acquisition' of the level. 'Values in the interval' (15%, 40%) means 'Low Acquisition' of the level. 'Values in the interval' (40%, 60%) means 'Intermediate Acquisition' of the level. 'Values in the interval' (60%, 85%) means 'High Acquisition' of the level. Finally, 'values in the interval' (85%, 100%) means 'Complete Acquisition' of the level'" (p. 43).

The mean score .93 of the control group can be explained with the scale described above. The score .93 can be placed into the last interval named "Complete Acquisition" of the level. In other words, students who were in the control group completed the previous level, level-0 (Pre-recognition), identified by Clements & Battista (1990), and they have attained the next level, level-I (Visualization or Recognition), described by van Hiele (1986). At level-I students recognize and identify geometric figures according to their appearance, but they do not understand the properties or rules that define the figures. For example, they can identify a rectangle, and they can recognize it easily because of its shape, which looks like the shape of a window or a shape of a door. On the other hand, the interpretation of the mean' score 1.05 for the treatment group would be that students' average van Hiele level falls between levels-I and -II. Using the interval scale, the .05 indicates that there is no acquisition of level -II understanding. Therefore, students in both groups demonstrated level-I reasoning stage in geometry.

Another way to see a difference (again, not statistically significant) between the control and treatment groups is to look at students' progress from one level to another level (Table 3). For example, 20% (37.3% - 17.3%) of students in the treatment group moved to a higher Van Hiele level, while 10% (37.4% - 27.6%) of students in control group moved from level-0 to the higher levels. Thus, more students in the treatment group progressed from level-0 to level-I than

Table 1. Descriptive Statistics and the Paired-Samples T-Test for Students' van Hiele Levels by Instructional models

Groups	N	Pretest		Posttest			Posttest*	
		M	SD	M	SD	t	M	SE
Treatment	150	.69	.581	1.05	.698	-5.923**	1.05[a]	.05
Control	123	.71	.610	.93	.710	-3.342***	.93[a]	.06
Total	*273*							

Note. a: Evaluated at covariates appeared in the model: Pre- level = .70,
*Estimated Marginal Means.
**$p < .001$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$.
***$p < .025$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$.

Table 2. Summary of ANCOVA for Students' van Hiele Levels by Instructional models

Sources	Sum of Squares	df	Mean Square	F-statistic
Pretest	15.767	1	15.767	35.959
Group	.974	1	.974	2.222

Note. p >.05

Table 3. Frequency Table for Students' van Hiele Levels by Instructional models

Groups	N		Level-0 n	Level-0 %	Level-I n	Level-I %	Level-II n	Level-II %
Treatment	150	Pre- levels	56	37.3	85	56.7	9	6
		Post- levels	26	17.3	98	65.3	26	17.4
Control	123	Pre- levels	46	37.4	67	54.5	10	8.1
		Post- levels	34	27.6	64	52	25	20.4

Note. n is the number of students in selected group.

in the control group. Students' progress from levels-0 and-I to level-II are almost the same for both groups, 11.4 % (17.4% - 6%) for the treatment group, and 12.3 % (20.4% - 8.1%) for the control group.

DISCUSSION

Students' Overall van Hiele Levels

None of the sixth-grade students in the study progressed beyond level-II (analysis). Most students' van Hiele geometry levels were level-0 (prerecognition) and -I (visualization). This result is in accordance with the findings of Burger & Shaughnessy (1986), Crowley (1987), and Fuys et al. (1988) who found that generally level-I reasoning took place in grades K-8. This supports the idea that most younger students and many adults in the United States reason at levels-I (visualization) and –II (analysis) of the van Hiele scale (Usiskin, 1982; Hoffer, 1986). One would expect a greater performance from these students in both the treatment and control groups, because the curricula used in both groups contain levels-0 (pre-recognition), -I (visualization), -II (analysis) and -III (ordering) geometry knowledge. Nonetheless, students taking the geometry classes with the intended curricula were directed toward level-III geometry knowledge at the end of the geometry instruction, which is an implicit expectation of the students in both groups.

Acquisition of the van Hiele Levels

The paired-samples t-test regarding the attainment of the levels for both the treatment and control groups indicated that there was a gain for both groups. The growth of students in the treatment group between the pre-and post Van Hiele Geometry Test scores was statistically significant. Similarly, the mean score differences of the students in the control group was also statistically significant. Therefore, one would say that both instructional models, whether based on the van Hiele theory or not, have positive impacts on the students' acquisition of the levels in geometry. But the gain of the students in the treatment group was numerically higher than that of their counterparts in the control group. Based on the ANCOVA results, the mean score differences of the students' attainment between the two groups, however, was not statistically significant. This means that students instructed according to the conventional curriculum for five weeks of instruction in the sixth-grade level on the geometry test matched the reasoning stage of the students instructed with the reform-based curricula.

The National Council of Teachers of Mathematics (NCTM) (2000) recommends the use of new styles and approaches in teaching and learning in mathematics. These new styles and approaches may help students develop mathematical learning. Moreover, research has documented that standards-based curricula (e.g., Connected Mathematics Project, MATH Thematics, University of Chicago School Mathematics Project, Core-Plus Mathematics Project, and Everyday Mathematics) have a more positive effect on students' learning of mathematics more than the more traditional curricula (cf., Fuson, Carroll, & Drueck, 2000; Huntley, Rasmussen, Villarubi, & Fey, 2000; Thompson & Senk, 2001; Carroll & Isaac, 2003; Reys, Reys, Lapan, Holliday, & Wasman, 2003; Senk & Thompson, 2003).

In this study, teachers in the treatment group implemented the van Hiele theory- based materials for five weeks. Although the implementation of these materials showed positive impact on students' learning to some extent, students did not reach levels expected by the researcher. This is in contrast with the argument stating that the van Hiele theory-based curriculum may be more helpful than the conventional one (e.g., Crowley, 1987). In other words, the finding of this study related to students' growth in terms of levels in geometry did not support Crowley's claim. Clearly, one study does not suffice to observe and examine the effects of the van Hiele theory-based curricula; in this area, more studies are needed. In the study, the two teachers who instructed the students in the treatment group were knowledgeable, but not at an expertise level with regard to the van Hiele theory and its philosophies. According to Swafford, Jones, & Thornton (1997), an intervention program consisting of a content course in geometry and a research seminar presenting the van Hiele theory and its philosophies had significant effects on the middle grade teachers who claimed that knowing the van Hiele theory and its philosophies positively changed their perception of teaching geometry and their approaches to their students in the classrooms. In addition, Mayberry (1983) and Fuys, Geddes, & Tischler (1988) stated that content knowledge in geometry among pre-service and in-service middle school teachers is not adequate. According to Chappell (2003) "Individuals without sufficient backgrounds in mathematics or mathematics pedagogy are being placed in middle school mathematics classrooms to teach" (p. 294).

The finding of the study does not resonate with the argument of Usiskin (1982) who said that if students were supported with a systematic geometry instruction, they could have greater geometry knowledge than other students. Authors of the two textbooks used in the treatment group, expressed that they wrote these books based on the van Hiele levels that are hierarchical and continual. One would expect a relatively stronger impact from these materials on students' learning in geometry because the curriculum materials (e.g., textbooks) profoundly affect teachers and guide the instructions in the mathematics classes (e.g., Driscoll, 1980; Reys et al., 2003).

The finding of the present study, on the other hand, is in accordance with the reports of Reys et al. (2003) who conducted research that compared the achievement of eighth grade students using NSF-funded standards-based middle grade mathematics curriculum materials (MATH Thematics or Connected Mathematics Project) with students using traditional textbooks for at least a two-year period from 1997 through 1999. In the study, "geometry and spatial sense" was one of six content strands examined: Number Sense; Geometry and Spatial Sense; Data Analysis, Probability, and Statistics; Algebra; Mathematical Systems; and Discrete Mathematics. Their study showed that the mean' score (60.94) of students using the Connected Mathematics Project (SB3) in terms of achievement on geometry and spatial sense was numerically higher than the mean score (57.27) of students not using the same curriculum materials at the eighth grade level. This achievement difference, however, was not statistically significant for geometry learning. They stated, "Students using the NSF Standards-Based curriculum (using the CMP materials) had significantly higher scores than nonusers (not using the CMP materials) on two of the six content Standard scales: Data Analysis, Probability, and Statistics; and Algebra" (p. 86).

Reys et al. (2003) resolved that students using the NSF-funded standards-based curriculum (the Connected Mathematics Project or MATH Thematics) materials equally performed or showed greater performance on the mandated state mathematics achievement test than students who used other traditional curriculum materials in middle grades for at least two years. Although the present study was not done with eight graders, one of the van Hiele theory-based curricula was "Shapes and Designs" for sixth graders from the Connected Mathematics Project materials. The result of the study as to the students' acquisition of geometry knowledge is consistent with their finding. However, the study of Reys et al. (2003) pointed out that students using MATH Thematics curriculum materials, an NSF- funded standards-based curriculum, outscored their counterparts using traditional textbooks in all the six content strands. In other words, in particular students using MATH Thematics curriculum materials displayed statistically significant performance on the mandated state mathematics achievement test than nonusers in geometry and spatial sense.

In light of the effects of the standards-based curricula on students' learning, one would expect that students instructed with a reform-based curricula designed on the van Hiele theory may have shown more gain in learning geometry than their counterparts instructed with a conventional one. Indeed, in this study both instructional models either reform-based or traditional one made equally positive impacts on students' learning of geometry. When interpreting the students' test scores representing an overall low performance with respect to the objectives specified in the curriculum materials, it is prudent to take into account the fact that the teaching-and-learning process can be affected by other factors, such as classroom settings, instructions, parents' support, teachers' help, peers' support, students' interests, learning styles, cognitive competencies, and fear of punishment (e.g., Usiskin, 1982; Burger & Shaughnessy, 1986; Reys et al., 2003). In practice, it is difficult to control one of these variables in order to measure precisely the impact of the curricula on the students' acquisition of geometry knowledge. Therefore, the researcher was not able to control them under the circumstances of the study.

According to Berliner (1989), "The parents who know how to deal with schools will seek ways to help their children. These will be people who were successful school attendees, generally middle-class parents" (p. 336). Students who were involved in this study were from low socio-economic income families. In addition, Eccles & Midgley (1989) claimed, "many young adolescents experience decrease in teacher trust of students, opportunities for student autonomy, teachers' sense of efficacy, and continuous, close, personalized contact between teachers and students and between students and their peers" (p.140). Moreover, Weinstein (1989) said, "important relationships were found between classroom environmental attributes and learning outcomes. Children's perceptions of classroom climate became important as a source of environmental description" (p. 192).

In short, according to Usiskin (1982), Mayberry, (1983), Burger & Shaughnessy (1986), Fuys et al. (1988), and Geddes & Fortunato (1993), the quality of instruction is one of the greatest influences on the students' attainment of geometry knowledge in mathematics classes. And the students' progress from one level to the next also depends on the quality of instruction more than other factors, such as biological maturation or students' age, environment, parents' support, and peers' support (e.g., Crowley, 1987). The curriculum materials (e.g., textbooks) deeply influence teachers and guide the instructions in the mathematics classes (e.g., Driscoll, 1980; Reys et al., 2003). In addition, another factor behind students' low van Hiele levels in the study might be teachers' geometry knowledge. Mayberry (1983) and Fuys et al. (1988) argued that content knowledge in geometry among pre-service and in-service middle school teachers is insufficient.

Limitation

A student can perform better in one area and yet not show the same performance level in other areas (Fuys et al., 1988; Burger & Shaughnessy, 1986). The geometry topics investigated in the study were polygons and tessellations. The findings of the study could not be applied to all geometry topics. The duration of time given by the schools for the topics to be learned was not enough. Time constraints also pushed the teachers to limit their instruction and the students' interactions with each other in the classes. Certainly, students needed more time to think about the subject matter, work on the tasks assigned by the teacher, and to share their ideas in the class. There were also four mathematics teachers involved in the study. The teachers being in different age groups and having different levels of experience may have limited the findings of the study. Romberg & Shafer (2003) expressed that "the instructional experiences affect students' learning of mathematics with understanding" (p. 245). In addition, the vast majority of the students were from low socio-economic income families. Therefore, these findings should not be assumed to generalize to students from other socio-economic income families.

CONCLUSION

Finally, the study reached several conclusions based on the quantitative data. First, most of the students' van Hiele levels on the Van Hiele Geometry Test in both the treatment and control groups were levels-0 (pre-recognition) and -I (visualization). No one performed above level-II (analysis) among the students involved in the study. Second, both instructional models on either reform-based or traditional had positive impacts on the students' acquisition of the geometry knowledge, but there was no difference between the effects of the curriculums on the students' progress. In other words, students instructed with the reform-based curriculum designed on the van Hiele theory on the geometry test for five weeks at the sixth grade level equaled the progress of the students instructed with a conventional curriculum material.

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Secondary School Students' Partipation in Environmental Action: Coercion or Dynamism?

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This article reports emerging findings from qualitative research in 22 secondary schools in Bungoma District of Kenya. It focuses particularly on the nature and dynamics of students' participation in environmental action within the framework of the established school curriculum. Drawing on in-depth pilot study during the first year of the research, the paper discusses the type of environmental activities in which students frequently participate in their local environments and the mode of such participation. Informed by the relevant literature, it is shown that dynamic qualities, which seem to facilitate environmental action, develop in those students exposed to active environmental education. It is hoped that this paper will lead to further dialogue in this critical area of practice and research.

Keywords: Participation, Coercion, Qualitative Research, Dynamic Qualities, Environmental Action, Environmental Education

INTRODUCTION

Background of the Problem

Although the exploitation of the Earth's resources for development purposes started since the beginning of humankind, much of the environmental degradation we see today is the result of increased human consumption of natural resources which began during the industrial revolution. Since that time up to now humankind's relationship with the planet Earth has been guided by the "anthropocentric paradigm": That nature is separate from, and it subordinates, the needs and wants of humans. Hence resources have been exploited indiscriminately as if this has no long-term effect on humans themselves. As a result of humans' unsustainable development activities, the planet Earth is now in critical danger.

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To correct and prevent any further environmental degradation the United Nations Conference on the Human Environment held in Stockholm in 1972 urged all countries of the world to incorporate environmental education in their curricula at all levels of education. A follow-up conference held in Tbilisi in 1977 outlined the objectives and implementation strategies of environmental education. The primary goal was to empower the world population to maintain and enhance environmental quality. One of the key specific objectives was that environmental education should provide individuals and social groups with an opportunity to be actively involved at all levels working towards the resolution of environmental problems (UNESCO, 1980). Environmental education was therefore symbolic of modern environmentalism espousing the "biocentric" and "new environmental" paradigms that had began and have continued to gain ground all over the world. Modern environmentalism start with the premise that we bear the responsibility of our actions towards nature and therefore our eyes and hearts must be educated. The anthropocentric view of nature as being separate from and external to human consciousness is thus challenged.

The United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 reiterated, in Agenda 21, that through environmental education school children are obliged to participate actively in guarding the quality of the environment. This is because they comprise half of the world population and are highly vulnerable to the effects of environmental degradation now and in the future (United Nations, 1994). Moreover, secondary school students are usually receptive and strongly motivated and are capable of understanding the implications of environmental destruction and of trying to take preventive action (UNEP, 1990). However, for school children to meaningfully participate in environmental conservation activities, they should posses dynamic qualities gained through environmental education (Kelley - Laine, 1991). Dynamic qualities are personal qualities of thought, feeling and action which develop in the students through a process of learning in which understanding and action are key features (Posch, 1991, p.3).

Statement of the Problem

As efforts to intensify environmental education in schools have continued to increase over the years, a considerable number and variety of claims have been raised severally concerning the inability of the students to participate in environmental action. In Kenya for example, whereas environmental education has existed in secondary schools since 1985, concern has been raised to the effect that students do not adequately participate in protecting and enhancing environmental quality. In 1991, for example, the Minister for Environment and Natural Resources voiced his concern for the lack of practical conservation principles in the students' daily activities (Kenya Times, Nairobi, 19 August, 1991). Similar observations have been made in other parts of the World (Tubianosa, *et al.*, 1995). It is becoming increasingly necessary to see the evidence supporting these claims.

Research dealing with students' participation in environmental action has tended to focus on the products in the environment rather than on the process involved in arriving at such action. The studies done by Buskov (1991), Folkedal (1991), Pieters (1991), Sutti (1991), Gagliardi and Alfhtan (1994) and Lindhe *et al.* (1993) are valid examples. Most of these researchers employed the systems – analysis approach that focuses on easily quantifiable variables relating to the quality of the products arising from environmental action projects as directed by the teachers. Data produced in this way may not necessarily provide an insight into the process of students' participation in environmental action. As Emmons (1997) observes, the relationship between environmental education and positive environmental action is a complex one and requires a deeper understanding of the contributing factors. This is because a behavioural manipulation of many variables can result in students' participation in environmental action in the manner that is pedagogically undesirable. Research designs that elicit phenomenological data could help us understand students' participation in sustaining and improving environmental quality.

Purpose of the Study

The purpose of this study was therefore to understand the impact of environmental education on secondary school students' participation in environmental action. The following specific research questions were addressed:-

1. In what environmental activities do the students participate to protect and improve the quality of their local environments?
2. How do the students participate in protecting and improving the quality of their local environment?
3. Which dynamic qualities affect students' actions in their local environments?

METHOD

This was a descriptive survey study which focused on the secondary school students' participation in environmental action. The method used to conduct the study is described more fully below.

Population

The study was conducted in Bungoma District, Kenya. The target population was 2,900 fourth form students (ranging in age from 16-18) who studied biology and geography in 111 secondary schools. The two subjects were selected because they contained more environmental topics than other subjects. The students were therefore presumed to have attained better competence in environmental education than the rest of the population.

The Sample

A modified stratified random sampling technique based on three geographical regions of the district was used to select the sample. From each stratum 20% of the schools were selected, giving a total of 22 schools. The accessible sample of students in these schools was 899, this being 31% of the target population. Because of fiscal and time constraints purposive sampling based on first term (1995) performance in the two subjects in teacher made tests was used to select 272 students, this being 30.25% of the accessible sample. In selecting the

Table 1. Sample Size and Distribution

Geographical Regions	No. of Schools	No. of Schools in sample (20%)	No. of Geography & Biology students	No. of student in sample (30%)
Mount Elgon & Slopes	12	2*	80	24
Middle Level Upland	53	11	493	149
Lowlands	46	9	326	99
Total	111	22	899	272

* Rounding off error

sample from each school only the top 30% were selected. It was assumed that better performers in the two subjects would provide greater information required for the study than their counterparts. Table 1 summarizes the size and distribution of the sample.

Pilot Study

The pilot study was carried out at Busakala secondary school to collect data that would help the researcher to develop and test the instruments. In the first phase which took twelve months qualitative data were collected through in-depth interviews, document analysis and participant observation.

In-depth interviews involved 11 informants. The informants included four top fourth form students in geography and biology, one geography teacher, one biology teacher, one teacher in charge of environmental club and four fourth form students who were members of the environmental club. All informants were interviewed individually. The interviews were semi-structured and allowed open-ended responses on the environmental matters at issue. The interviews focused on students' environmental action in their school, community and home environments. The interviews were based on the observed state of these environments. The researcher also visited the students' homes to validate the data.

The documents analyzed included syllabuses, past examination papers and students' textbooks and notebooks. The data collected from the documents focused on the kinds of environmental action activities students engaged in, the kinds of teaching methods and procedures employed in the activities, and the factors that supported or constrained teaching and learning environmental issues.

The researcher also joined students in activities such as games, lunch and tea break, and manual work assignments to observe how they interacted with the environment. A detailed account of these interactions was written later in the day. The data were analyzed to determine the environmental activities in which students frequently participated their mode of participation in the activities and the role of dynamic qualities in their environmental action.

Table 2 indicates a summary of the four environmental activities listed in each of the four broad categories in which the students frequently participated.

Table 2. Environmental Activities in which students Frequently Participated in Local Environments

Category of Environmental Activities	Individual Environmental Activities
A. Controlling visual pollution	1. Clearing cobwebs 2. Clearing garbage 3. Clearing graffiti 4. Clearing derelict
B. Taking environmental health and safety measures	1. Slashing grass/bush 2. Cleaning/repairing dormitories, classrooms, residential premises. 3. Boiling drinking water 4. Cleaning toilets/household gear
C. Improving environmental aesthetics	1. Planting flowers 2. Caring for flower beds 3. Landscaping 4. Pruning hedges
D. Conserving resources	1. Planting trees 2. Caring for trees 3. Conserving soil 4. Conserving water

It was also recognized that environmental action was mainly realized through punishment, routine manual work assignments, clubs, learning at school, and personal initiative. Eight dynamic qualities were identified which seemed to facilitate environmental action among some students. The qualities were categorized into basic and integrated dynamic qualities. The basic dynamic qualities included: showing sensitivity to environmental quality; monitoring one's action in relation to environmental quality; showing concern for environmental quality; and showing interest in environmental management. The integrated qualities included: Accepting and seeking responsibility for environmental action; Exercising initiative in conserving environmental quality; showing commitment to environmental conservation; and showing independence of thought and action in environmental action.

In the second phase one interview schedule (Appendix A) was developed based on the data gathered. The first section of the instrument consisted of two tasks and focused on the various environmental activities in which students frequently participated in their local environments, and the mode of participation in the activities.

The second section of the instrument which consisted of eight tasks elicited responses that would help determine the type and role of dynamic qualities developed by the students. The dynamic qualities were ascertained with the help of the second instrument titled 'Indicators of Dynamic Qualities Guide". The instrument was developed from the characteristics identified by Elliott (1990), Hungerford *et al.* (1989) and Vivian (1973) (See Appendix B).

The face and content validity of the two instruments was ensured by preparing a definition of what each purported to measure and took this along with the instruments to three independent researchers who scrutinized them for suitability of format and content. The interview schedule was then modified in light of their comments and administered to the third form students in the same school. The responses given by the students also helped in refining the instrument.

Procedures

In the main study each participant was interviewed with regard to his or her local environment (School, community, home) to identify the environmental activities he or she frequently participated in and the mode of such participation. For participation in any activity to merit being frequent, the student should have been involved in all the four major activities in each of the four broad categories for at least two days in a week in the last four or more months. To determine if they had developed a specific dynamic quality, the students were variously asked to state why they had either resolved or not resolved the problems in their local environments associated with the activities. From their responsive characteristics it was possible using the indicators in Appendix B to determine if they possessed the dynamic quality or not. The students were said to have developed the dynamic quality if they participated in all the environmental activities identified for the dynamic quality.

All the responses were recorded on the interview schedules and where the students accepted, these were tape –recorded and transcribed later. The interview transcripts were prepared and analyzed on a daily basis to allow the researcher get clarifications and to fill the gaps in the data before leaving the site.

Data Analysis Plan

Qualitative data analysis was done which continued during and after fieldwork. The responses on the interview schedule obtained from each site were examined and coded in relation to students' participation in environmental action. For the aspects dealing with dynamic qualities each response was matched with indicators of dynamic qualities to determine the quality expressed. From the categories frequencies were computed and percentages determined. Summary tables were then prepared for the purpose of data presentation and interpretation. Data were also presented verbatim to illustrate the common responses, where necessary.

RESULTS

The results presented in this section represent the common characteristics of secondary school students' participation in environmental action. These characteristics are grouped under the following broad environmental action dimensions:

- Environmental activities
- Mode of action
- Dynamic qualities.
- Environmental Activities

In this first task the students were required to state whether they frequently participated in all the four environmental activities in each broad category in the school, community and home environments. The students' responses were summarized as indicated in Figures 1-4.

From the figures it is clear that while the students participated in all 16 activities contained within the four broad categories, the proportions are very low considering the compelling significance of improving the quality of their local environments. On the average, only 42.5% participated in the activities while at school, 16.9% at their homes and 5.3% in the community surrounding the school. However, it is interesting to note that a greater proportion of the students tended to concentrate their efforts on controlling visual pollution and improving environmental health and safety in their school environments. This is related to the obvious emphasis by the school authorities on keeping the school premises clean and safe.

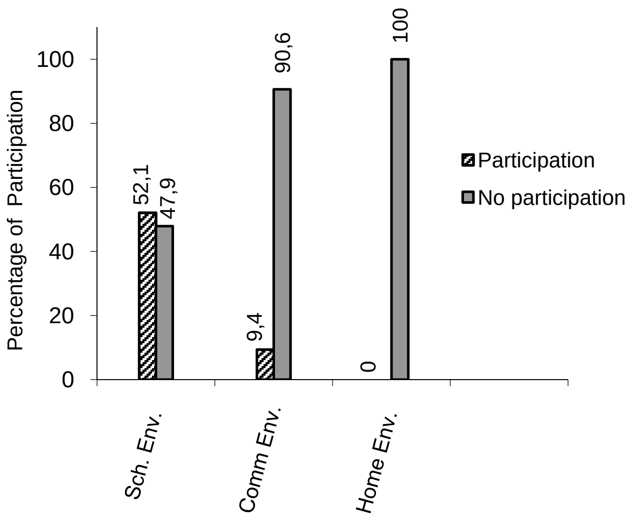

Figure 1. Proportion of students frequently participating in controlling visual pollution in local environments (*N*=272).

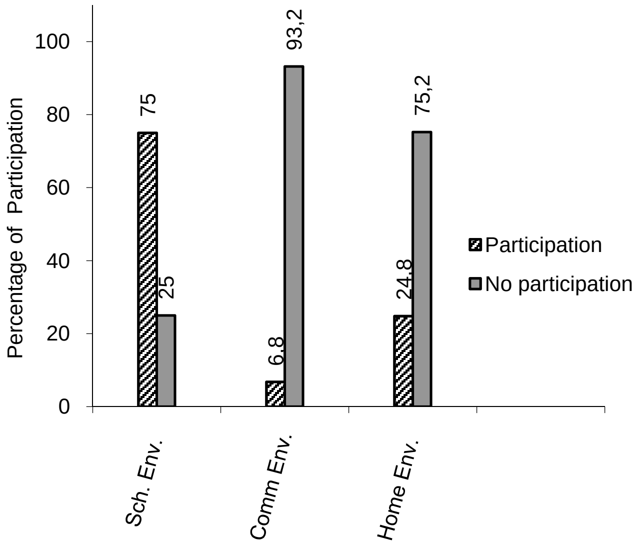

Figure 2. Proportion of students frequently participating in taking environmental health / safety measures in local environment (*N*=272).

Students' participation in caring for their local environments greatly improves their perception of it (Kelley - Laine, 1991). But if this is to be done within the framework of teaching and learning in environmental education, the students should take the lead. These results show the contrary as less than half of the students participated to some extent in protecting and improving the quality of their local environments.

Mode of Environmental Action

This task required the students to state the circumstances in which they frequently participated in each of

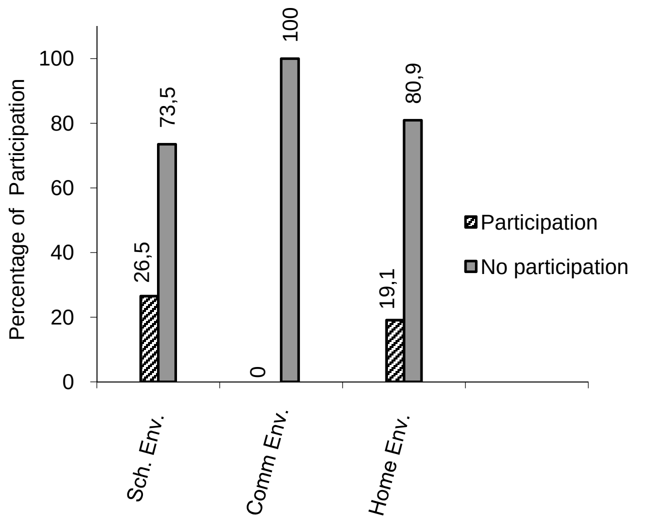

Figure 3. Proportion of students frequently participating in improving environmental aesthetics in local environments (*N*=272).

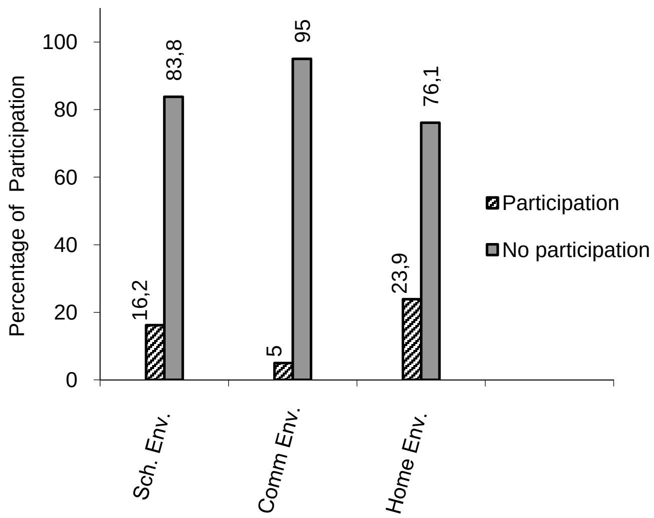

Figure 4. Proportion of students frequently participating in conserving environmental resources (*N*=272).

the four broad categories of environmental activities (outlined in Table 2) in the school, community and home environments. Their responses were as summarized and presented separately in Tables 3, 4 and 5.

Table 3 indicates that while at school, the students participated in the activities mainly as part of routine manual work assignment (26.4%) and punishment (12.1%). Very small proportions did the activities either as club work (2.5%) or as part of the learning program (1.5%). Similarly in Table 4, only very few students (5.3%) participated in community environmental management. They participated exclusively through environmental based clubs, namely, Young Farmers' Club, environmental based clubs, namely, Young

Table 3. Mode of Students' Participation in Environmental Activities in School (*N*=272)

Environmental Activity	% Responses for each mode of participation					
	Punishment	Class Work	Routine Manual Work	Club Work	Personal initiative	Never
Controlling visual pollution	19.9	0.0	32.3	0.0	0.0	47.9
Taking environmental health/safety measures	20.1	0.0	54.9	0.0	0.0	32.1
Improving environmental aesthetics	8.2	3.5	14.8	0.0	0.0	73.3
Conserving resources	0.0	2.6	3.6	10.0	0.0	83.8
Average	12.1	1.5	26.4	2.5	0.0	59.3

Table 4. Mode of students' Environmental Action in Community (*N*=272)

Category of environmental Activity	% Responses of students carrying out activity as:						
Environmental Activity	Punishment	Class Work	Routine Manual Work	Club Work	Personal initiative	Never	Total Action (%)
Controlling visual pollution	0.0	0.0	0.0	9.4	0.0	90.6	9.4
Taking environmental health/safety measures	0.0	0.0	0.0	6.8	0.0	93.2	6.8
Improving environmental aesthetics	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Conserving resources	0.0	0.0	0.0	5.0	0.0	95.0	5.0
Average	0.0	0.0	0.0	5.3	0.0	94.7	5.3

Table 5. Mode of Students' Participation in Environmental Activities at Home (*N*=272)

Category of environmental Activity	% Responses of students carrying out activity as:						
Environmental Activity	Punishment	Class Work	Routine Manual Work	Club Work	Personal initiative	Never	Total Action (%)
Controlling visual pollution	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Taking environmental health/safety measures	0.0	0.0	6.5	0.0	18.2	75.3	24.7
Improving environmental aesthetics	0.0	0.0	7.7	0.0	11.4	80.9	19.1
Conserving resources	0.0	0.0	11.6	0.0	12.3	76.1	23.9
Average	0.0	0.0	6.5	0.0	10.5	83.1	17.0

Farmers' Club, Wildlife Clubs of Kenya, Kenya Red Cross Association and Kenya Scouts and Girl Guides Associations. In their home environments (Table 5) the students performed the activities primarily through their own initiative (10.5%) and routine manual work assignment by their parents and guardians (6.5%). Interestingly none of the students reportedly did the activities at their homes through punishment.

Dynamic Qualities

Data from the students' responses indicate that their day today experiences and actions in their local environments resulted in the development of dynamic qualities. Tables 6 and 7 are summaries of the students' key responses revealing these dynamic qualities (basic and integrated respectively) as expressed in their feelings, concerns, ideas and actions relating to the various environmental problems in their local environments. The proportions of the students who developed the dynamic qualities are summarized in Table 8. From Table 8 it is clear that less than 50% of the students developed all the dynamic qualities. On the overall only 14.0% developed the qualities while 86.0% did not. In terms of individual dynamic qualities, the responsive characteristics are more revealing as outlined in the rest of this section.

(a) *Showing Sensitivity to environmental quality*

To establish if the students had developed this dynamic quality, they were asked if they were bothered by the attributes that adversely affected the quality of their local environments and if this recognition was based on informed awareness of visual pollutants (garbage, graffiti, cobwebs, derelict), environmental health and safety hazards (leaking roofs unhygienic environment, unsafe water), unaesthetic environment (lack of flowers, poor landscape, unkempt hedges and grass lawns) and un-conserved resources (trees, soil, and water). The students (48.5%) who demonstrated the possessions of the dynamic quality were fully informed on all these issues (see Table 6 and 8).

The rest of the students (51.5%) who lacked the dynamic quality also displayed a lack of understanding of the issues. For example, they indicated that since visual pollutants were temporary in nature they would just disappear on their own from the environment and that they did not change its nature.

(b) *Monitoring one's actions in the environment*

The students (10.3%) who demonstrated the development of this dynamic quality in them frequently and voluntarily monitored all their actions that caused changes in the environment with a view to correcting them. The students were members of environmental based clubs. The other 89.7% had not developed the dynamic quality and only participated in picking and burning the litter and conserving water resources when they were coerced or told to do so (see table 6).

(c) *Showing concern for environmental quality*

Only 10.3% of the students who were members of environmental based clubs demonstrated that they had developed this dynamic quality. The students were disturbed by the degraded state of their local environment and voluntarily campaigned for its improvement and/or prepared a report to facilitate action by local authorities. The students exclusively acted through clubs and class work assignments. On the other hand, 89.7% who did not demonstrate the dynamic quality seemed not to identify the problems, or if they did, they were not concerned (See Table 6).

(d) *Accepting and seeking responsibility for environmental action*

The students who possess this dynamic quality are remorseful for their own and others degradation of the environment and therefore enthusiastically recognize the need for corrective action. They are guided by, and display a sense of, personal ethic in their actions. From this prescription, only 10.4% of the students who were members of environment – based clubs possessed the dynamic quality. The students who did not express the dynamic quality usually gave unconvincing reasons for their non-participation such as gender, culture, lack of authority and apathy (see Table 7).

(e) *Exercising initiative in conserving / improving environmental quality*

The main indicator for this dynamic quality is the ability to identify problems and voluntarily improve the quality of the environment without being forced or told to do so. On the average only 15.5% of the students who were also members of clubs demonstrated the possession of the dynamic quality and were exclusively identified in those who acted on their own in their home environments. Those who participated in conserving environmental quality on their own initiative tended to have a clear understanding of the issues at hand and were members of environment based clubs. Those who lacked the dynamic quality gave defeatist reasons for not participating in the activities such as lack of authority from school administrators and parents (See Table 7).

(f) *Showing commitment to Environmental action*

In this task the students were asked to say what really propelled them to voluntarily and frequently participate in conserving environmental quality. The students (10.3%) who had developed the dynamic quality tended to consciously plan, and show a strong and continuous desire, to protect and enhance environmental quality. This was done primarily through club assignments and personal initiative. Those who lacked the dynamic quality blamed their non-action on one barrier or the other such as gender and lack of authority (see Table 7).

Table 6. A Summary of Common Responsive Characteristics and Relevant Basic Dynamic Qualities Acquired by Students

Categories of environmental activities	Task	Common Responsive Characteristics	Dynamic Quality
Visual pollution control: - garbage, graffiti, cobwebs, derelict Improving environmental aesthetics: - flowers, hedges, lawns	Are these regarded as pollutants in your school/home environments? Why do you say so? Would you need to remove them and why?	…graffiti, cobwebs, garbage…all make environment untidy…that is why I usually remove them from our homestead…	Showing sensitivity to environmental quality
	How would you describe environment with lack of flowers, unkempt grass and hedges? How do these affect your school/home environment?	… I don't need to remove litter, graffiti, cobwebs… these things are temporary… some will rot away, others will fade…they will just disappear…they don't affect our environment…	Not showing sensitivity to environmental quality
		…flowers, well trimmed grass and hedges are good… I feel satisfied when I look at them… they make environment beautiful…	Showing sensitivity to environmental quality
		…it is not necessary to have flowers, lawns and hedges… they give unnecessary work instead of concentrating on our studies…	Not showing sensitivity to environmental quality
Visual pollution control: - litter, conserving resources such as water	Do you continuously recognize the way you change the environment through litter disposal and usage of water both in school home? Please explain…	…in school we are punished for throwing litter anywhere… I now find it bad to throw litter anyhow… I always throw it in the litter bin… at home we throw rubbish in compost pit…	Monitoring one's actions in environment
		Water is scarce in school and even at home… I store water in bottles (drinking) and buckets for use… …I put litter in bin because I don't want to be punished…	Monitoring one's action in environment
		Water is difficult to get… that is why we keep in buckets…sometimes I don't keep so I borrow …	Not monitoring one's actions in environment

Any of the four categories	Are there any studies you have Carried out on your own on any environmental issue and on which you keep relevant information? Please elaborate	…I'm interested in water matters because it is important but scarce… I read about water in Encyclopedia…in future I want to be water engineer…	Showing interest in environmental conservation/ management.
		…I have read about soil erosion and conservation…I keep pictures from magazines and newspapers about it.	
		…I keep information on how to plant/care for trees…I hope to start my tree nursery…	
		…you can't just read or study until the teacher tells you…I read only story books on my own…	Not showing interest in environmental conservation
Visual pollution control - cobwebs, garbage Improving Environmental aesthetics: -planting/caring for flowers. Environmental health/safety measures: - cleaning/repairs. Conserving resources: - planting trees	Have you ever been disturbed/bothered by the presence of cobwebs in roof, litter in compound, dirt in class/living room, empty spaces without trees/flowers in residential premises, and leaking roofs and worn out walls in buildings?	…I personally organized a campaign and we cleared garbage and cleaned premises in our local hospital…it was untidy and the lives of the patients were at risk… this was in line with the objectives of our club…	Showing concern for environmental quality.
	Have you ever taken any corrective measures? Please elaborate.	…I have not seen any serious problem in the community (the same public hospital nearby)…if there is any problem there are people out there employed who should solve it… …teachers have not told us to be repairing leaking roofs or planting trees and flowers…when we just do that…otherwise workmen should plant trees and flowers here in school, it is their work… …we have no permission to plant flowers or trees in school; even at home parents may not like flowers…also as a girl, I m not allowed to plant trees or repair leaking roofs…	Not showing concern for environmental quality

Table 7. A Summary of Common Responsive Characteristics and Relevant Integrated Dynamic Qualities Acquired by Students

Categories of environmental activities	Task	Common Responsive Characteristics	Dynamic Quality
Environmental health/safety measures: -repairing roofs -clearing household gear/toilets Conserving resources: - water visual pollution: - garbage	Have you ever developed a habit or belief that motivates you to conserve or improve your local environment from time to time particularly in cleaning living rooms, toilets, and household gear, burning litter and repairing leaking roofs? Please elaborate	…the home must be clean…I always ensure that the living rooms and the courtyard are cleaned every time I am at home… at first my parents did not like this…that the work should be done by females, not males…but now they are used…	Accepting and seeking responsibility for environmental action.
		…I cannot repair a leaking house at home…we girls are not allowed to carry out most of the activities meant for men…the parents don't allow it… … as for toilet in school, we girls do it as part of duty roaster…	Not accepting and seeking responsibility for environmental action.
Environmental health/safety measures: - repairing roofs boiling water	Have you ever conserved or improved the environment on your own without being told to do so, particularly in terms of repairing leaking roofs, boiling drinking water, cleaning toilets and household gear, planning and caring for trees an flowers, conserving water, and pruning hedges?	…I planted hedges at home to make the compound neater and to create a habitat for beautiful animals like birds…my parents did not like this but I convinced them… they believed hedges attract snakes and snails… but since I care for the hedges they no longer fear…	Exercising initiative in conserving/improving environmental quality
		…I did not plant hedges at home …parents do not like them…they say these attract dangerous animals like snakes and foxes… you can only carry out activities in the home if the parents tell you to do so…	Not exercising initiative in conserving/improving environmental quality.
		…we don't boil the water for drinking…we have never had any problem with it although it comes from our well…	

Visual pollution control: - cobwebs, garbage, graffiti environmental, health/safety measures: - repairing roofs - boiling water Cleaning households' gear/toilets/living rooms.	Do you plan for and continuously carry out environmental management activities? Is there any external force in your motivation? Is this reflected in the following: clearing cobwebs, garbage and graffiti, repairing leaking roofs, cleaning toilets and living rooms, boiling water for drinking, cleaning households gear, planting and caring for trees and flowers and conserving water and soil?	….when I am at home I always make sure that I clean and dry all the household gear and keep them safely…at least three times a day….This prevents diseases causing germs from contaminating the gear…the plant is usually in my head everyday… I learnt this in home science.	Showing commitment to environmental action
Improving environmental aesthetics: - Planting/caring for trees and flowers Pruning hedges		….Cleaning household gear is the work of girls and women…The gear is usually cleaned by my sisters or mother…unless they are sick or away, I can t wash… I have never been taught how to do this….	Not showing commitment to environmental action
Conserving resources: - water soil		…in planting trees, or flowers…even in preventing soil erosion…we in our club…that is Scouts and Girl guides Association…we must plan what we want to do before we act…	Showing commitment to environmental action.
Any of the four categories	Is there any idea of your own that you came up with that helped you conserve or improve your local environment? Please elaborate	…. I read a book on how to improve the home environment… this was part of the of the project plan for our club… but since we did not continue with the project plan for our club… but since we did not continue with the project I decided to do it at our home… I landscaped our compound…it is beautiful…	Showing independence of thought and action in environmental action.
		……unless the teacher gives an assignment or the parents give you some work at home, you can't just start doing your own thing….we also don't have the time for things not in the syllabus…	Not showing independence of thought and action in environmental action.

Table 8. Summary of Results Showing Dynamic Qualities Acquired by students

Dynamic Quality	% Response (*N*=272)		
	Dynamic quality demonstrated	Dynamic quality not demonstrated	Total (%)
1. Showing sensitivity to environmental quality	48.5	51.5	100
2. Monitoring one's action in relation to environmental quality	10.3	89.7	100
3. Showing concern for environmental quality	6.2	93.8	100
4. Showing interest in environmental management	10.0	90.0	100
5. Exercising initiative in conserving environmental quality	15.5	84.5	100
6. Showing commitment to environmental action	10.3	89.7	100
7. Showing independence of thought and action in environmental action	0.7	99.3	100
8. Accepting and seeking responsibility for environmental action	10.4	89.6	100
Average	14.0	86.0	100

(g) *Showing independence of thought and action in environmental action*
The students who possessed this dynamic quality demonstrated original ideas in selecting environmental action projects or tasks and strategies and in voluntarily implementing the strategies. Only two students (0.7%) who were members of the Red Cross society of Kenya demonstrated that they had developed the dynamic quality. The students landscapped their homes to improve environmental aesthetics. The rest of the students (99.3%) did not display such originality in changing the environment (see Table 7).

(h) *Showing interest in environmental conservation*
The students who possessed this dynamic quality tended to display an interest in environmental conservation by carrying out independent studies and/or frequently reading about or keeping materials about the environment. In this regard 10% of the students kept up to date information on water and soil conservation as well as information on planting and caring for trees. All students except one were members of environment related clubs (see Table 6).

DISCUSSION

Several important observations are apparent about the manner in which the students participated in protecting and improving the quality of their local environments. First, the students participated majorly because they were coerced into environmental action particularly in their school environment. If the objective of the school authorities was to achieve a quality environment, this strategy was admissible. But it was not admissible if the students were also expected to develop a positive commitment to the protection and enhancement of environmental quality.

Second, while a very low rate of students' participation was experienced, the role of clubs in this process, particularly at community level, is worth noting. The current view as posited by Hart (1997) that environmental clubs have the potential of positively involving more students in the process of conserving the quality of their local environments than the regular school program is thus supported.

Third, it is noteworthy that out of the 16 activities, the students participated in only three in their school environment as part of the learning process. Thus practical work was not the focus of learning about environmental issues in the schools.

Fourth, students participated in environmental action through their own initiative primarily while at home rather than when they were at school. This seems to indicate that students had more freedom to exercise their initiative at home than at school. The explanation to this seems to lie in the contention that schools operate within a fairly rigid time frame. Consequently, teachers find it easier to assign students to work on environmental tasks rather than involving them in identifying problems themselves and collaborating with them in finding solutions. This approach obviously discourages students from developing a genuine concern for the environment as they see the tasks as a source of trouble rather than of opportunity for fruitful participation.

Fifth, there was some distinction in the distribution of activities between boys and girls, particularly at home. This is indicative of the specialized role of men and women in environmental action in our society. Whereas this may be acceptable in most African traditions, the practice denies both boys and girls access to very useful experiences and skills. The essence of environmental education should be to bridge this gap. Environmental action should be based on students' abilities and interests rather than on gender.

Sixth, the way students perceived the attributes affecting environmental quality seemed to affect their participation. For example, the students did not control visual pollution apparently because they considered pollutants as temporary and of no significant change on the environment.

A recent model promulgated by Hart (1997) uses an eight-wrung ladder as a metaphor to illustrate the different degrees of initiation and collaboration students can have when participating in environmental action projects or tasks. In the model, the overwhelming use of punishment and routine manual work assignment by the teachers to accomplish environmental action does not constitute genuine participation on the part of the students. The two modes of environmental action could be represented by the fourth-rung of the ladder where the students participate but they are not informed. This is because the projects in which the students are involved are designed simply to use students as free labour to achieve some of the environmental objectives. The projects are not usually used as part of an exercise to encourage students' critical reflection on the causes of the environmental problems (such as littering) and how they might influence the adults to also change their behaviour towards the environment. Genuine participation should be such that even if environmental projects are designed by teachers the students are encouraged to understand the process, are consulted, and have their opinions treated seriously. It is a learning process whose primary objective is to develop in the students' abilities necessary for informed environmental action. Moreover, if not properly executed, the model shows that even these environmental action projects expected to be accomplished through school learning and clubs may just carry simple messages from top down and have only a short – term impact on the students.

The few students in this study (an average of 14.4%) who had developed the eight dynamic qualities showed a clear tendency to conserve environmental quality than those who lacked such qualities. They also acted on the environment on their own volition without being coerced or directed to do so. More significantly, all members of the Kenya scouts and Girl Guides Association, wildlife clubs of Kenya, Red Cross association of Kenya, and Environmental clubs developed all the eight dynamic qualities.

The students who lacked dynamic qualities variously displayed traits that suggested that some barriers hindered effective development and functioning of the qualities. The first category of barriers ranged from students' lack of time, opportunity and authority on one hand and their gender, cultural values and apathy towards environmental action on the other. They appeared to pass the buck with regard to solving environmental problems. They would say "– the teachers did not tell us to do that –". While these barriers are genuine and difficult to overcome, only one determined to attain optimum environmental quality would attempt to overcome them. Such a student should have developed requisite dynamic qualities that would drive him or her to participate in the needed environmental action: exercising initiative and independence of thought; showing concern; realizing individual responsibility; and showing interest and commitment with regard to environmental enhancement.

The second category of barriers hinged on students' lack of awareness and misconception of certain environmental phenomena that affected environmental quality. This greatly influenced their lack of two dynamic qualities, namely showing sensitivity to environmental quality and monitoring one's actions in the environment.

It is evident that environmental education had neither erased the misconceptions nor eliminated the barriers that affected the development of dynamic qualities in the students. The results confirmed that dynamic qualities develop in the students if the later are exposed to practical activities. For dynamic qualities can only be promoted where they are needed and where opportunities exist for becoming active (Posch, 1991). Where such strategies are not used students are not in the habit of positively acting in the environment on their own; they can only be told what to do or coerced to do the needful as the results indicated. Thus possession of dynamic qualities seems to provide the drive to carry out environmental action. This observation is supported by the "motivation theory of action" as postulated by Edward Tolman and Kurt

Lewin (Hill, 1985; Birch and Veroff, 1966). The theory suggests that people act positively on the environment if they are urged by their deep beliefs and attitudes that act as a drive.

CONCLUSION

In this study, secondary school students were questioned about their participation in environmental action. This was done through use of situations prevalent in their home, community, and school environments. The situations selected were those that made it possible to depict the students' mode of environmental action and the dynamic qualities which they had developed. The most significant observation about students' environmental action revealed by this study are as follows:

Secondary school students tended to sustain or improve the quality of the environment by conserving local resources, controlling visual pollution, and improving environmental health, safety and aesthetics.

Although only very few students attempted to sustain or improve the quality of their local environments a higher proportion did that while at their schools than while at their homes. However, the students through punishment and routine manual work assignment while at school did many of these activities. The smaller proportion that participated in environmental action while at their homes exercised their initiative in carrying out environmental improvement than while at school.

Most students rarely ventured into the community surrounding the school to assist in protecting and improving the quality of the environment. The few who assisted did that through club work.

The students who participated in environmental action on their own volition or through class or club assignments appeared to have developed one or more of the eight dynamic qualities.

The students who did not participate in environmental action, or those who participated through punishment and routine manual work assignment, did not seem to have developed the dynamic qualities.

The rather low level of students' participation in environmental activities revealed in this study should be a matter of concern to environmental educators. The results are not surprising since most students indicated a lack of environmental awareness and dynamic qualities that are a prerequisite to environmental action. For participation in environmental management demands that students be equipped not only with personal knowledge of the environment, leading to affection, but also dynamic qualities that can come only from practicing these attributes in real environmental activities (Emmons, 1997). Perhaps of greater interest is the fact that only very few students participated in environmental action through their own personal initiative than through other modes of participation. It is also instructive that this was only done by the students while at their homes. This could be attributed to schools which emphasized self-restraint and doing what one is told. This made the students dependent and overly restrained, thereby killing their desire to learn and work independently. These findings remind us that whatever structures for participation are established they must allow flexibility for students to explore and develop their actions in the environment in ways consistent with their own abilities, interests and cultures (Rickinson and Sanders 2005; Dyment and Reid, 2005; Emmons, 1997; Lee Smith and Chaundry, 1990).

The results have revealed that only through genuine participation can students develop dynamic qualities. Most students had not developed dynamic qualities since they were not given opportunities to define situations and problems, to seek and accept responsibility, to develop initiative and self-reliance and to monitor themselves on the basis of reflected values in their local environments. If a primary goal of environmental education is to be the development of dynamic qualities in the students then much effort and research must be directed toward establishing effective means for achieving this end. If dynamic qualities of students are to be translated into responsible social behaviour (environmental action) it would appear that these qualities should be deeply rooted and based upon environmental knowledge and awareness, and experienced through genuine participation in their local environments rather than superficially "learned" or instilled by coercion. It is imperative that environmental education curriculum should focus on practical problems of living within the environment which are experienced by students as well as problems and issues related to their own actions (Rickinson and Sanders, 2005; Malone and Tranter, 2005). The positive environmental action model proposed by Emmons (1997) and the operation – environment model (Toili, 1996) provide relevant framework in which action research is employed to facilitate this kind of learning. Environmental action by the students realized through decree and coercion is thus pedagogically unsound. However this should be predicated upon students dynamism (development and use of dynamic qualities) rather than on coercion or limitless orders and decrees by school authorities and parents. This kind of action is voluntary (self-determined) based on good habits of planning, decision-making, reflection and aimed at environmental improvement and can only be achieved through a well coordinated environmental education programme.

APPENDIX A: INTERVIEW SCHEDULE FOR STUDENTS

SECTION A

1. For each of the four broad categories of environmental activities, indicate those you have frequently participated in (i.e. at least two days or two hours in each week for the past four or more months) in each of the school, community and home environments.

Category of environmental activity	**Type of Environment**		
	School	**Community**	**Home**
Controlling visual pollution: - clearing cobwebs, garbage, graffiti and derelict.			
Taking environmental health/safety measures: - Slashing grass, cleaning/repairing dormitories/classrooms/residential premises, boiling water, cleaning toilets/households gear			
Improving environmental aesthetics: - Planting flowers, caring for flowerbeds, landscaping, pruning hedges.			
Conserving resources - Planting trees, caring for trees, conserving soil and water			

2. (a) For each activity listed in (1) above state the circumstances under which you frequently participated in the activity at school, community or home environment i.e. by punishment (P) personal initiative (PI), school learning (L), routine manual work (MW) club work (C). If you did not participate in the activity, say never (N). (probe for more information)

Category of environmental Activity	**Mode of Environmental Action**																	
	School Environment						**Community Environment**						**Home Environment**					
	P	**PI**	**L**	**MW**	**C**	**N**	**P**	**PI**	**L**	**MW**	**C**	**N**	**P**	**PI**	**L**	**MW**	**C**	**N**
Controlling visual pollution: - Clearing cobwebs, garbage, graffiti and derelict.																		
Taking environmental health/safety measures: - Slashing grass, cleaning/repairing dormitories/classrooms/residential premises, boiling water, cleaning toilets,/households gear																		
Improving environmental aesthetics: - Planting flowers, caring for flowerbeds, landscaping, pruning hedges.																		
Conserving resources: - Planting trees, caring for trees, conserving soil and water																		

(b) If you participated through club work, name the clubs, and if through classroom activities, name the subjects and the type of activities.

SECTION B

3. Showing Sensitivity to Environmental Quality:
   (a) Which of the following in your school/home environment act as pollutant? (garbage, graffiti, cobwebs, derelict). Why do you say so? Would you need to remove them? Why?
   (b) How would you describe a school/home environment without flowers, pruned hedges and untrimmed grass lawns? Do these situations affect the home/school environment? Please explain.
4. Monitoring one's Action in the Environment
   (a) Do you continuously recognize the way you change the environment through disposal of litter and unsparing use of water in your school or home environment? Please explain your response.
   (b) Have you carried out any corrective measures as a result of realizing your actions? Please explain.
5. Showing concern for environment quality.
   (a) Have you ever been bothered or disturbed by the presence of the following things in your school/home environment?
      - Cobwebs in roofs/corners of buildings
      - Litter/garbage carelessly discarded
      - Leaking roofs/worn out walls
      - Dirty floors of living rooms/classrooms/toilets
      - Empty premises without flowers/trees
      - Stunted trees / flowers
   (b) Have you ever taken action to rectify any or all of the above situations? Please explain.
6. Showing interest in environmental management
   Are there any environmental issues/problems on which you have carried out your own studies and on which you keep relevant information? Please elaborate (you may need to look at the records).
7. Accepting and seeking responsibility for environmental action
   (a) Have you ever developed a habit/belief that motivates you to conserve or improve your school/community/ home environment from time to time in terms of the following: cleaning toilets/living rooms/classrooms, repairing leaking roofs and worn out walls, cleaning household gear, conserving water, collecting and binning litter.
   (b) Why do you act the way you do? Please elaborate.
8. Exercising initiative in conserving/improving environmental quality
   Have you ever conserved or improved the environment on your own without being told to do so? Is that reflected in the following in your school/home/community environments? Please elaborate:
   - Cleaning toilets, living rooms, classrooms, households gear
   - Repairing leaking roofs/ worn out walls
   - Boiling water for drinking
   - Conserving water
   - Planting and caring for trees/flowers
   - Pruning hedges.
9. Showing commitment to environmental action
   Do you plan for and continuously carry out environmental management activities? Is there any external force in your motivation to improve your home/ school/community environment? Is this reflected in the following activities? Please elaborate.
   - Clearing cobwebs, garbage, graffiti and derelict
   - Repairing leaking roofs/worn out walls
   - Clearing household gear/living rooms/classrooms
   - Boiling water for drinking
   - Planting and caring for flowers/trees/hedges
   - Conserving water and soil.
10. Showing independence of thought action in environmental action
   Is there any idea of your own that you came up with that helped you conserve or improve your school/home/community/environment? Please elaborate.

APPENDIX B: SOME INDICATORS OF DYNAMIC QUALITIES

1. Showing Sensitivity to environmental quality:
   - Shows sensitivity to the effects of one's actions and those of others on the environment.
   - Aware of the conditions of the built, social and natural environment and how they have been brought about.
2. Monitoring One's actions in relation to environmental quality
   - Frequently and voluntarily monitors ones actions that cause changes in the environment with a view to correcting them.
3. Showing concern for environmental quality:
   - Disturbed by or appreciates what is seen in the environment.
   - Forwards report of state of environment to relevant authorities for action and/or campaigns actively for environmental conservation.
4. Accepting and seeking Responsibility for Environmental Action.
   - Remorseful for one's/others' degradation of the environment and enthusiastically recognize the need for corrective action.
   - Guided by, and display a sense of, personal environmental ethic and therefore unwilling to make changes that will degrade the environment; will always try to do the correct thing – e.g. binning litter instead of throwing it any how.
5. Exercising initiative in conserving environmental quality
   - Demonstrates ability to identify problems in the environment and to voluntarily act without being forced or told – e.g. designing and landscaping the environment to improve its quality.
6. Showing commitment to environmental action
   - Consciously plans, and shows a strong and continuous desire, to protect and enhance environmental quality – e.g. recycling materials instead of wasting them, vigilant about the changes in the environment and constantly taking appropriate action and using resources sparingly.
7. Showing independence of thought and action in environmental action.
   - Demonstrates original ideas in selecting environmental action projects or tasks and the strategies to be used and in voluntarily implementing the strategies.
   - Forms reasoned opinions and develops balanced judgments about environmental situations by looking for relevant information.
8. Showing interest in environmental conservation.
   - Demonstrates an interest in the environment by carrying out independent studies and/or frequently reading about or keeping materials about the environment – e.g. trying to find out why the environment is the way it is, asks questions about environmental phenomena, displays an aesthetic appreciation of the environment and checking out certain things in the environment to see their progress.

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The Effects of Problem-Based Active Learning in Science Education on Students' Academic Achievement, Attitude and Concept Learning

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The aim of this study was to determine the effects of problem-based active learning in science education on students' academic achievement and concept learning. In the study, both quantitative and qualitative research methods were utilized. Quantitative data were obtained via the pre/post-test, treatment-control groups test model. Qualitative data were obtained via document analysis. The research study was conducted on 50, 7th grade students in 2004-2005 school year, in a public school in Istanbul. The treatment process took 30 class hours in total. In the research, three measurement instruments were used: an achievement test, open-ended questions, and an attitude scale for science education. The reliability coefficient of the achievement test was calculated to be KR20=0.78. Cronbach α value of the attitude scale was 0.89. While the subject matters were taught on the basis of problem-based active learning in the treatment group, traditional teaching methods were employed in the control group. In the face of the data collected and the evaluations made in the research, it was determined that the implementation of problem-based active learning model had positively affected students' academic achievement and their attitudes towards the science course. It was also found that the application of problem-based active learning model affects students' conceptual development positively and keeps their misconceptions at the lowest level.

Keywords: Teaching Sociology, Science, Education, Problem-based learning, Active Learning, Concept Learning, Program Development

INTRODUCTION

The student-centered active learning process within which teacher is merely a guide is the focal point of contemporary education systems. The active learning is a learning process in which the learner takes the responsibility of his/her learning and s/he is given the opportunity to make decisions about various dimensions of the learning process and to perform self-regulation (Açıkgöz, 2003). In active learning process, learning is no longer a standard process, but it transforms into a personalized process. Here, the skills of problem-solving, critical thinking and learning to learn are developed. Humans face various problems in their lives and they try to find particular ways to solve these problems. In this respect, it is important for students to be prepared for the future by facing real or real-like problems in their learning environment and producing appropriate solutions to these problems. What is expected from education is to enable individuals to become an effective problem solver in their actual lives (AAAS, 1993; Brooks & Brooks, 1993; Tobin, 1993; Gallagher, 1997; Herreid, 1997; Walker & Lofton,

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2003; Chin & Chia, 2004). To learn problem solving is to learn how to learn. The most convenient approach with regard to reaching this aim in teaching and learning environments is the problem-based learning taken part in active learning. The basis of problem-based learning is rooted in Dewey's "learning by doing and experiencing" principle (Dewey, 1938). The problem-based learning is an active learning which enables the student to become aware of and determine his/her problem solving ability and learning needs, to learn to learn, to be able to make knowledge operative and to perform group works "in the face of real life problems".

The "Problem-Based Learning" being increasingly used in several areas recently was firstly implemented in medical science in the 1950s, specifically in the Medical School of Case W. University in the USA. It was begun to be implemented in the Medical School of the McMaster University in Canada at the end of the 1960s (Rhem, 1998; Herreid, 2003). Today, the problem-based learning model is used in pre-clinic classes within medical faculties of many universities such as the Harvard University, New Mexico University and McMaster University. This teaching model is put into practice in medical faculties of the Hacettepe University, Ankara University, Dokuz Eylül University and Pamukkale University in Turkey. In addition to medical faculties, the problem-based learning model is also implemented in other educational institutions comprised of fields like natural sciences, engineering and law. When the literature is examined, it is seen that the studies focused on the use of problem-based learning model in primary education, secondary education and high education have been reached by the 1980s (Duch, 1995; Gallagher, 1997; Kaptan & Korkmaz, 2002; Lambros, 2002; Şenocak, 2005). The problem-based learning is a learning model which centers on student, develops active learning, problem-solving skills and field knowledge, and is based on understanding and problem-solving (Barrows & Tamblyn, 1980; Maya *et al.*, 1993; Mechling, 1995; Skrutvold, 1995; Major *et al.*, 2000; Malinowski & Johnson, 2001). In the classrooms where problem-based learning model is used, learners take much more responsibility for their own learning progressively. They have become more independent from their teachers gradually. And they have become independent learners who can continue to learn in their whole lifetime.

PROBLEM-BASED LEARNING MODEL

The problem-based learning model turns the student from passive information recipient to active, free self-learner and problem solver, and it slides the emphasis of educational programs from teaching to learning. This model enables the student to learn new knowledge by facing him/her the problems to be solved, instead of burdened contents (Çuhadaroğlu *et al.*¸ 2003). By means of problem-based learning, some attitudes of students in relation to such areas as problem-solving, thinking, group works, communication, information acquisition and information sharing with others are affected positively. The basis of the problem-based learning is mainly comprised of 'Problem, Solution, Practice, Research, Questioning, Realism, Originality and Integration." The aim of this learning model is to provide acquisition of information based on facts. In order to achieve this aim, problems are chosen out of the real world. The individual is being developed by making possible the integration with information accumulation of the student. Even though some differences are observed in practice, the problem-based learning is performed in sessions within which there are small working groups comprised of 6 or 8 persons guiding by an education mentor. They deal with scenarios involving several problems in above-mentioned sessions and try to find appropriate answers to these problems. These sessions constitute the foundation of problem-based learning system. In these sessions, it is aimed to enable the student to learn by setting off the problems that explain the subject matter in best way (Yuzhi, 2003; Skrutvold, 2003; Kılıç, 2006). The most important role of the mentor in the problem-based learning being operated in a student-centered manner is to facilitate learning activities by guiding students. Teaching mentors fulfill this role by monitoring discussions, asking questions, helping the resolution of occasional conflicts, enabling the participation of each group member to classroom discussions, giving examples when required, preventing scatter of discussions and making evaluations (Maxwell & Dornan, 1995; Duffy & Cunningham, 1996; Rhem, 1998; Greenwald, 2000; Posner & Rudnitsky, 2001; Nakiboğlu & Altıparmak, 2002; Açıkgöz, 2003; Çuhadaroğlu *et al.,* 2003; Onargan *et al.,* 2004).

PROBLEM-BASED LEARNING AND SCIENCE EDUCATION

When the aims of science education are examined, it is seen that the problem-based learning is quite appropriate for realization of these aims (Tobin, 1986; AAAS, 1993). Today, many science educators considering this connection have increasingly started to apply problem-based learning approach in science education (Lazear, 1991; Treagust & Peterson, 1998; Gallagher *et al.,* 1999; Slavin, 1999; Greenwald, 2000; Yuzhi, 2003; Şenocak, 2005; Wilson, 2005; Kılıç, 2006). The facts that science education is based on both practice and interpretation, that it is so connected with real life and that it requires cooperation facilitate the problem-based learning practices.

Implementation of problem-based learning in science education

In using problem-based learning system, firstly the concepts, learning aims and duration of the subject matter are set. Before implementation of this system, students are informed about problem-based learning. Small student groups comprised of 5 or 7 persons are formed. Students are given opportunity to examine and recognize problems by distributing prepared problem scenarios to them. If students have information about the problem, they are expected to propose solutions to this problem. If they do not have information about the problem, they are encouraged to make research using various data sources. All of the information obtained in this process is shared, discussed and evaluated among group members. Then, the solution of the problem is reached. This solution is presented to other groups. All information related to the targeted concept is revealed by discussing the acquired results at the guidance of the teacher (Dori & Herscovitz, 1999; Duch, Groh & Allen, 2001; Kılıç, 2006). In problem-based learning model, main tools which are used can be stated as the case-study method, problem-solving based learning approach, project-based learning approach and cooperative learning approach. The problem-based learning model which is closely connected to these learning models and methods seems to be enriched by increasingly spreading new methods such as 'portfolio-based learning' and 'experimental learning' (Dicle, 2001).

The characteristics which call attention in problem-based learning

- Learning process must be started with a problem; especially a problem which is evidently critical/still unsolved must be used.
- Contents and practices must include situations which attract students' attention.
- Teacher must merely be a guide in the classroom.
- Students must be given necessary time to think or gather information and to set their strategies in problem solving, and their creative thoughts must be encouraged in this process.
- The difficulty of the subject matters to be studied must not be at a high level which could discourage students.
- A comfortable, relaxing and safe learning environment must be established in order to develop students' skills on thinking and problem-solving by themselves (Greenwald, 2000; Taşkıran *et al.,* 2001; Parim, 2002; Yaman & Yalçın, 2004).

The characteristics of the learning scenario that constitutes the basic education tool in problem-based learning are as follows (Çuhadaroğlu *et al.,* 2003);

- Problems must be chosen from among the problems which are the most fitting to the real world.
- Problem must be open-ended.
- It must arouse sense of curiosity.
- It must focus on only one issue.
- It must teach good and ethical behaviors rather than negative events and behaviors.
- It must help students to reflect on freely and express themselves.
- By making suitable personifications, students must be given the opportunity to treat the problem as if it were their problem and to be willing in solving it.

The advantages and limitations of problem-based learning can be stated in the following manner:

Advantages of problem-based learning

- Classes are student-centered instead of being teacher-centered.
- This learning model develops self-control in students. It teaches making plans prospectively, facing realities and expressing emotions.
- This model enables students to see events multi-dimensionally and with a deeper perspective.
- It develops students' problem-solving skills.
- It encourages students to learn new materials and concepts when solving problems.
- It develops sociability levels and communication skills of students by enabling them to study and work in a team.
- It develops students' high level thinking/critical thinking and scientific thinking skills.
- It unites theory and practice. It allows students both to merge their old knowledge with new knowledge and to develop their judging skills in a specific discipline environment.
- It motivates learning for both teachers and students.
- Students acquire the skills of time management, focusing, data collection, report preparation and evaluation.
- It paves the way for learning in whole lifetime (Dinçer & Güneysu, 1998; Treagust & Peterson, 1998; Kalaycı, 2001; Şenocak, 2005).

Limitations of problem-based learning

- It could be difficult for teachers to change their teaching styles.
- It could take more time for students to solve problematic situations when these situations are firstly presented in the class.
- Groups or individuals may finish their works earlier or later.
- Problem-based learning requires rich material and research.
- It is difficult to implement problem-based learning model in all classes. It is unfruitful to use this strategy with students who could not fully understand the value or scope of the problems with social content.
- It is quiet difficult to assess learning (Dinçer & Güneysu, 1998; Treagust & Peterson, 1998; Kalaycı, 2001; Şenocak, 2005).

By setting off the idea underlying the fact that life means to recognize problems faced, to be aware of the importance of these problems, to understand why these problems occur and to eradicate possible problems at an earlier stage, the problem-based learning serves the view that learning must be complete and must be based on adequacy. The efficiency level of problem-based learning should be examined in order to acquire the skills of reflecting on problems faced and of solving these problems, to increase critical thinking level and not to be afraid of possible or actual problems. Problem-based learning model orients students towards reflecting on, interpreting and searching solutions to the problems faced by them not only in science classes but also in their daily lives, instead of compelling them to ignore all these problems. In the classrooms within which problem-based learning model is applied, students are encouraged to access knowledge by themselves. The fact that the scenarios implemented as required by problem-based learning model are connected with students' daily lives enables students to understand how science classes are so interrelated with real life. Furthermore, since students find the events and characters pictured in these scenarios so close to themselves, science classes become attractive to them automatically. In problem-based learning model in which teaching activities are carried out with small groups composed of 6 or 8 students, it is achieved that these students could strengthen their interaction and communication with each other and their environment. Their skill to express themselves develops. In general, students define problems as incomprehensible, complicated, complex and abstract. This prevents students from reflecting on, interpreting and solving problems. In order to change this situation, it is necessary to concretize problems and associate them with students' lives. It is an issue of great importance that the science knowledge assumed to be learned through science education in school could not be transmitted to their actual lives by students and some misconceptions are carried again by them. In this respect, active learning models should be put into practice in primary education level. The aim of this research is to determine whether the implementation of problem-based learning model taking part in active learning applications in "The Meeting of Force and Motion—Energy" unit of 7th grade in primary education brings about significant differences with regard to students' academic achievement, their attitudes towards science class and their concept learning.

With this aim, following hypotheses were set:

1. Does teaching of 7th grade science classes by means of the Problem-Based Active Learning Model bring about significant differences with regard to students' academic achievement?
2. Does teaching of 7th grade science classes by means of the Problem-Based Active Learning Model bring about significant differences with regard to students' attitudes towards science class?
3. Does teaching of 7th grade science classes by means of the Problem-Based Active Learning Model have any impact on students' concept learning?

METHOD

Model of the research

Both quantitative and qualitative research methods were used in this study. In quantitative research dimension, the test model based on a pre-test and post-test with research-control groups was utilized. In qualitative research field, document analysis was executed.

Implementation

The research was conducted on the students who were at the 7th grade in primary schools in the county of Kadıköy located in the city of Istanbul during the 2004-2005 school year, and their academic achievement and concept learning levels in regard to "Everything in the Universe is Moving" and "How Do Matters Behave at Force Effect?" subject matters included by "The Meeting of Force and Motion—Energy" unit of the Science Program were considered. With this aim, a primary school was chosen randomly. By applying the pre-test including 25 questions prepared by the researcher to the 7th grade students, research and control groups at same level were formed. 50 students were participated in the research in total. Of 50 students having participated in the research, 30 of them were females and 20 of them were males. After research and control groups had been formed, 10 open-ended questions prepared by the researcher and "The Attitude Scale for Science Classes" developed by Akınoğlu (2001) were executed in each group. The study was carried out by the researcher. While classes were given by means of traditional method in the control group, following techniques were employed in the research group: Before subject matters were proceeded, information about the problem-based active learning model used in the research had been presented to the research group and thus, it was enabled the members of this group to recognize and approximate this model. The problem-based active learning model is comprised of scenarios. In this manner, some scenarios were prepared in accordance with the acquisition of the subject matters of "Everything in the Universe is Moving" which is composed of two sub-headings and "How Do Matters Behave at Force Effect?" which is composed of six sub-headings. Working groups comprised of 5 or 6 students were created in the research group. In the first session of the problem-based active learning model implemented in sessions, the scenarios prepared in relation to the subject matter were handed out to the members of all groups without having presented any information. These scenarios were also showed by using an overhead trajectory. By giving time to them, students were enabled to recognize problem and to organize their thoughts. After stimulating a brain storming activity about the causes and possible solutions of the problematic conditions in the scenarios, students' suggestions were evaluated. Here, the researcher made students to concentrate on important questions. In the second session of the model, firstly, the answers prepared by the groups were shared and personal preparations were presented by students. Group members were encouraged to adapt new knowledge to the original problem, to revise previous hypotheses and to re-adjust these hypotheses if necessary. Lastly, the working process of groups was assessed. With this model, it was achieved that students participated the class actively. Moreover, by employing the model through groups, it was accomplished that the knowledge could be learned properly and transferred among students. At the same time, students' skill of expressing themselves in the classroom and sense of self-confidence were supported. The research took 30 class hours (10 weeks) in total. At the end of the research, the post-test, open-ended questions and attitude scale were given to the students again. The results were assessed by the researcher by taking specialists' opinions.

Data collection and assessment

In the research, three main assessment tools including academic achievement test, open-ended questions and attitude scale towards science classes were used. The data acquired by using these assessment tools were transferred to computer environment and evaluated by means of SPSS 10.00 package program. Some detailed information about preparation, implementation and evaluation of the assessment tools used in data collection is given below.

The preparation, implementation and evaluation of the academic achievement test

The academic achievement test was prepared in accordance with the aims and acquisitions in the subject matters of "Everything in the Universe is Moving" and "How Do Matters Behave at Force Effect?" of the "The Meeting of Force and Motion—Energy" unit taken part in the Science Curriculum for Primary Schools of the Turkish Republic—National Education Ministry. The subject matter was divided into sub-concepts and then, 50 questions comprised of four options were asked by the researcher in conformity with the students' acquisitions with regard to these sub-concepts. At the end of a pilot study performed on 55 students, the reliability and validity of the questions were calculated. Then, by taking opinions of a specialist group comprised of four persons, namely a counselor, an academician working in the science teaching department of a reputable university and two science teachers, the questions which had low validity and reliability levels were excluded from the test and total question number was reduced to 25. When the reliability coefficient of the academic achievement test was calculated, it was found as KR20=0, 78. This expression indicates that the academic achievement test is reliable by 78%. When general difficulty level of the academic achievement test was computed, it was found as P_{ave}=11.76/25 = 0, 47. This figure shows that the academic achievement test is at medium-level in terms of difficulty. When the distinctiveness levels of the questions formed the academic achievement test were calculated, it is seen that 96% of these questions are at or above the value of 0, 40 which is desired. Average distinctiveness of the academic achievement test was found as D_{ave}=12.88/25 = 0, 51 and it was accepted that the academic achievement test whose reliability is detected has a high distinctiveness level. When the academic achievement test was implemented, the researcher was present in the classroom. Students were given 1 class hour (40 minutes) to answer this test.

The preparation, implementation and evaluation of the open-ended questions

At the beginning, twenty open-ended questions were prepared by the researcher by classifying the concepts chosen in accordance with the national education curriculum in the subject matters of "Everything in the Universe is Moving" and "How Do Matters Behave at Force Effect?" of "The Meeting of Force and Motion—Energy" unit. Later on, by taking recommendations of three specialists, namely an academician in the science teaching department of a reputable university and two science teachers, total question number was reduced to 8 in order to prevent students from getting misconceptions and to be able to determine adequately whether students learned concepts meaningfully or not. The subject matters which were assessed through open-ended questions are given in Table-1.

Table 1. The subject matters assessed by open-ended questions

Question number	The subject matter to be assessed
1	Motion- Moving matters- Motionless matters
2	Position
3	The way moved toward and The replacement made
4	Inactivity
5	Force and The effects of Force
6	Friction force
7	Scalar magnitude– Vectored magnitude
8	Gravity force

When open-ended questions were answered, the researcher was present in the classroom. Students were given 1 class hour (40 minutes) to answer these questions. The open-ended questions used in the research were encoded by means of open-encoding method in qualitative dimension. In open-encoding, the answers of all students were examined by the researcher. At the end of this, the codes reached were grouped with the codes resembled to them. And, some theses were created after giving names to these groups. The theses acquired in pre-implementation and in the post-implementation were compared with each other and interpreted.

The implementation and evaluation of the attitude scale

The 20-itemed "Attitude Scale for Science Classes" developed by Akınoğlu (2001) was used in the research in order to determine whether the problem-based active learning model affects students' attitudes towards science classes or not. The reliability of this scale developed by Akınoğlu is $\alpha = 0.89$. The 5-step Likert type attitude scale includes twenty positive and negative sentences aiming to probe students' views about science classes. Students were given 30 minutes to respond.

FINDINGS AND COMMENTS

The findings regarding the effect of problem-based active learning on academic achievement

In order to examine the effect of the "Problem-Based Learning model" employed during the implementation process on students' academic achievement, the findings acquired in pre- and post-application of the academic achievement test to the research and control groups were drawn in tables, and some comments were made in parallel to these findings.

As it can be seen in the Table 2, the arithmetic mean of the pre-test scores taken by the research group students was found 8.56 and the respected figure of the control group students was found 9.16. It is observed that there is a 0.6 point difference between group means and p value is more than 0.05. This indicates that there is no significant difference at the 0.05 confidence interval between the pre-test scores of the research group and control group students. By the fact that there is no significant difference between the pre-test scores of the research and control group students, the condition concerning the nearness of pre-knowledge level of the research and control groups before the research is fulfilled.

Table 2. The results of the detached "T" test carried out regarding the difference between the pre-test scores of students in the research group and in the control group

	GROUPS	N	X	Standard deviation	Standard error	Detached group "t" test sd	t	P
PRE-TEST	Treatment Group	25	8,5600	2,9451	,5890	48	0,822	p > 0,05
	Control Group	25	9,1600	2,1541	,4308			

Table 3. The results of the detached "T" test carried out regarding the difference between the post-test scores of students in the research group and in the control group

	GROUPS	N	X	Standard deviation	Standard error	Detached group "t" test sd	t	P
POST-TEST	Treatment Group	25	12,7600	4,2650	,8530	48	-2,273	p < 0,05
	Control Group	25	10,1200	3,9404	,7881			

Table 4. The results of the detached "T" test carried out regarding the difference between the pre-attitudes of students in the research group and in the control group

	GROUPS	N	X	Standard deviation	Standard error	Detached group "t" test sd	t	p
PRE-ATTITUDE	Treatment Group	25	77,1600	10,9418	2,1884	48	-1,649	p >0,05
	Control Group	25	71,7600	12,1802	2,4360			

Table 5. The results of the detached "T" test carried out regarding the difference between the post-attitudes of students in the research group and in the control group

	GROUPS	N	X	Standard deviation	Standard error	Detached group "t" test sd	t	P
POST-ATTITUDE	Treatment Group	25	73,8000	13,2225	2,6445	48	-2,343	p <0,05
	Control Group	25	65,6000	11,4673	2,2935			

As it can be seen in the Table 3, when post-test scores of the research group and control group students were examined, it was found that the arithmetic mean of the post-test scores taken by the research group students was 12.76 and the respected figure of the control group students was 10.12. It can be seen that there is a 2.64 point difference between group means and p value is less than 0.05. This indicates that there is a significant difference at the 0.05 confidence interval between the post-test scores of the research group and control group students on behalf of the former group. This result demonstrates that the problem-based active learning model plays a role in regard to increase in academic achievement.

The findings regarding the effect of the problem-based active learning on attitudes towards science classes

As it can be seen in the Table 4, the arithmetic mean of the pre-attitude scores revealed by the research group students was found 77.16 and the respected figure for the control group students was found 71.76. There is no significant difference between the pre-attitude scores of the research group and control group at the 0.05 confidence interval.

As it can be seen in the Table 5, the arithmetic mean of the post-attitude scores revealed by the research group students was found 73.80 and the respected figure for the control group students was found 65.60. In this respect, there is a significant difference between the post-attitude scores of the research group and control group at the 0.05 confidence interval on behalf of the former group. Namely, it is observed that there is a positive change in the attitudes of the research group students towards science class. In addition to the statistical data obtained, the opinions expressed by the research group students at the end of the applications performed also mirror the positive change in their attitudes. Some of the opinions expressed by students from this group during the activities carried out in the research process are given below.

Ö.S: *"I liked this class very much. The scenarios were enjoyable. The scenarios made us to like problems. Group works were good as well. I was very contented with the applications. I believe that I will be successful with the help of these scenarios."*

Y.S.E: *"We spent a very good time with the scenario technique, which is the newly applied technique in science class, by both having fun and learning. In the problem-based method, it is so easy to answer questions and it is so good and fruitful to add our own ideas and discuss within group."*

B.A: *"The problem-based learning attracted me. It is a good method. We both learn and have fun. We started to like solving problems. We are learning concepts with respect to animated characters. I advocate that the teaching should go on in such way."*

S.K: *"In my opinion, the class is enjoyable, because the scenarios are handed out and groups are formed. I like the distribution of problem-based scenarios."*

Y.S: *I like the scenario system in science class very much. I understand subject matters better. The problems seem to be so easy."*

General evaluation of the effect of problem-based active learning on concept learning in the scope of the qualitative findings obtained from the open-ended questions

When the answers given by the control and research groups to the open-ended questions which measure their conceptual development were examined in general, it can be said that there is no positive improvement in the control groups to which traditional teaching methods were applied. Yet, the teaching model employed in the research group brought about positive improvements in the conceptual development of the students. However, these changes were not taken place at the desired level. When the conceptual development levels of the control and research groups were compared, it was seen that the model applied in the research group had positive effects on the students. When the groups' answers to the 1st, 2nd, 5th and 7th questions asking conceptual definitions in order to measure concept learning level were examined, the success of the research group with regard to learning concepts and dispelling misconceptions is seen. In the scenarios prepared in accordance with the method applied to the research group, students do not receive the information from teacher passively. The questions prepared from easier to harder in connection with the scenarios enable students to access to the information by themselves. In relation to this, while the control group students express their answers on the required concept definitions with textual sentences, the research group students do so with their own sentences. When answers given to the open-ended questions were examined at the end of the research process, it was observed that the research group students reduced their misconceptions, but they could not dispel them completely. Nevertheless, the research group is more successful in dispelling misconceptions than the control group. In the research group in which a teaching model based on group work is applied, since students are in communication with their group members and other groups, they could find the opportunity to discuss and share their ideas. In this way, information transfer among students is accomplished. The examples given are chosen out of daily life and they are enriched by students. The scenarios applied in the model play an important role in the fact that the examples are so connected to daily life. It was considered that the scenarios should be prepared in connection with daily life so as to attract students' attention and to help keeping it alive. It was ensured that events were visualized through pictures in the scenarios. Furthermore, it was aimed that the method has positive effect on students' concept development by placing previously learned concepts in the successive scenarios. Thus, the concepts learned by students become enduring. To sum up, it is seen that the problem-based learning model applied is influential on students' conceptual development.

CONCLUSION AND DISCUSSION

In this study in which the effects of the Problem-Based Active Learning applications in the unit of "The Meeting of Force and Motion - Energy" in 7th grade science classes on students' academic achievement, concept learning and attitude changes were examined, following results were obtained. It was observed that the research group in which the problem-based learning model was used is more successful than the control groups to which traditional teaching methods were applied. When pre-test and post-test scores of the research and control groups were compared with each other, it was observed that there is a rise in success in both groups. However, the fact that this rise is significantly high in the research group shows that the model employed in this group is more successful than traditional methods. This result verifies the hypothesis constructed at the beginning of the research, which is "Teaching science classes in the 7th grade of primary schools through problem-based active learning has effect on student achievement." Kayalı *et al.* (2002) showed that the active learning methods are more effective than the classic method by relying on the findings of their research conducted on the basis of problem-based learning, brain storming and cooperative learning. Şenocak (2005) used problem-based learning approach in "The Gas State of Matter" unit. In the light of the findings, the researcher determined that the problem-based learning approach is more influential than the traditional teaching approach. The results of our research and of these studies seem to support each other.

In respect of the findings acquired via analyses of the open-ended questions applied to the students both at the beginning and at the end of the study, it is seen that conceptual development of the students was affected positively and their misconceptions were minimized through problem-based learning model. This is observed clearly in the 1st, 2nd, 5th and 7th open-ended questions by which conceptual definitions are asked. After examining respective answers, it was understood that examples in students' answers have diversified in the 1st question, that students have used concepts of direction when they are describing their place in the 2nd question, that their misconceptions concerning the concept of "force" has reduced in the 5th question, and that students could place the concepts given in pursuant to the concepts of "scalar magnitude" and "vectored magnitude" and they defined concepts accurately in the 7th question. This result proves the hypothesis that "Teaching science classes in the 7th grade of primary schools through problem-based active learning has effect on student achievement." In his study examining the effect of problem-based learning model on teaching of the gas state of matter, Şenocak (2005) found that the problem-based learning model is more effective than the traditional teaching approach in regard to learning concepts related to this topic by students. Throughout the application process, it was observed how students approached the problems they faced and how they solved these problems in the problem-solving stage of the scenarios used in problem-based learning model. Based upon these observations, it was seen that the research group students implemented the stages of problem-solving method and there was a positive change in their problem-solving skills. In the study titled as "Learning to Teach Primary Science through Problem – Based Learning" conducted by Treagust and Peterson (1998), it was commented that the problem-based learning model used in educating pre-service teachers affects pedagogical learning judging skill positively. The judging skill is one of the problem-solving and critical thinking skills. Since the first stage of problem-based learning is a problem to be solved, it is expected from students who study in a problem-based learning environment to have developed problem-solving and critical thinking skills. To give students the chance to solve problems they face ensures development of their problem-solving skills (Kaptan & Korkmaz, 2002). At the end of the research, written comments were asked from students. Students' opinions about problem-based learning approach and application are given below.

> ***T.Y:*** *"I liked this class very much. It has improved my problem-solving skill. I did not like solving problems before, but I like it now. Unlike others, these problems are not boring and they have pictures. They are enjoyable. I have liked picture side of this problem-based application for the most part. I am curious about what kind of picture and topic there would be in each paper. There is also group working. I take my friends' opinions in each problem and I learn new things. In short, we both learn and have fun with this application."*
>
> ***E.B:*** *I enjoy science class. The scenarios handed out makes this class more enjoyable. Learning through scenarios is both beneficial for me and my group in regard to understanding subject matters better and consolidating them more. We both learn and have fun in the class."*
>
> ***S.S:*** *"I have already liked science class, but I started to like it more with this method. This method embroidered with various animated characters increases my willingness to solve problems. I could understand subject matters better now."*
>
> ***H.S:*** *"I think that it is better for me to solve scenarios during the class. Solving scenarios with group members attracts my intention of studying. I understand better subject matters when I solved scenarios. Science class is better when solving scenarios. I like discussing with group decision very much. I understand problems more when I am solving them."*

When students' opinions about the classes in which problem-based learning model is used were examined, it is seen that the approximation with daily life of and the visualization through pictures of the scenarios utilized in problem-based learning model were successful in pulling the attention of students to the class. This is caused by the fact that students were enabled to participate actively to the class by expressing the problems taken part in scenarios' content with pictures. In the study titled as "The effects of multiple intelligence-based teaching on 9th grade students' achievement level in ecology class, attitudes towards ecology and multiple intelligence" conducted by Aşçı and Demircioğlu (2002), it was found that the achievement level in ecology class of the students from the classroom wherein multiple intelligence-based ecology lecture plans were implemented was higher than the students from the classrooms wherein traditional teaching methodology was employed. It was determined that choosing scenario contents out of daily life brought about removing students' fears of problem-solving, facilitating learning and making students be aware of the fact that science is a very part of life. Thus, this has been quite influential regarding students' developing positive attitudes towards science class. The hypothesis of "Teaching science classes in the 7th grade of primary schools through problem-based active learning has effect on student achievement" was verified with the results of analyses and observations. In their study upon determining effectiveness of problem-based learning model, Walker & Lofton (2003) found that students' willingness to learn increased and their attitudes improved in a positive manner. By benefiting from the problem-based learning model in teaching subject matters of analytic chemistry course to students, Ram (1999) came to the conclusion that there were positive progressions in students' attitudes towards the mentioned course at the end of his study. Besides in this study, students expressed that they found the opportunity to see practical fields of fundamental chemistry knowledge by transferring this knowledge to problems in daily life. The results of our research and of these studies seem to support each other.

At the end of the studies carried out by the students through problem-based learning model, it was observed that their cooperation with each other and social development were influenced positively and some positive changes occurred in their social tendencies such as making decisions together with other group members or acting in team spirit, etc (AAAS, 1993; Brooks& Brooks, 1993; Tobin, 1993; Gallagher, 1997; Herreid, 1997; Rhem, 1998; Greenwald, 2000; Chin & Chia, 2004). In the study conducted by Sharmann & Orth-Hampton (1995), the relationship between cooperative learning and self-efficacy belief levels of the pre-service teacher candidates on science was searched. At the end of this study, it was revealed that cooperative learning affected teacher candidates' self-efficacy levels on science positively. Problem-based learning is relied on group working and group solidarity in the same manner as cooperative learning. The rise in students' social development, information dissemination and activity in line with team spirit are unavoidable in the classroom wherein problem-based learning model involving group works and solidarity is used. These are qualities of great importance in terms of both social life and science education.

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Geometry Sketching Software for Elementary Children: Easy as 1, 2, 3

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This paper discusses insights for using geometry sketching software to teach geometric concepts for kindergarten to grade 4. The authors created hands-on resources that incorporate technology in a user-friendly environment. When working with *Geometer's Sketchpad* with middle and high school students, the teacher educators noticed the ease of student use after creating such activity sheets and felt such activities may be used at the K-4 grade levels as well. The second graders who participated in the activities commented on the fun and ease of such software and compared it to the software *Paint*. The paper provides a literature review and appendices with geometry worksheets that can easily be used by elementary teachers to excite students about mathematics while incorporating the technologies reflected in the National Council of Teachers of Mathematics *Standards* (1989) and *Principles and Standards for School Mathematics* (2000).

Keywords: Elementary, Geometry, Mathematics, Sketchpad, Spatial Visualization, Semi-concrete

INTRODUCTION

The importance of using technology in the teaching of mathematics has been advocated by the National Council of Teachers of Mathematics (NCTM) for many years (NCTM, 1989 and 2000). Computers are an integral part of everyone's life, and students need to be prepared to use the technology to solve problems and access information as young adults. Currently, there exists many Internet websites and mathematics software for learning math concepts K-12 and beyond in an interactive and dynamic manner. What was once considered sophisticated software is now being used even by elementary students as the advanced technology of yesterday is slowly being brought down to the lowest levels of learners in our classrooms.

In particular, the K–4 grade students are excited when using the computer. By harnessing this excitement, teachers need to expose their students to such educational activities that employ "best practices" such as incorporating technology while helping construct students' understanding of important mathematics concepts. The National Council of Teachers of Mathematics has placed a great deal of importance on technology usage in the teaching of mathematics by making technology once of its six principles for teaching and learning mathematics (NCTM, 2000). NCTM is well aware of the role of technology in our advancing global society and wants students to learn and understand the mathematics while using the software which may be similar to such software a career person may use on the job as an architect, nurse, X-Ray Technician, and perhaps someone at the DMV who produces driver licenses. Educators are better preparing their students for their futures when they incorporate technology in their teaching. Math teachers can better help students construct their understanding when they allow them to investigate semiconcrete and abstract ideas using both concrete manipulatives and current geometry-sketching software. Bridging the gap between hands-on manipulatives and computer simulations helps to better create understanding for the learner. One dynamic math

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software is *Geometer's Sketchpad (GSP,)* which promotes the exploration of geometric concepts. Reys, Lindquist, Lambdin, Smith, & Suydam (2006) and Perkins, Schwartz, West, & Wiske, M. S. (1997) advocate that geometry is best learned in a hands-on active manner, one that should not rely on learning about geometry by reading from a textbook. Instead, as Reys, Lindquist, Lambdin, Smith, & Suydam (2006) point out, based on research by Piaget, young learners of mathematics need to (1) experience hands-on (concrete) use of manipulatives for geometry such as geoboards, pattern blocks and tangrams, (2) connect the hands-on to visuals or semiconcrete models such as drawings or use the sketching software on a computer, and (3) comprehends the abstract understanding of the concepts by seeing and operating with the picture or symbol of the mathematical concept.

MAKING IT INTERESTING FOR STUDENTS TO LEARN

As educators, we need to make mathematics interesting for students to learn and enjoy while also providing a focus on important mathematical concepts. While developing their confidence and ability to do math, learning such math skills using the technology may impact their lives in positive ways creating good attitudes toward mathematics and developing substantial mathematical content knowledge. By preparing them to learn and understand mathematics using existing technology**,** we are preparing our students to compete and function in our high-tech world. It is our obligation, as an educational community, to make the difference for the future of our students in an ever-growing, competitive global environment, which in today's society depends so heavily on mathematics, science, and technology (Furner, 1998).

Students today are motivated to learn when activities are presented in a dynamic hands-on engaging manner. The *GSP* software is an excellent interactive tool that allows students to create their own understanding of geometry and mathematical ideas. By utilizing "best practices" in mathematics instruction (Zemelman, Daniels, & Hyde, 2005; NCTM, 1989, 1995, & 2000*)* such as incorporating emerging technologies, educators can see greater gains in math achievement among their students; hence, eradicating much math anxiety and fear of using computer software and learning mathematics. The use of such technology also prepares young people to feel confident to use such sophisticated software as adults on the job. Almeqdadi (2000) has found in a controlled/experimental study that children who learned geometry using both a textbook and *GSP* software had significant gains in achievement over students who used only a textbook without software use. *GSP* makes the learning of geometry exciting and dynamic where one constructs his or her own understanding of geometry, not just reading it passively from a textbook.

TRANSITION FROM HANDS-ON MANIPULATIVES TO SOFTWARE

Research suggests that in elementary school classrooms students should learn shape recognition through hands-on manipulatives (Reys, Lindquist, Lambdin, Smith, & Suydam; 2006). In Pre-K and first grade, students should experience activities that involve shape recognition with real-life examples. They should recognize that the shape of the table-top is a rectangle and that the shape of a pizza is a circle or a honey comb is like the hexagon in the pattern block set. A problem occurs when three-dimensional real-life objects are represented in a two-dimensional computer screen environment. One study by McClintock, Jiang, & July (2002) found *GSP* provides opportunities to have a distinct positive effect on students' learning of three-dimensional geometry when using the sketching software.

Students have difficulty moving from the three-dimensional world to a two-dimensional world. Experiences that bridge this gap will help students move from concrete to abstract examples of shapes. Reys, Lindquist, Lambdin, Smith, & Suydam (2006) feel that teachers need to emphasize the stages of concrete (manipulatives), semiconcrete (the sketching software), and the symbolic (the paper and pencil).

One such example is found in the Appendix A using *Geometer's Sketchpad* (Recognizing Shapes). This activity shows the two-dimensional representation of real life objects and asks the students to use the tools of *GSP* to outline various geometric shapes. The culminating activity asks the students to find their own examples on the Internet to include with their projects.

Another activity in the Appendix A, Triangle Shapes, helps students learn about the different classifications of triangles. They experience the triangle classifications by sides and then by angles. As a review, students classify selected triangles by sides and angles and then check their answers. Geri Anderson-Nielson (n.d.) has complied an extensive set of activities entitled, *Sketchpad Activities for the Little Ones,* which like the activities above emphasize exploration of geometrical ideas using the *GSP* software. Many other activities for primary grades can be found in the *Websites Related to Geometer's Sketchpad Activities* section found below.

Many activities can be created to introduce students to the tools of *GSP* and to help students with the transition from real-life objects into the two-dimensional computer graphics (See Appendix C for *GSP* Software Website Resources). *Geometer's Sketchpad's* initial activities were created for high school and college students, but recently more *GSP* activities have been created for elementary and middle school levels. As many young students have used *Window's Paint* on their own home computers to create designs and pictures, it also provides a smooth transition into the *GSP* environment.

It is important for students to move gradually into the computer environment by relating hands-on manipulatives to two-dimensional computer shapes. These hands-on manipulatives include items collected in the real world and translated into free hand drawings and designs (two-dimensions). These drawings could be used to recognize and classify shapes and then construct them in *GSP* to analyze mathematical relationships. Teachers can help students first by using the commercial manipulatives like pattern-blocks, geo-boards, and tangrams as well as daily life items like buttons, CD's, books, cans, and cones. By introducing students to these activities at an early age, they will be able to proceed to more abstract mathematical concepts in the upper elementary grades and beyond (McClintock, Jiang, & July, 2002). When primary age children are learning mathematics concepts, Berlin and White (1986) found that computer simulations provide a smooth transition from concrete manipulation of objects to their abstract understanding. Colker (1990) contends that using a multi-media videodisc system allows children to manipulate real-world objects in order to acquire concrete knowledge about abstract concepts. Teachers should of course do concrete activities first using such manipulatives, teachers may first lead their students into using software like *MS Paint*, which most students are familiar with prior to enter school, for drawing, from this, students can easily be lead into using GSP for creating shapes, exploring properties, and even doing animations which most young students enjoy with GSP. GSP is much more sophisticated than *MS Paint* and exposing students to this software early on better prepares them for use with it in the middle and high school grades. Teachers can lead the instruction of GSP as a whole class demonstration, or walk around to monitor student progress using such activities sheets (See Appendix A). Allowing students to work together in groups/partners or individually doing such activities while the teacher observes and interacts during the activities serves also as another form of assessment for the teacher to see if students really understand and apply the concepts they are learning, the activity sheets can serve as both a guide and an assessment for the students (see Figure 3).

GEOMETRY SKETCHING SOFTWARE

Geometer's Sketchpad (by Key Curriculum Press) is one of the dynamic construction and exploration tools that exists to enable students to explore and understand mathematics in ways that are simply not possible with traditional tools. With *GSP*, students can construct an object and then explore its mathematical properties by dragging the object with the mouse. All mathematical relationships are preserved, allowing students to examine an entire set of similar cases in a matter of seconds, leading them by natural course to generalizations. *GSP* encourages a process of discovery in which students first visualize and analyze a problem and then make conjectures before attempting a logical proof.

Geometer's Sketchpad, although stated in its user's manual that it is geared toward Grades 5 through college level, can be lowered to a level of use and understanding for younger children. With its active, visual approach, *Geometer's Sketchpad* allows younger students to develop the concrete foundation to progress into more advanced levels of study (Hannafin, Burruss, & Little, 2001; Key Curriculum Press, 2001; Marinas, 2003). The features of the software invite exploration and play and enable users to define their own roles in shaping and crafting their understanding of mathematics using *GSP* (see Figure 1, Figure 2). In 1998, Manouchehri, Enderson, and Pugnucco shared their observations about teaching and learning geometry by describing how the *GSP* software program allows for the implementation of many recommendations from the National Council of Teachers of Mathematics (NCTM) *Standards* documents, as NCTM advocates the use of technology and a dynamic approach to teaching/learning, such recommendations include: developing spatial sense, the use of manipulative materials, questioning and making conjectures, justification of thinking, use of calculators and computers, teachers as facilitators of learning, and using multiple assessment techniques, including written, oral, and demonstration formats. These recommendations are all aspects of a child applying and using the GSP software when learning mathematics.

There are many elementary geometry concepts that could be explored using some fairly basic features of GSP: identifying congruent figures, giving reasons using sides, angles, etc.; drawing and describing parallelograms, rhombuses, trapezoids; characteristics of parallel and perpendicular lines; finding areas of shapes by dividing them into basic shapes such as rectangles and triangles; discovering formulas for perimeter and area; observing that rectangles with the same area can have different perimeters, etc. Some of the special features of GSP would make it a powerful tool for dealing with these topics. Their main value may be to serve as a catalyst which motivates teachers to create their own GSP activities that engage students in ways not previously feasible. Such uses of GSP would be significant and useful and better prepare our youngsters for middle and high school mathematics.

Geometer's Sketchpad works well in a variety of classroom settings with an overhead projector, with one or two classroom computers, or in a computer lab. Students can work on assigned explorations independently or collaboratively. Teachers can use *GSP* to create worksheets, exams, and reports by exporting *GSP* figures and measurements to spreadsheets, word processors, other drawing programs, and the Web (Key Curriculum Press, 2001). When primary age students have mastered the basic sketching tools, they then are curious to explore the measurement tools and even animations. Young children can play for hours using this software to create their own understandings of mathematics. Many benefits can occur as young students use the GSP software, many of the elementary students compared *GSP* to *MS Paint* and thought it was very easy to use, benefits such as the following are key to student learning: hands-on, practice drawing, visualizing, comparing to real-life objects, being artists, verbalizing the geometry as they draw, ease of interacting with the software, etc. See Appendix B for photos of second graders using the *GSP* software. In addition to *Geometer's Sketchpad*, Key Curriculum Press has recently added *TinkerPlots*. This product can be used in the primary grades for data collection and analysis which provides a foundation for Probability and Statistics concepts. *KaleidoMania!* is also another unique tool by Key Curriculum Press developed for dynamically creating and analyzing symmetric designs and for exploring the mathematics of symmetry which offers a comprehensive, interactive unit on transformational geometry and symmetry. Students build important mathematical analysis skills that give them a deeper understanding of, and appreciation for, the patterns they see all around them.

SUMMARY

Using math software, such as *Geometer's Sketchpad*, encourages elementary students to take an active role in their own learning. These experiences provide a foundation for future math classes that build these ideas into abstract mathematical relationships. This software is no longer just for the middle school, high school, or college student; primary age learners can also benefit from employing such sketching software. Today's children are more advanced technologically than they were five or ten years ago. One can see this advancement by observing young students using the sketching software.

Technology is forever advancing, and our young students need to continue to keep abreast of the latest technology for learning. The authors have found that although geometry sketching software is most frequently used with middle, high school, and college students, such software may also be brought down to the age and developmental level of primary-age learners as well. While young children benefit from using hands-on manipulatives to construct their own understanding of geometry, the sketching software creates the bridge needed for children at a young age to connect their concrete understanding to more abstract mathematical ideas.

Teachers often need to review the existing software and resource materials to adapt to their curricular goals. Geometry-sketching software, such as *Geometer's Sketchpad*, serves as a dynamic motivating tool to help students learn for understanding while lessening any math anxiety or reluctance to do mathematics. As educators**,** we would be remiss if we did not expose our students to the technology. By using geometry-sketching software**,** the teachers are implementing NCTM's *Standards* into the curriculum and better preparing young people for using the emerging technologies that surround us in an ever-advancing, globally competitive world.

APPENDIX A: A SAMPLE OF GEOMETRY SKETCHING SOFTWARE ACTIVITY SHEETS KINDERGARTEN – GRADE 4

Name________________________________ **Date**____________

(**Note**: These activities assume students have had some prior experiences using the *GSP* Tools to draw, measure, and explore geometry shapes. Teachers may need to demonstrate these steps.)

Audience: Grade 1

Geometer's Sketchpad

Recognizing Shapes

1. The teacher should download this *GSP* file prior to bringing students to the computer lab for easy access of students (http://mcs-cmarinas.barry.edu/net/gsp/clip.gsp) to the hard drive (zip drive or CD). [See Note below]
2. Open *Geometer's Sketchpad* and then open clip.gsp.
3. This file has many pages. At the bottom, you will see tabs called: <u>Intro</u>, <u>Triangles</u>, <u>Quadrilaterals</u>, <u>Circles</u>, <u>Mixed Shapes</u>, <u>Create Your Own Shapes</u>.
4. Click on the <u>Triangles</u> tab. Remember a triangle has 3 sides.
    a. Use the **STRAIGHTEDGE TOOL** of *GSP* to create outlines of triangles around these shapes.
    b. In order to see the outline clearly, the segments can be selected using the **SELECTİON ARROW TOOL** and then use the Display pull-down menu and change the color and/or thickness of the line.
    c. Find at least 5 triangles that are sides of theses shapes.
5. Next, click on the <u>Quadrilaterals</u> tab. A quadrilateral has 4 sides.
    a. Use the **STRAIGHTEDGE TOOL** to create outlines of quadrilaterals.
    b. Change the outlines colors or shapes so they are clearly seen.
    c. Find 5 quadrilaterals on this page.
6. Click on the <u>Circles</u> tab next.
    a. Circle are round so we will use the **COMPASS TOOL** (the circle) to outline the circles.
    b. Change the outlines colors or shapes so they are clearly seen.
    c. Find 5 circles on this page
7. Click on the next tab: <u>Mixed Shapes</u>. You will see many triangles, quadrilaterals, and circles on this page.
    a. Find 3 examples of each shape.
    b. Make sure that the outlines are clear.
8. Click on the final tab: <u>Create Your Own Shapes</u>. On this page, you will find pictures on the Internet to show these shapes.
    a. Minimize your GSP program, using the **–** box in the upper right corner of this window.
    b. Go to <u>http://www.google.com</u> and click on the IMAGES tab. Put **triangle** in the Search Box and click on the Google Search button.
    c. Find a triangle that you like. Right click with your mouse and then copy. Minimize your Google site, using the **–** box in the upper right corner of this window.
    d. Open the *GSP* program, by clicking on *GSP* in the Task Bar area. In the Create Your Own Shapes page, use the pull-down menu **Edit** and then **Paste Picture**.
    e. The **SELECTİON ARROW TOOL** can then move the picture into position. Do the same steps for **quadrilateral** and **circle**.
    f. When you have your pictures, outline the shapes.
9. Save the file as clipart [yourname].gsp. Example: clipart bob.gsp

NOTE: clip.gsp contains graphics that make this file large. It will not fit on a 3.5" diskette. Also it is suggested that you do only one shape per day. This gives the students the time to get used to the *GSP* environment. Many young children who have used the software *Window's Paint* will see that *GSP* is very similar and will find *GSP* easy to use. You may want to ask the class how many have used *Paint* before on their computers.

Name__________________________________ **Date**____________

Audience: Grade 4

Geometer's Sketchpad

Triangle Shapes

1. The teacher should download this *GSP* file prior to bringing students to the computer lab for easy access of students (http://mcs-cmarinas.barry.edu/net/gsp/Triangles.gsp).
2. Open *Geometer's Sketchpad* and then open Triangles.gsp.
3. This file has many pages. At the bottom, you will see tabs called: Intro, Triangles by Sides, Triangles by Angles, What Kind of Angles?, Create the Following Angles.
4. Click on the tab Triangles by Sides. Click on the **Show Definitions** button to get an explanation of the shapes. Click on Show Shapes button to see some triangles in each group. Look at the definitions and compare to the shapes.
5. Click on the tab Triangles by Angles. Click on the **Show Definitions** button to get an explanation of the shapes. Click on **Show Shapes** button to see some triangles in each group. Look at the definitions and compare to the shapes. Click on the Animate Point A button to see that the shapes remain the correct classification.
6. Click on the tab What Kind of Triangles? Classify each shape by Sides. Classify each shape by Angles. Click on the **Show Classifications** button to check your answers.
7. Click on the tab Create the Following Angles. Use the hint buttons to help you construct these triangles. Click on the **Show Shapes** button to check your answers. For more help use, the Show All Constructions button.
8. Save this file as triangles [your name].gsp. Example: triangles bob.gsp
9. Students can use the TEXT TOOL to label their triangles.

NOTE: Many young children who have used the software *Window's Paint* will see that *GSP* is very similar and will find *GSP* easy to use.

APPENDIX B: PHOTOS OF 2ND GRADERS USING GEOMETRY SKETCHPAD

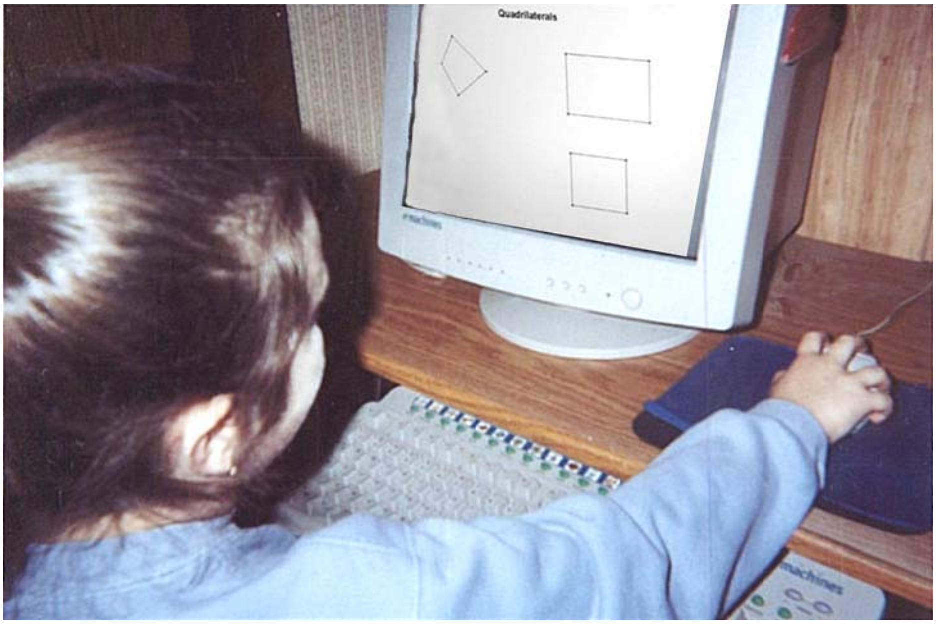

Figure 1. Student A with GSP quadrilaterals

Figure 2. Student B with GSP quadrilaterals

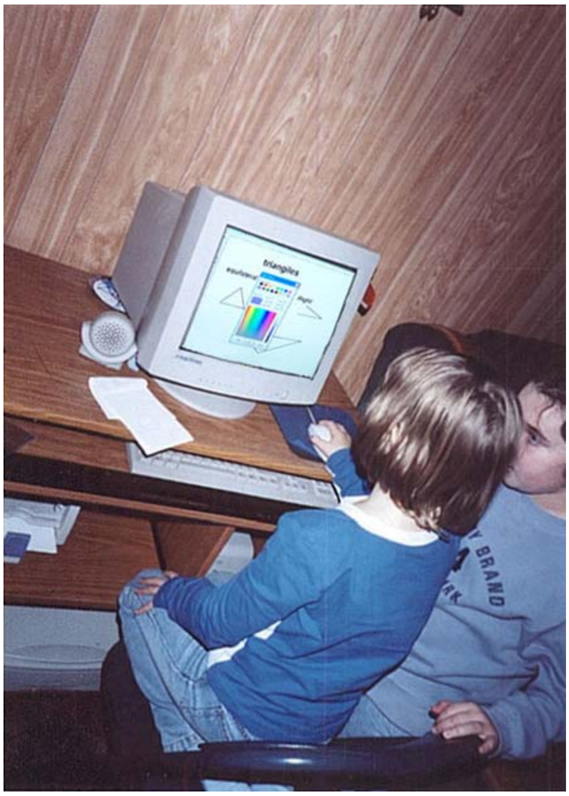

Figure 3. Students A & B experimenting with colors

APPENDIX C: WEBSITES RELATED TO GEOMETER'S SKETCHPAD ACTIVITIES

Carol A. Marinas	http://mcs-cmarinas.barry.edu/net/gsp/index.htm
Key Curriculum Press	http://www.keypress.com/sketchpad/ http://www.keycollege.com/tinkerplots/ http://www.keycollege.com/sketchpad/general_resources/classroom_activities/index.php http://www.keypress.com/sketchpad/general_resources/user_groups/nctm_2004/index.php
GSP Tutorial	http://members.aol.com/markwestbr/GSPtutorial/home.html
Lesson Plans Using *GSP*	http://www.math.byu.edu/~lfrancis/readings302/GSP/GSPLessonPl.html
Math Forum	http://mathforum.org/dynamic/classroom.html http://mathforum.org/sketchpad/sketchpad.html http://mathforum.org/dynamic/sketchpad.weblinks.html http://mathforum.org/sketchpad/littleones
The National Library of Virtual Manipulatives for Interactive Mathematics	http://matti.usu.edu/nlvm/nav/vlibrary.html
Triangle Circles	http://faculty.evansville.edu/ck6/tcenters/index.html
Virtual Institute	http://www.ettc.net/techfellow/sketch.htm
Primary School	http://www.primaryschool.com.au/mathematics-lessonsresults.php?strand=Space%20and%20Geometry&unit=2D&grade=56
Geometer's Sketchpad Resources	http://www.hpedsb.on.ca/sg/quinte/gsp_02.htm

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Book Reviews

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ICT FLUENCY AND HIGH SCHOOLS: A WORKSHOP SUMMARY

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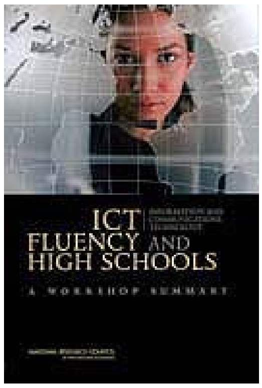

High speed improvements which have appeared in recent twenty years in information and communication technologies (ICT) which have marked our era require each individual who will constitute societies of the future to have at least the basic skills relevant to the use of ICT. For this end, it is inevitable that the ICT has great importance especially in secondary education and takes place in the many curricula starting from elementary school years. Because it should be expected from an undergraduate-level student to be able to show certain abilities on using ICT, and to be able to learn new concepts on her/his own by taking advantage of this knowledge accumulation that s/he has acquired. This will be also a significant step for the "life-long learning" mission stressed in the book.

It is no doubt that adaptation of the ICT to curricula will bring many challenges along. For instance, a standard ICT integration practice in schools that differ a lot from one another in terms of both their curricula and the social environments in which they are situated, will it enable obtaining equally successful results from all of these schools? (Tearle, 2003). Additionally, practices implemented have demonstrated that in order to be able to improve the efficiency of ICT integration and to enhance the expectations from this concept, it is necessary to conduct many research studies before initiating a new modernization which may be considered as a reform in this field (Reynolds, Treharne and Tripp, 2003).

Adaptation of ICT to curricula has become one of the most important issues that were particularly addressed by states' ministries of education. China, for example, rendered an information technology course compulsory for all high school students. Likewise, Australia is encouraging the use of ICT in schools and preparing various programs regarding this subject. Finland in Europe, on the other hand, is working on diverse education programs aiming at developing teachers' and students' knowledge-building skills. Moreover, it is conducting various studies related with bringing down ICT integration which it takes for the most significant key of becoming an information-society to pre-primary education level (Sinko and Lehtinen, 1999). As for the United Kingdom, which adopts a more innovative and enthusiastic approach, a programme called *Key Stage ICT Literacy Assessment* that was developed for ICT literacy of 12-13 year-old children has been put into force.

This book, which is of report nature, summarizing topics of a workshop which was held in October 2005 in the United States and which targeted generalizing use of information and communication technologies among high school students, has been edited in such a way that each session of the workshop is covered by one chapter. The main objective of the Workshop was to enhance "Being Fluent with Information Technology" report published by the National Research Council in 1999. Presentations of speakers have been generally shaped

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around capabilities relevant to information technology concept which may be grouped under three main levels as follows:

1. Ability to use up-to-date computer practices.
2. Adoption of fundamental principles which are computing, networking and information science.
3. Possessing the ability of benefiting from experience and knowledge accumulation acquired on ICT in bringing solutions to complex situations and problems.

In addition, capabilities that one should have under each level are given in detail under 10 items.

The given workshop which was held in 2005 commits to enhance "being fluent with information technology" phenomenon which takes place in the report published in 1999 in three ways; which are firstly setting the requirements for updating the report of 1999, secondly revealing promising efforts for developing high school students' ICT skills and finally putting forth new approaches for assessment of these skills, which is, in our opinion, the most important of all.

The workshop organization committee requested all participants to take into consideration the following four critical questions in their presentations:

- Do developments in the field of ICT require the renewal of qualities necessary for being fluent in this field?
- In high school students' field of ICT, what may be the necessary elements that may enable them to be functional in the society now and in the future?
- To what extent are the courses in practice to promote students' ICT information accumulation effective?
- What may be advanced level researches to constitute the base for the reform necessary for students to acquire formerly-mentioned capabilities on three levels?

Major topics and some attention-drawing points addressed by the participants may be listed as follows:

Rather than the importance of ICT themselves, how they would be taught was underlined and it was stressed that change in this regard was inevitable. Social effects of developments that have appeared in recent 50 years generally in the field of technology and specifically in the field of ICT are undeniable. It was expressed that particularly between 1950-1990 where computers were through a development process, including people in important positions in those years, none could imagine the progress achieved as of today. Bill Gates' statement in mid-80s in this respect which implied that nobody would need a computer RAM of more than 640 kb was referred to. Parallel to this rapid progress, it was emphasized that the ICT related skills that are supposed to be held by individuals forming up the society need to be continuously updated.

It was noted that it was necessary for a teacher to have ICT fluency in order to make a preference as for which ICT s/he has to use while teaching a lesson. In more general terms, attention was drawn to the fact that another meaning of ICT fluency possession was the ability to decide on cases in which ICT were to be used.

It was expressed that use of technology by students were quite broad but also shallow at the same time, and as an example to this, it was told that children playing with Sims software were observed to be interested in 3D construction techniques in the game, rather than the mathematical model which took place in the background of the game and which would ensure a more profound learning. It was mentioned that it was necessary to adapt ICT especially to the field of science and mathematics education so that a more profound ICT learning could be ensured; and furthermore, it was stated that one of the important points in ICT learning was the necessity to support teachers' professional development.

It was emphasized that as much as it was for making students obtain ICT skills, it was also important to encourage students' willingness to acquire these information and skills. Tom Friedman's ascertainment in this regard, quoted by Eric Klopfer, is interesting: "Youth's Britney Spears in Japan is Bill Gates. However, in this country, youth's Britney Spears is Britney Spears" (Friedman, 2005).

High school students are more familiar with today's computer and information technologies than their teachers, because unlike their teachers, these students were directly born into this technology. Hence, it was underlined that teachers, too, would be obliged to change their attitudes and approaches in the face of their students as a result of studies to be conducted in order to promote ICT fluency of their students. Thus, ICT education for teachers is also important, which is the first one of the facts relevant to this issue. A second fact is the problem of financial source that would be necessary for schools to adapt themselves to ICT. The third fact in this respect is noted to be the necessity to keep the bar as high as possible while preparing ICT programs. Because it has been argued that the more students are expected to perform, the higher is their success in terms of ICT fluency.

In conclusion, consensus has been reached on the view that the rapid development appeared in recent twenty years in ICT and effects of this development on social structure of the society as well as changes probable to occur in curricula in coming years are inevitable. It would not be so correct to call 21st century as the era of technology or specifically the era of computers. It is observed that topics standing out in this century are improving individuals' and as a natural result of this, primarily high school students' ability of thinking, problem solving and self-learning by ICT literacy and applying lifelong learning principle to these concepts. Consequently, it was stated that teachers' missions concerning ICT was not only to make students acquire formerly-set skills, but also to improve their skills and to access on their own new and more advanced information related to ICT. Since information learning in literal sense will not be realized unless it is also used by the individual her/himself. Moreover, it was stressed that ICT education had to be introduced through integration to current courses, not as a separate module in curricula, and some components were proposed to be included in science, mathematics and some others in social courses.

I believe that forming the platform which will constitute a base for several scientific studies needed in this field and putting forth realistic problems and concrete proposals to solve these problems; this work makes up for an important gap.

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THE ART OF TEACHING SCIENCE: INQUIRY AND INNOVATIONS IN MIDDLE AND SECONDARY SCHOOLS

by Jack Hassard
Oxford University Press, New York.
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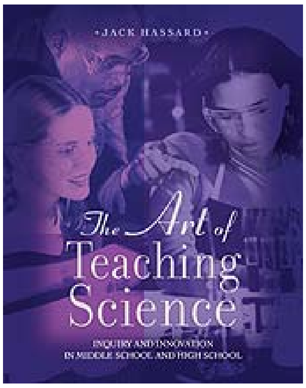

The title of Hassard's *The Art of Teaching Science* indicates that the book was written for the reader who is concerned with pedagogy. Beyond the need to know science content, it appears that Hassard's primary preoccupation in this book is for the science pedagogue to see the artistry of science teaching. Therefore, the book is written in a hybridized handbook-methods tone, yielding a welcome innovation.

Reminiscent of his earlier books, such as *Science as Inquiry* and *Minds on Science,* Hassard's *The Art of Teaching Science* captures both tradition and innovation. Each chapter includes two sections. The first section deals with traditional treatments of the topics, similar to that found in traditional textbooks. However, in a very Hassardian fashion, there are departures from the conventional through the inclusion of what he calls "Invitations to inquiry." These are sets of questions which pose, not only as harbingers of things to come, but as potential discussion questions. The second section combines such elements as case studies, "science-teaching literature," and "science teacher gazettes" to situate the previous and forthcoming information for better understanding. There are also "minds-on" strategies which are meant to be corollaries to the "hands-on" components of teaching and learning.

The book is broadly divided into four parts: 1) The art of teaching science, 2) The goals and the curriculum of school science, 3) Connecting theory and practice in science teaching, and 4) Strategies of science teaching. The topical treatments harmonize with the inherent, natural progression in science methods courses.

In part one, "The art of teaching science," Hassard explains the "artistry of teaching" (p. 4), noting that the imagination and creativity of the artist is no different from that of the effective teacher. In the tradition of conventional methods texts, he provides a fundamental view of the nature of science, science and human values, science and inquiry, and different modes of instruction. He then raises some philosophical questions for the reader's contemplation. He leaves no stone unturned in this matter. Therefore, even a reading of chapter one alone provides the reader with a historical network of knowledge as if he were weaving knowledge with a thread; the thread of inquiry. By chapter 2, Hassard would have impressed the reader with a solid, comprehensive platform from which to thrust the reader into deeper waters.

In chapter 2, captioned, "Science for all," Hassard treats about global issues at length, and then tackles the issue of multicultural science teaching, gender issues, and exceptional learners of science firmly. These issues are brought to life by the inclusion of multiple case studies of real classroom experiences.

In part two of the book; "The goals and the curriculum of school science," Hassard provides a historical account of science teaching in the United States, including a historicized account of science in the school curricula. These kinds of accounts are generally insipid to the palates of many students. However, Hassard manages to make this information more palatable by relating the information as if he were a historian-story-teller. For example, on p. 92, one reads the following: "Now, let's shift our attention away from the content of the early science and take a look at the nature of inquiry in science teaching. What were its roots? When did it emerge in science teaching?" Whereas some avoid the historical and may think that Hassard offers too much history, others may find the blend of historical information, coupled with a strong reference base a treasure trove from which to do further probing on specific points of interest.

In part three, "Connecting theory and practice in science teaching," Hassard confesses that he is a reversalist who prefers going from "practice to theory" because of his own professional experiences (p. 171). He believes that experience and reflection are more powerful ways to learn about the art of teaching. However, Hassard apparently realizes other preferred orientations. Therefore, he includes comprehensive contents for understanding the learning of science—from the most generic constructs to the most specific concepts of learning and cognition—with illustrations, thus mitigating any possible deficiencies his personal preference may pose for his readers.

By part three of this book, Hassard's strength and veteranship in metacognition are apparent. For the methods teacher, the names to know and the concepts and theories about learning to understand are explained and illustrated in scientific terms. For the lover of metacognition-pedagogy, vertical and lateral connections are made in order to foster understanding. It appears that Hassard sets this part up in order to usher the reader into the next part of the book, where the connections between "how students learn science" (p. 167) ultimately translates into "strategies fostering thinking in the science classroom" (p. 331).

In Part IV, "Strategies of science teaching," Hassard really struts his stuff as a master strategist, and takes on the reader with him. In chapter 9, he talks of strategies for fostering thinking in the science classroom, followed by how to facilitate learning in the science classroom (chapter 10). One aspect; the art of questioning, is particularly interesting. This is so, because many of the issues raised in science education literature are fluidly translated into practice. For example, on pages 335-6, Hassard discusses the concepts of low-inquiry and high-inquiry questioning and "wait time," and provides ideas to accommodate them. Vygotsky's language-related concepts are translated into the sociology of teaching science, thereby connecting "talking science" (p, 341) with the art of questioning. In this section of the book, Hassard's inclination to classroom practice becomes obvious when he devotes pages to issues such as room arrangements (p. 380), student misbehavior in the lab (p. 395), and parent-teacher conferences (p. 395).

At the end of Part IV, Hassard appears to get into his element as a leading technologist in science education. He treats Science, Technology, and Society with excellent fluidity that will be very difficult to rival—especially through the topics and ideas provided for engaging students through the use of technology. Throughout the chapter—and indeed throughout the book—Hassard offers simple, yet elegant ideas for teaching the topics.

This is the last of Hassard string of science textbooks. The print is smaller and looks serious. However, he mitigates this with a friendly writing style, thus making the whole text more inviting. A causal, perusal of the detailed table of contents would reveal that Hassard wanted this book to become his compendium for science teachers: It contains an encyclopedic caliber of knowledge base, thus making it not only a comprehensive textbook, but also a strong reference book. Given this observation, it comes as no surprise that he calls it a "handbook" (p. xv). In terms of content, this book was written with authority and confidence—as a master would teach his students. However, the tone of inquiry leaves open doors for reader reflection and questioning. This intermingling offers a sense of comforting finality to the contents, yet with the voice of invitation. Ultimately, this open-boundedness grants the reader the permission to wander within tangible, cognitive boundaries—yet knowing that there awaits solid, research-based, teacher-attested information.

Another impression Hassard leaves his readers is that he is a collector—of knowledge. From the very start to the end of the book, he includes real-life teachers' experiences to suit every chapter or oftentimes topics. There are ideas scattered throughout the book for not only the new teacher, but also for veterans to refine their skills. This kind of teacher-originated information could only be executed in several years of active collection.

For instructors of lateral entry teachers; teachers who are obsessed with the everyday, practical challenges of teaching, Hassard's "practice to theory" approach is a very good fit. Incidentally, it is for this reason that veteran teachers may also find this book useful. Interesting, however, it appears that Hassard is in luck, for this "practice to theory" approach is actually a multi-edged sword in practice: whereas the in-service professional may read the book from a practical standpoint, the pre-service student may benefit all the same, since the book is replete with practical applications of the theory. Concomitantly, for instructors who are concerned with bringing real-life teachers' voices into their science methods courses, Hassard's book becomes an attractive option.

In summary, Hassard's *The Art of Teaching Science* is a compendium of science education knowledge base that all readers—from pre-service and in-service teachers through science educators—will find a handbook to keep on hand.

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