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EDITORIAL

M. Fatih Taşar, Associate Editor
Gazi Üniversitesi, Ankara, TURKEY

Dear members of EURASIA family,

On behalf of the editors of EURASIA I would like to express my deepest gratitute to our readers, authors, and reviewers. Thanks to their great efforts we are able to publish our fourth volume. In this issue there are 8 papers and a conversation/interview between Sandra Abell and Patricia Friedrichsen of University of Missouri-Columbia on science teacher learning. I strongly believe that when in time this genre of writing develops in EURASIA (and perhaps also elsewhere) together with the audio recordings they will prove to be a great source of information for future researchers. It can also be forseen that these documents can become a good resource for graduate education in our field.

I am also happy to inform you that as an Endeavour Executive Awardee I will be travelling to Australia to spend four months at RMIT University. Professor Annette Gough has kind ly offered to be my host during my scholarly work there. I am sure it will be a most benefial time period for my work. I will engage in activities for understanding the school system, teacher education, teacher development and curricula in the state of Victoria.

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Learning Science through the PDEODE Teaching Strategy: Helping Students Make Sense of Everyday Situations

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The aim of this study was to investigate effectiveness of PDEODE (Predict-Discuss-Explain-Observe-Discuss-Explain) teaching strategy in helping students make sense of everyday situations. For this, condensation concept was chosen among many science concepts since it is related to many everyday-life events. Forty-eight eleventh graders students were involved in this study. In order to assess students' application of their knowledge to problem solving in everyday situations, a test including two everyday problems were presented to them as pre- and post-test. As an intervention phase, two PDEODE tasks were utilized to teach condensation. The test scores were analyzed both qualitative and quantitative methods. Statistical analysis using paired t-test of student test scores point to statistically significant differences in tests and total scores ($p<0.05$) suggesting that the PDEODE teaching strategy either facilitates students to help students make sense of everyday situations or helps students to achieve better conceptual understanding for the concept of condensation.

Keywords: Conceptual Change, Condensation, Everyday-Life Experiences, PDEODE Teaching Strategy

INTRODUCTION

Most instruction in science does focus on helping students amass information about scientific ideas, but does not foster development of understanding of these ideas, nor does it help them learn how to apply the concepts outside of school in the real world in which they live (Jarman & McAleese, 1996; Soudani et al, 2000). It is not surprising that most of students could not apply their science knowledge learned in schools to everyday-life events, because they do not have opportunity to do so in schools (Gallagher, 2000). Whereas, connecting science to students' everyday-life experiences has been an important issue in science education and this should be included in science lessons (Ogborn et al, 1996). Several reasons have been given for incorporating everyday-life experiences and focusing on everyday-life applications of science (Driver et al., 1994; Campbell & Lubben, 2000). Firstly, as argued by Campbell & Lubben (2000), everyday-life experiences are a way to make science meaningful to students. Secondly, there is another argument is that if it is wished to educate students as scientifically literate citizens, everyday-life theme related to science is necessary (Harlen, 2002). Finally, it is also an argument about constructivist view on learning in which students' alternative conceptions derived from their everyday-life experiences before the formal instructions has been seen as a starting point in teaching (e.g. Smith et al, 1993). Studies in the area of students' alternative conceptions have showed that isolating the school science from students' everyday-life could make students develop two unconnected knowledge systems related to science: one is used to solve science problems

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in schools, and the other is used for their everyday-lives (e.g. Osborne & Freyberg, 1985). Similarly, several studies have focused on the effect of including everyday science applications into school science on the students' mastery of school science (e.g. Driver et al, 1994). However, this study focused on the unexplored area of students' use of science knowledge from teaching in everyday situations.

Because of the importance of everyday-life applications, both researchers and teachers wish to emphasize on this issue in teaching science. Although they focused on the connecting science to students' everyday-life experiences and taught their students in similar ways, they still fail to provide for students to apply their science knowledge to make sense of everyday situations (e.g. Jarman & McAleese, 1996). Thus, teaching strategy should be developed for teachers in order to provide students to make connection between their knowledge of science and related everyday situations. The present study tries to assess effectiveness of PDEODE teaching strategy on the degree to which students accept scientific concepts and use them for interpreting the phenomena in their everyday-life. In order to reach this, condensation concept was chosen among many science concepts since it is related to many everyday-life events. The study presented here mainly focused on phenomena about condensation on cool surfaces due to having seen many alternative conceptions in students' minds (see e.g. Osborne & Cosgrove 1983; Bar & Travis 1991; Chang 1999; Gopal et al, 2004; Paik et al, 2004). These studies show that students have several alternative conceptions and difficulties about this topic despite science teachers' extensive efforts in teaching. The alternative conceptions identified by the previous researches are summarized in Table 1.

According to popular opinions, many of them are caused by daily life experiences of chemical phenomena which students bring into science classes (e.g. Driver & Easley, 1978). Hence, PDEODE tasks were developed based on this topic.

Table 1. Students' alternative conceptions and difficulties about condensation on cool surfaces

Condensation on the cool surface (a beaker filled with ice) in an open system
Particles of air form drops on the cool surface due to cooling
Drops are formed due to the difference in temperature (or when cold surface encountered heat, drops are formed or when cold and hot air meet each other, drops are formed)
Ice on the surface melts and forms drops of water
Sweating happens (similar to human beings) and drops are formed
The coldness caused hydrogen and oxygen to change into water
Drops are made of water particles from inside penetrated the cool surface
Cold water evaporated when encountering heat
Drops of water on the outside of the cold surface comes from inside the beaker
The cold surface and dry air (oxygen and hydrogen) react to form water

PDEODE Teaching Strategy

PDEODE strategy initially is suggested by Savander-Ranne & Kolari (2003) and firstly used by Kolari et al., (2005) in engineering education. This is an important teaching strategy in which there is an atmosphere that supports discussion and diversity of views. Hence, it is intended that this strategy is used as a vehicle in helping students make sense of everyday situations.

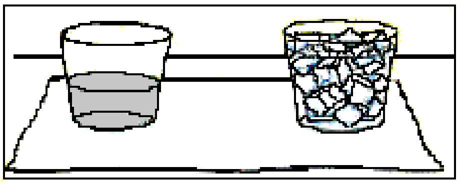
The PDEODE teaching strategy used here consisted of six steps. In the first step (P: Prediction), teacher presented a phenomenon about condensation to students so as to predict the outcome of the phenomenon individually and to justify their prediction.

In the second step (D: Discuss), it is wanted the students to discuss in your group to share their ideas in own group and to ponder together. In the third step (E: Explain), students in each group are asked to reach a mutual solution about phenomenon and to give their result to other groups through whole-class discussions. Afterwards, the students worked in groups perform hands-on experiment and record individually their observations what happened. In this step (O: Observe), the students observe changes in the phenomenon and teacher should guide them to make observations that are relevant to target concepts. In the fifth step (D: Discuss), the students are asked to reconcile their predictions with their actual observations made in the early step. Here the students were asked to analyze, compare, contrast and criticize their classmates in the groups. In the last step (E: Explain), the student confronts all discrepancies between observations and predictions. Doing these, the students begin to resolve the contradictions that may exist between their beliefs. A sample PDEODE teaching activity sheet containing the six steps mentioned above was presented in Figure 1.

In accord with this theoretical background, the aim of this paper was to investigate PDEODE teaching strategy about condensation in helping students make sense of everyday situations. It was expected that by following this teaching strategy:

(a) The majority of students will interpret everyday phenomena about condensation after teaching with PDEODE tasks (hypothesis 1).

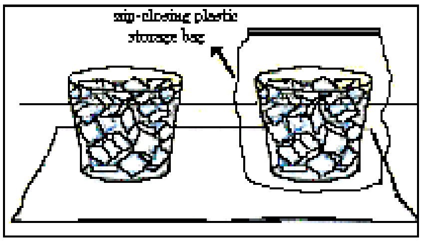
Task 1. Condensation on a beaker filled with water and on a beaker filled with ice cubes.



- ✓ Have 2 clear plastic cups
- ✓ Fill in one of the plastic cup lots of ice cubes. Do not add any ice to the other cup. Place the cups on a paper towel.
- ✓ Wait a few minutes

- What happens to the outside of each plastics cup, a few minutes later? Predict? State and explain the reason(s) for your prediction.
  …………………………………………………………………………………………………
- Discuss your prediction and the reason(s) in your group. Then explain your reasons in detail.
  …………………………………………………………………………………………………
- Observe changes in the outside of each plastics cup. What happened? Do you notice any difference between them? State your observation.
  …………………………………………………………………………………………………
- Why do you think these happen? Discuss in your group. Then explain your reasons in detail.
  …………………………………………………………………………………………………
- Compare your observation with your prediction. Are they in agreement or disagreement? Explain with your reason(s). What did deduce from the above experiences? Please write your deduction below.
  …………………………………………………………………………………………………

Task 2. Condensation on a beaker filled with ice cubes and on plastic bag in which there is a beaker filled with ice.



- ✓ Have 2 clear plastic cups
- ✓ Fill in the cups with lots of ice cubes.
- ✓ Put one of the cups in a zip-closing plastic storage bag. Place both cup on a paper towel.
- ✓ Wait a few minutes.

- What happens to the outside of each plastics cup and plastic storage bag, a few minutes later? Predict? State and explain the reason(s) for your prediction.
  …………………………………………………………………………………………………
- Discuss your prediction and the reason(s) in your group. Then explain your reasons in detail.
  …………………………………………………………………………………………………
- Observe changes in the outside of each plastics cup and plastic storage bag. What happened? Do you notice any difference between them? State your observation.
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  …………………………………………………………………………………………………
- Compare your observation with your prediction. Are they in agreement or disagreement? Explain with your reason(s). What did deduce from the above experiences? Please write your deduction below.
  …………………………………………………………………………………………………

Figure 1. PDEODE teaching tasks used in this study as an intervention

Problem 1.
In a cold day, you have noticed that dampness occurs on the windows surface of a house or a car. Why? Explain your reasons in detail.
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Problem 2.
You have noticed smokes rising form a huge ice cube taken from a refrigerator. Actually ice cube give off smoke? How the smokes occur? Explain your reasons in detail.
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Figure 2. Test items used in this study

Table 2. The criteria for the classification of students' responses to test items

Level of understanding	*Criteria for the classification of student responses*	*Score*
Sound understanding **(SU)**	Responses that included all components of the validated response.	4 points
Partial understanding **(PU)**	Responses that included at least one of the components of validated response, but not all the components	3 points
Partial Understanding with Specific Misconception **(PUSM)**	Responses that showed understanding of the concept, but also made a statement, which demonstrated a misunderstanding	2 points
Specific Misconceptions **(SM)**	Responses that included illogical or incorrect information	1 points
No Understanding **(NU)**	Repeated the question; contained irrelevant information or an unclear response; left the response blank	0 point

(b) Students who held alternative conceptions about condensation will show a conceptual change after teaching unit with PDEODE tasks (hypothesis 2).

METHODS AND MATERIALS

Subjects

Participants in this study comprise of 48 eleventh grader students (25 girls and 23 boys, whose ages were ranged from 17 to 19 years) at a secondary school in Turkey. The students in this investigation all had been taught the concept of condensation.

Data Collection

In order to test hypotheses, an exploratory test designed without control groups was chosen. The test including two everyday problems was developed based on the alternative conceptions about condensation on cool surfaces in open systems. Each item posed an everyday, science-based problem and students were asked to suggest solutions to them. The test was presented in Figure 2.

The test was validated by a panel consisting of two chemistry teachers and one teacher educator. The final form of the test was administered to the sample seven weeks before (pre-test) and after the teaching (post-test). It is assumed that duration between application of the same test as pre- and post- tests is sufficient for students to forget the items.

Teaching Intervention

As teaching intervention, it is used two PDEODE tasks about condensation given earlier. Teaching intervention based on two PDEODE tasks was administered to the sample in groups (total twelve groups: four students in each). At the beginning of each teaching activity, the activity sheet on which students would write down their explanations was handed out to each group. Students worked collaboratively in groups and they filled in each activity sheet individually. These sheets were collected at the end.

Data Analysis Procedure

The test items were analyzed under the following categories and headings (see Table 2), which were suggested by Abraham et al, (1994).

The categorizations of students' into the Table 2 were decided by a panel of three experts, all of whom are experienced science and science education. These qualitative responses and their categorization were subsequently validated by the same panel. Any disagreements were resolved by discussions and the categorizations presented here represent consensual agreement of the panel. Differences in pre-and post-intervention evaluation scores were investigated by conventional statistical means using paired t-test and a Windows version of Statistical Package for the Social Sciences (SPSS), and thematic analysis of reasons as described above. In addition, students' responses were analyzed qualitatively. In this analysis, it was taken into consideration the changes in students' responses from pre-test to post-test.

RESULTS

The results from the test items are shown in Table 3. Here it can be seen that more students gave responses that were classified in the sound understanding (SU) category, after the teaching intervention. For example, the percentage of students' responses in this category for problem 1 changed from 12%, to 90% for pre- and post-test scores. Similarly, students' responses that were classified as specific misconceptions (SM) decreased from pre-test to post-test. For example, the percentage of students' responses in this category for problem 2 changed from 86%, to 29% for pre- and post-test scores.

Students' responses were also analyzed in order to determine specific alternative conceptions or difficulties and their changes through pre- and post- test. These are presented in Table 4.

Table 3. Frequency and proportion of students' responses for test items for categories of understanding

Category	Problem 1				Problem 2			
	Pre-Test (N=48)		Post-Test (N=48)		Pre-Test (N=48)		Post-Test (N=48)	
	f	%	f	%	f	%	f	%
SU*	6	12	43	90	1	2	14	29
PU*	20	42	2	4	2	4	16	34
PUSM*	7	14	1	2	0	0	4	8
SM*	14	29	2	4	41	86	14	29
NU*	1	2	0	0	4	8	0	0

SU: Sound understanding*,* **PU:** Partial understanding*,* **PUSM:** Partial understanding with specific misconception*,* **SM:** Specific misconception*,* **NU:** No understanding.

Table 4. Students' alternative conceptions and difficulties elicited by analyzing each test. Conceptual changes about SAC through each test.

Students' alternative conceptions and difficulties (SAC)	Pre-Test		Post-Test		Conceptual Changes
For problem 1	**f**	**%**	**f**	**%**	**%**
1. When hot and cold air encountered, condensation occur	**S2, S5, S6, S8, S9, S17, S20, S21, S25, S29, S40*	23	*S17, S21*	4	*+ 19*
2. Air condensed as water	*S10, S11, S15, S19, S32, S39*	13	-	0	*+ 13*
3. Condensation occur due to pressure changes	*S22*	2	-	0	*+ 2*
4. Not understand the water itself can exist as a vapor	*S10, S11, S15, S19, S24, S32, S39*	15	*S24*	2	*+ 13*
For problem 2	**f**	**%**	**f**	**%**	%
5. Ice cube melts when it taken from the refrigerator and forms drops of water on it. The water drops evaporated and smoke gave off.	*S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S13, S14, S17, S19, S23, S25, S26, S29, S30, S32, S34, S36, S38, S39, S42, S44, S45*	56	*S1, S3, S5, S6, S7, S9, S10, S14, S17, S19, S22, S28*	25	*+ 31*
6. Ice changed in to water vapor. That is, it sublimated.	*S11, S12, S16, S21, S24, S33, S40, S43*	17	*S11, S21*	4	*+ 13*
7. Air condensed as water vapor.	*S15, S20, S41*	6	*S20, S41*	4	*+ 2*
8. Condensation occur due to pressure changes	*S35, S37*	4	*S37*	2	*+ 2*

Note: S1, S2 ... refer to the particular students in the study

As seen from Table 4, students' alternative conceptions (SAC) and their difficulties changed over time (pre-, and post-test), which are generally positive. Their frequency varied considerably, and this data is also presented in the Table 4. As seen from the Table 4, positive conceptual changes occurred in students' minds. This shows that students' alternative conceptions and difficulties decreased after the intervention. For example, percentage of the 5nd SAC decreased from 56% to 25% for pre- and post-tests. These differences were examined for statistical significance with paired sample t-test (see, Table 5).

As can be from the Table 5, there are statistically significant differences between the pre- and post-test scores in favor of post-test ($t(48) = -12.214$, $p<0.05$).

Table 5. The summary of the paired sample t-test

	Subject (N)	Mean	Std. Deviation	df	t	p
Pre-test	48	42.19	19.06	47	-12.214	.000
Post-test	48	80.21	19.09			

DISCUSSION AND CONCLUSIONS

The main purpose of this study was to evaluate the effectiveness of PDEODE teaching strategy in helping students making sense of everyday situations. The study answered the two hypotheses given in the introduction, the first of which is related to effectiveness of the teaching intervention on students' interpretations everyday phenomena about condensation. Results obtained suggested that the teaching strategy was an effective means of providing students to make sense of everyday situations. Data presented in Tables 3 and 4 clearly show that after the intervention students improved their interpretations of everyday problems in the test. Furthermore, this positive result strengthened with statistical analysis which was found to be statistically significant (Table 5). The success of the teaching strategy in this study could be attributed to the inclusion of verbal and non-verbal actions (Van Oers, 1998) embedded within the context of inter and intra-group class discussions among peers (Howe et al, 1992; Lee & Anderson, 1993). The discussions provide students to examine either own or classmates' pre-conceptions and experiences about everyday problems. Hence, they have chance to realize explanation of everyday problems in variety of perspectives and afterwards they learn scientific explanations of them guided with teacher.

With respect to the second hypothesis, this study provided evidence that the teaching strategy used in the present study was effective in altering students' alternative conceptions towards scientific ones (name as conceptual change) and facilitated greater conceptual understanding about condensation. The findings presented in Tables 3 and 4 suggest that after the intervention the students' understanding improved. Furthermore, the students' alternative conceptions (see Table 4) were reduced from the pre-test to the post-test and this conceptual change was found to be statistically significant (see Table 5). These findings are consistent with respect to the research literature on conceptual change in various topics (e.g. Başer, 2006; Case & Fraser, 1999; Chiu et al, 2002; Niaz, 2002; Çalık et al, 2007; Dilber & Düzgün, 2007). The success of this strategy stems from the fact that the PDEODE tasks helped the students to evaluate their prior knowledge and to re-examine their ideas within their groups and in whole-class discussions. As outcome of the PDEODE tasks, the students became dissatisfied with their existing knowledge through their observations in the tasks, and this helped them to accept better, more scientific, explanations to the problems presented. Finally, they modified their ideas towards the scientific ones and enhanced their newly structured knowledge about condensation from discussions after the observations.

To sum up, the study provides some evidence that PDEODE teaching strategy as used in the present study can be an effective means both of helping students make sense of everyday situations and conceptual change for condensation. Teachers or researchers may wish to consider such an approach in their own classrooms, for this topic and perhaps other related topics.

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Reform-Based Science Teaching: Teachers' Instructional Practices and Conceptions

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Received 10 August 2007; accepted 19 November 2007

This study aimed at exploring the practices and beliefs physics teachers have about introducing reform-based instruction into the physics class. Data were collected from semi-structured interviews held with 11 experienced physics teachers. The results revealed that the teachers occasionally introduced a small number of enhanced instructional strategies explicitly required by the formal curriculum into their class, such as presenting, analyzing and generalizing experimental results in different forms. However, the teachers used much fewer other strategies aimed at enhancing higher-order thinking, such as asking students to formulate their own questions or introducing them to problem-solving strategies used in class. Although physics is considered a relatively well-established subject in Israeli schools, extensive differences have been identified among teachers in issues such as using rich instructional strategies in class, their self-confidence in utilizing progressive instruction, and their beliefs about students' abilities to develop higher-order thinking. Teachers often regard reform-based instruction as an idealistic view rather than a clear schooling practice; further work is required in teachers' pre-service and in-service training to make the fostering of higher-order thinking a common ingredient in science teaching.

Keywords: Higher-Order Thinking, Instructional Strategies, Perceptions, Science Teaching

INTRODUCTION

A major goal of science education today is fostering students' intellectual competencies, such as independent learning, problem-solving, decision-making and critical thinking (American Association for the Advancement of Science (AAAS), 1994; National Research Council (NRC), 1996). It is widely agreed that in order to achieve this end, science teaching must be shifted from traditional schooling to more constructivist-oriented instruction. Schraw, Crippen and Hartley (2006) stress the obligation of science education to foster student's meta-cognition and self-regulation, and mention six strategic areas essential for achieving this goal: (a) inquiry-based learning; (b) the role of collaborative support; (c) strategy instruction to improve problem-solving and critical thinking; (d) strategies for helping students to construct mental models and experience conceptual change; (e) the use of technology; and (f) the impact of students' and teachers' beliefs.

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Over the past few decades, these ideas about the objectives and methods of science education have prevailed within the community of science educators. However, the change instigated at the school level has been very slow, and most studies today still take place using routine methods, i.e., the teacher delivers content or the students algorithmically solve many exercises. There is almost unanimous agreement that in order to foster students' higher-level thinking, teachers must possess not only in-depth subject matter knowledge in the field they are specializing in, such as mathematics, physics or biology, but also good pedagogical knowledge on how to develop students' higher-order thinking in the context of the subject matter they are dealing with (Brickhouse, 1990; Bybee, 1993; Fullan, 1993; Kagan, 1992; Hollon et al., 1991; Pajares, 1992; Richardson, 1996). Moreover, it is increasingly being recognized that the ability of teachers to reflect on their instruction is very consistent with their capability to plan, execute and improve instruction aimed at fostering higher cognitive processes in class (Leou, 2006). Zohar (2006) stresses that in order to support students' learning in reforms that highlight inquiry and thinking, teachers require "sophisticated knowledge that cannot be embedded in curriculum materials or scripted into instructional routines."

In Israel, considerable efforts have been made to promote the professional development of science teachers in areas such as biology (Zohar, 2004a, 2004b), chemistry (Hofstein et. al., 2004) and physics (Yerushalmi and Eylon, 2004). Yet, relatively little is known about what teachers working in regular schools believe or do about promoting students' thinking skills by teaching science, and to what extent they see themselves committed to this goal. Consequently, the general purpose of this study was to investigate teachers' practices regarding the promotion of higher-order thinking in teaching the required curriculum and to understand their beliefs about reform-based schooling.

THEORETICAL FRAMEWORK

Dancy and Henderson (2007) claim that although terms such as reform, change and improvement are frequently used in the dialog on science education, these terms are not clearly defined and no consensus exists as to their exact meaning. These authors suggest a comprehensive framework for articulating reform-based science education, consisting of two parts. The first part relates to educational *Practices***,** namely teachers' behaviors regarding *1) Interactivity, 2) Instructional decisions, 3) Knowledge source, 4) Students success, 5) Learning mode, 6) Motivation, 7) Assessment, 8) Content, 9) Instructional design* and *10) Problem-solving.* Regarding the aspect of *Instructional decisions*, for example, while a reform-oriented science teacher shares decisions with his/her students, a conservative teacher decides exclusively on his/her own. Regarding the aspect of *Content*, alternative instruction means that a teacher explicitly teaches students how to learn, think and solve problems, in addition to teaching scientific content; in contrast, a teacher in a traditional class deals mainly with facts and principles.

The second part of the framework mentioned above describes teachers' *Conceptions*, namely attitudes, goals and other similar types of mental behavior regarding science education. This part relates to teachers' views on *1) Learning , 2) Expertise, 3) Knowledge, 4) Nature of science, 5) Role of school, 6) Students 7) Teacher's role, 8) Diversity, 9) Desired outcomes,* and *10) Scientific Literacy.* In the aspect entitled *Role of school*, for example, while teachers holding alternative educational beliefs regard school as a place to help students develop as independent thinkers and enrich their personal lives, educators holding traditional views of education often regard school as a place to prepare students for their future roles in the workplace and society.

The distinction between teachers' *Practices* and *Conceptions*, as Dancy and Henderson (2007) suggest, is valid and useful, because a teacher might hold very progressive views about education, but in practice use conservative teaching methods; such a situation could be a result of various factors such as a teacher's lack of content or pedagogical knowledge, difficulties in adapting to change, or pressure at school. We will discuss this point in more detail later in the paper.

Teaching higher-order thinking in the science class

Questions like what constitutes good thinking or how to foster students' thinking in school in general, and in science lessons in particular, have been increasingly discussed in the educational literature over the past few decades (Beyer, 1988; Costa, 1985; Glaser, 1984; Pogrow, 1988; Sternberg, 1987; Zohar, 1999, 2004a; Zohar and Dori, 2003). Resnick (1987) suggested the concept of 'higher-order thinking,' which avoids a precise definition of thinking but instead points towards some general characteristics of higher-level thinking, as follows: higher-order thinking is non-algorithmic, complex, yields multiple solutions, requires the application of multiple criteria, self-regulation, and often involves uncertainty. According to the National Science Teachers Association (NSTA, 2003, p.18), "the ability to engage in effective inquiry using scientifically defensible methods is considered a hallmark of scientific literacy... Inquiry is characterized by a degree of uncertainty about outcomes... True inquiry ends with an elaboration and judgment that depends upon the previous reasoning processes." In accordance with the Benchmarks for Scientific Literacy (American Association for the Advancement of Science (AAAS), 1994) and the National Science Education Standards (National Research Council (NRC), 1996), authors like Zoller (1997) and Zohar and Dori (2003) include the following examples of higher-order thinking patterns in inquiry-oriented science education: formulating a research question, planning experiments, controlling variables, drawing inferences, making and justifying arguments, identifying hidden assumptions, and identifying reliable sources of information.

Swartz (2001) points out that during the late 1980s and throughout the 1990s, teachers in a wide variety of schools all over the United States, as well as in other countries, restructured the ways they teach common content to infuse instruction in diverse thinking skills.

Costa (2002) mentions two advantages of infusing the teaching of thinking skills into teaching science. First, skillful thinking cannot be performed in a vacuum – there must be something to think about. Second, the nature of scientific inquiry imposes certain constraints on problem-solving processes; scientific problems, in which the control of experimental variables is paramount, differ from social and aesthetic problems in which ethics and artistic judgment play a significant role. Swartz and Parks (1994) suggested four basic components that should be included in designing the teaching of problem-solving strategies in the science class: 1) explicitly *Introducing* a thinking strategy to the students in the context learning of the subject matter; 2) actively *Engaging* the students in the suggested strategy; 3) *Reflection* on the strategy after gaining some experience in using it; and 4) *Teaching* for *Transfer*, namely showing the students how the specific strategy can be used in other related situations. Figure 1 illustrates this model.

So far we have seen the potential of science education as a platform for developing students' thinking skills. Unfortunately, science studies are often dictated by a rigid syllabus or the obligation to prepare students for various types of tests, such as regional and national surveys or final high school exams. In Israel, for example, high school students must take matriculation exams ('Bagrut') in all subjects learned in high school. Since getting high scores in these exams is a key criterion for enrolling into higher education, particularly in areas such as engineering or medicine, most of the teachers and students focus their efforts on learning towards these exams. Indeed, the required curriculum demands that students be able to deal with non-routine questions and tasks both in theoretical studies and lab work. Yet, questions exist as to how teachers address the task of fostering students' thinking skills in science class. Since, as we noted earlier, both teachers' beliefs and behaviors play an important role in the educational process, in this study we aimed at exploring questions such as: What are teachers' conceptions about reform-based instruction versus traditional teaching of science? What teaching methods are actually used in science class using these two contrary methods?

The significance of this study lies in its potential to contribute to the literature and to educational practice related to teacher training, with special focus on instruction aimed at promoting higher cognitive processes in the classroom.

METHOD

Context of the study and the participants

The study involved the participation of 11 physics teachers, eight females and three males, most of them having over 10 years of experience in the teaching profession. Each participant taught physics in a different school; all of the schools were located in or close to a central city in the southern part of the country. Although these schools serve a heterogeneous population – from students living in affluent neighborhoods to students coming from relatively low-income families, physics students are quite a homogeneous group within these schools because they all learn the same curriculum and take the same official matriculation exams. The gaps between students in different schools cannot be extreme, because in Israel, as in many other countries, physics is frequently regarded as a subject aimed only at high-achieving students, an 'elite' subject in science studies (Angel et al., 2004; Osborne et al., 1998; Woolnought, 1994). We don't claim to have taken a random sample; instead, we selected the participating teachers to represent fairly well the profile of experienced physics teachers country-wide. A similar approach was adopted, for example, by Dancy and Henderson (2005), who explored the barriers in using researched-based instructional strategies in teaching physics by conducting semi-structured interviews with five well-respected, tenured physics faculty members from different institutions. In our study as well, most of the teachers were regarded as important figures in their schools, often in charge of preparing the physics class for the matriculation exam. Huberman (1989) described teachers having this type of background as being in the 'divergent period' of their professional development, characterizing them as follows: "Some teachers describe this as a period of experimentation and activism as they develop their own courses, try out new approaches to teaching, and confront institutional barriers. Yet, others see it as a period of self-doubt and reassessment; many teachers leave the profession at this stage as their level of frustration with the system reaches its peak."

We are aware of the limits of basing the study on a relatively small sample; however, we see an advantage in focusing the study on teachers from a specific discipline, in particular a relatively well-established field like physics, and from schools located within a relatively small geographical area. This enables concentrating the discussion on the knowledge and attitudes of teachers having a common professional background while reducing the influence of factors related to the differences between the disciplines or the diversity of the population served by the schools. It is also worth mentioning that the study addressed the teachers during their regular work throughout the school year, rather than under special circumstances, such as teaching a new curriculum or participating in an in-service course. Therefore, we believe that the context of the study described above contributed to the validity of the outcomes.

Data collection and analysis

The study adopted the qualitative methodology aimed at obtaining a holistic understanding of the participants' viewpoints on the issue of higher-order thinking in teaching physics, how they understand this concept, and what stays beyond their external expression of their behavior (Silverman, 1997). To this end, the main data collection method involved holding semi-structured interviews with the teachers individually in their schools. The principal value of interviews (Fontana and Frey, 2000; Silverman, 1993) is that they offer a rich source of data that provides access to how people account for their understandings and attitudes about everyday experiences.

The interviews, which lasted about 90 minutes, started out by presenting the teacher with a list of 22 strategies often used in teaching physics, such as formulating a research question, controlling variables, or drawing inferences from an experiment. These instructional strategies were selected from the current literature on physics education and materials used in teachers' courses in Israel (Yerushalmi and Eylon, 2004; Van Heuvelen, 1991). We chose to start the conversation in this way in order to create a convenient opening discussion during the interview. The interviewees were asked to comment on each strategy, for example, the extent he/she uses it in class, its advantages and disadvantages, or where he/she had learned it. The interviewees were also encouraged to add additional strategies they knew or used. The conversation, however, did not adhere to this format but rather developed into divergent directions according to each teacher's interests or preferences. Similar to the study Henderson and Dancy (2005) conducted, the participants were asked about their instructional goals, current and past instructional teaching experience, or attempts to make changes. The interviewer, the second author of this article, has herself been a physics teacher for about 15 years. To create a relaxed atmosphere, the interview started with an explanation to the interviewee that the study is about teaching physics in general, and that there is no intention to evaluate him/her in any way. The fact that the study is based primarily on what the teachers said without an attempt to evaluate the teachers in their practical work in the class is limiting on the one hand, but also advantageous on the other; since the interviewees were not in any position of being judged or at risk in any way, they could reflect freely on their teaching and honestly express their views. We believe that this approach encouraged the teachers to talk about their successes and their failures, rather than attempting to present themselves at their best.

The interviews were recorded and transcribed verbatim. An inductive analysis was performed (Patton, 1990) in which patterns, themes and categories of analysis were extracted from the data. First, we reread the transcripts separately to formulate a tentative understanding; in subsequent readings, we attempted to confirm this understanding. As part of the verification methodology (Strauss, 1987), we repeatedly reread the data; initial categories were revised following several rounds of discussion.

FINDINGS

In the Findings section, we refer to teachers' practices and beliefs regarding reform-based instruction, their views about students' abilities to acquire higher-order thinking, and the participants' reflections on their own abilities to teach higher-order thinking.

Teachers' use of reform-oriented instructional strategies

As previously noted, one of the main means used by teachers to enhance cognitive processes in class is applying diverse instructional strategies. At the beginning of the conversation, the interviewer showed the teacher a list of 22 strategies to enhance science learning and suggested that they talk about these strategies. The teachers were asked, for example, if they could indicate to what extent they use each strategy in their class on a four-level scale (never / seldom / often / very often), or express their opinions about the effectiveness of the various methods. The interviewees were also encouraged to cite additional strategies they knew or used. However, this was just a starting point for the discussion, which developed in divergent directions according to each teacher's interests or preferences, as detailed later in the paper.

The mean frequencies the teachers attributed to using each strategy are listed in descending order in Table 1.

It can be seen that among the strategies marked by the teachers as being the most useful in teaching physics were (ranked 1-4): generalization of physical concepts based on experimental results; teaching diverse problem-solving methods; guiding students systematically to justify their solutions to a problem or their decisions; and presenting data in diverse forms, i.e., graphs, tables or texts. These results, as illustrated in Figure 2, are not surprising because the skills mentioned above are required either in formal paper-and-pencil exams or lab exams. It should be noted, however, that most of the teachers often refer to the term 'problem-solving' as solving standard computation exercises. In contrast, the teachers marked instructional strategies (ranked 19 and 20 in Table 1), such as asking students to formulate their own questions or learning through teamwork, as being much less important. It is also worth mentioning that the teachers marked moderate use of strategies related to fostering reflection (between "often" and "seldom"), such as explicitly discussing thinking strategies used in class with the students, or asking the students to state the difficulties they encountered and explain how they resolved them.

Beyond the discussion of the specific 22 instructional strategies mentioned above, only two or three of the 11 teachers who participated in this study cited the development of students' thinking skills as being a major objective in teaching physics or presented examples of how they were actively attempting to achieve this goal. One of these teachers said the following:

> "I don't allow them to answer quickly because if I do, they won't have time to think. First I force them to think: I don't accept any answer for about two minutes, for example… the answer must be the result of the thinking process, and thinking requires time."

Another teacher said:

> "A student asks a question and I ask three… in the beginning, they are in shock, and I explain: never mind, I want to understand correctly what you are asking, to find out the answer from you, because sometimes after three questions you already know it by yourselves."

These examples illustrate cases in which the teachers regard students' thinking as an important issue in itself. However, this was not the common situation. More often, teachers consider problem-solving strategies as a matter of efficient learning. The following comments reflecting this perspective were noted in the interviews:

> "[Thinking strategies] are not methods for solving a specific question but are rather organizational methods; if you are well organized, you don't waste time and can concentrate on the subject matter."

Or:

> "[Efficient] working methods avoid redundant work and add to understanding the content."

Another view expressed by the teachers was that problem-solving strategies are intended to raise students' confidence. The following quote demonstrates this point:

> "I prepare a lot of charts for them [how to solve a question]: Do this in this case, do that in another case… what to do first and what later… The students love having strategies. They do not

Table 1: Teacher's use of instructional strategies aimed at fostering higher-order thinking in physics (n=11).

Rank	Strategy	Mean Frequency*
1	Presenting data in diverse forms, i.e. graphs, tables or texts	2.91
2	Guiding students systematically to justify their solutions to a problem or their decisions	2.73
3	Teaching diverse problem-solving methods	2.45
4	Generalizations based on experimental results	2.45
5	Asking for students explanations' before teachers' explanations	2.36
6	Stating the strong and weak points of different solutions to a problem	2.27
7	Linking what is learned in physics class to other scientific fields	2.27
8	Predicting the results of an experiment or a theoretical solution to a problem and providing justifications	2.18
9	Asking students to verbally present the thinking stages they used in solving a problem	1.91
10	Guiding students to add their own examples	1.91
11	Presenting conflicts: facts or examples that conflict with students' previous knowledge and intuitions	1.82
12	Discussions of questions to which the answers are vague	1.73
13	Allotting time for thinking in the class	1.73
14	Asking students to state the difficulties they encountered and explain how they resolved them	1.64
15	Discussions with students regarding the thinking strategies used in class, such as making decisions, asking questions	1.45
16	Creating situations whereby the students present contradicting positions and try to convince one other	1.36
17	Encouraging students to participate in scientific contests and projects	1.27
18	Guiding students to present diverse viewpoints around a particular issue	1.18
19	Asking students to formulate their own questions	1.09
20	Learning through teamwork in the class	1.09
21	Use of concepts maps	1.09
22	Involving students in determining evaluation criteria	0.34

* (0 – never, 1– seldom, 2 – often, 3 – very often)

always know how to use them but they feel more confident if they think they have strategies…"

A third reason mentioned by the teachers for trying to use various instructional approaches was that the matriculation exams are a requirement of the formal curriculum. Some teachers stated this explicitly, as seen in the examples below:

"Any additional word [verbal explanation for a computation exercise] in the matriculation exam is a plus for them… what will students do in the exam if they are unable to justify their answers?"

One teacher mentioned that the generalization of scientific concepts is also a matter of studying for the exam:

"[In a theoretical lesson] we present the results of a lab experiment and make a generalization… this has recently become a requirement… In the matriculation exam, the results of an experiment are presented and the student must draw conclusions from them."

In their efforts to 'help' their students instead of challenging them, the teachers quoted above tried to save the students the hard work of thinking.

Teachers' arguments for maintaining conservative teaching

While teachers' explanations as to how or why they use a specific teaching strategy refer mainly to educational practices, the reasons they give for maintaining conventional teaching give us a very good idea about their perceptions of reform-based science education. Beyond the common claims that the obligation to convey mandatory content does not allow enough time for more progressive instruction, the teachers mentioned other reasons for continuing to use traditional teaching. Two interviewees perceived the development of thinking as an issue separate from the teaching of physics, and suggested providing students with special courses to foster thinking skills. One teacher said the following:

"It is necessary to include the learning of logic in the curriculum. This is important."

Other teachers believed that the mere teaching of physics develops students' thinking, as the following quotes show:

"Nothing develops thinking like physics… for example graphs…this is abstract thinking… it requires concentration… solving problems… understanding concepts like energy conversion."

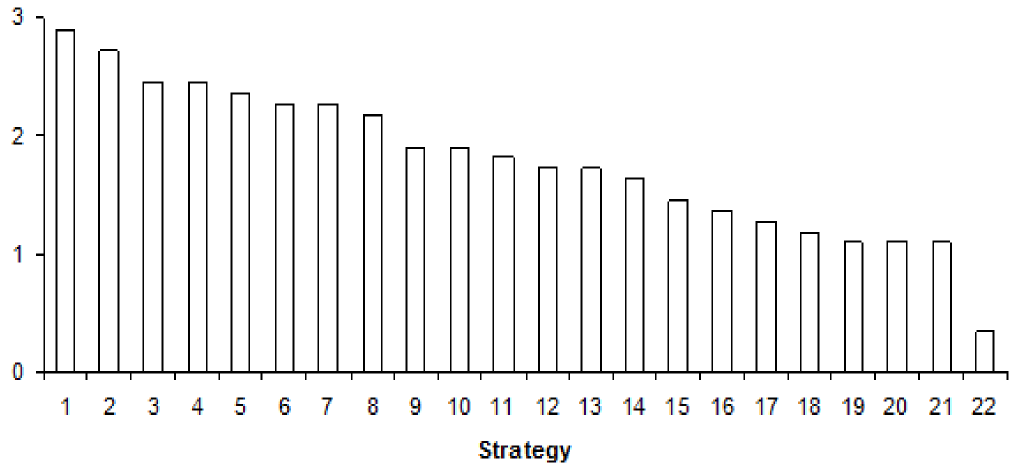

Figure 1: A four-stage model for the infusion of instructional strategies aimed at fostering thinking skills into teaching subject matter.

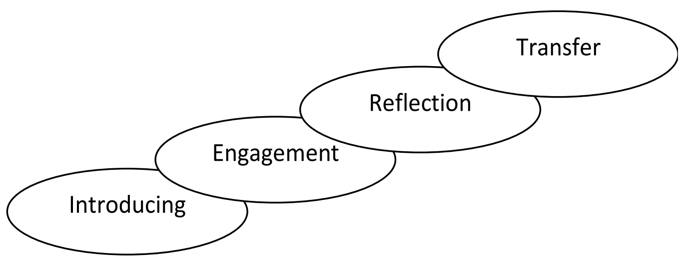

Figure 2: Teacher's use of instructional strategies

Or:

"It's easier to develop thinking in physics because you have the tools to do so. What are the tools of thinking? You have a collection of principles and rules… you use them to solve a problem or a conflict… therefore this discipline, physics, helps to develop thinking."

Since, as we have already mentioned, physics is commonly regarded as a difficult subject, when teachers in the current study talked about fostering thinking by teaching the subject matter, they probably took into account students having relatively strong scholastic backgrounds.

Another argument used by the teachers in their preference for conventional teaching was that the intensive delivery of subject matter is necessary in order to control the class:

"In today's situation, if you stop [teaching] you lose control over the class… the students start talking."

Or:

"If I had a quiet class I could hold more discussions. In our school, discipline is a problem. In a class that has discipline problems, all you can do is to teach technically."

And also:

"Since the students lack the culture of discussion, it is difficult. They start shouting at one another and so it is a waste of time."

Three teachers specifically stated that they felt insecure in using compound instructional strategies, as illustrated below:

"I don't like discussions… I don't know where they lead and I don't have the tools to deal with this later. In discussions, they [the students] sometimes exaggerate, so then what do I do?"

Teachers' beliefs about students' abilities in acquiring higher-order thinking

Certainly, teachers' beliefs about students' understanding, thinking and learning are critical factors in any educational reform (Kagan, 1992; Pajares, 1992). The conversations with the teachers indicated that the interviewees were divided into two extreme poles regarding their estimation of students' potential to acquire higher-order thinking. At one pole were four 'pessimistic' teachers who said things like:

"In the tests, I wish they knew [at least] one way to solve a problem, my poor students."

And

"Man was born the way he was… maybe it is possible to teach him to think a little bit but not too much. A creature that was born to crawl will not be able to fly. It is possible to improve, but if you study physics you must know how to both think and sit."

At the other pole were five teachers who had great confidence in their students, as expressed in the examples below:

"If you keep telling them 'you have to decide,' 'you decide for yourselves,' they get used to the notion that they also have a say in class."

And also:

"They are more intelligent than I am, but perhaps lazier; I always say that 'if I had their brains I would have gone a lot farther'."

The optimistic teachers frequently talk about the potential of their students to succeed but at the same time mention their own duty to support and encourage them. Since students majoring in physics are usually selected carefully in each school, the large gaps found in teachers' viewpoints about the students cannot refer exclusively to the students' scholastic backgrounds but must also deal with the teachers' beliefs. We will discuss this point in more detail later in the paper.

Do teachers' perceptions about their students relate to their self-esteem about teaching higher-order thinking?

So far we have examined separately teachers' reflections about their abilities to teach higher-order thinking and their views about students' abilities in acquiring higher-order thinking. We find it interesting to explore to what extent teachers' perspectives on these issues inter-correlate; if a strong correlation exists, it could hint that the teachers relate their self-esteem to how they assess their students ' abilities.

To this end, we classified the teachers according to the viewpoints they expressed in the interviews regarding two aspects mentioned above on a simple scale of **strong** (explicit positive position), **moderate** (indecisive) or **weak** (low perception), as illustrated in Table 2. Although we recognize that this type of grading is not very accurate, it can help in the current discussion.

Table 2 shows that teachers' estimations about their students' abilities in handling reform-oriented learning only partially match their self-esteem about using progressive instructional methods in class: three teachers (T8, T10, T11) expressed a low position in both aspects; three other teachers (T2, T3, T4) had strong viewpoints; three teachers (T5, T6, T7) had higher perceptions about the students than their self-confidence in teaching higher-order thinking; only two

Table 2. Mapping the 11 teachers (T1-T11) according to their self-evaluation in using higher-order instructional strategies and their views about their students

Self-confidence in applying higher-order instruction		Belief in students' abilities to acquire higher-order thinking		
		Weak	Moderate	Strong
	Strong	T9	T1	T2, T3, T4
	Moderate			T5
	Weak	T8, T10, T11	T7	T6

teachers (T1, T9) had stronger self-esteem than their evaluation of the students. Since, as mentioned earlier, students majoring in physics in high school are normally considered to be a relatively excellent group in their schools, and the teachers in this study were also experienced in their profession, it is likely that the above findings indicate a type of confusion among the teachers regarding the use of reform-guided instruction of physics in their classes.

SUMMATIVE DISCUSSION

This study aimed at exploring the practices and beliefs that physics teachers have about introducing reform-based instruction into their class. Although all the participants in this study were experienced teachers, and the fact that physics is considered to be a well-developed field in Israeli schools, extensive differences have been identified among the teachers in issues such as the use of rich instructional strategies in the class, their self-confidence in utilizing progressive instruction, and their beliefs about their students' abilities to develop higher-order thinking. These findings exhibit some parallel lines with a similar study (Dancy and Henderson, 2005; Henderson and Dancy, 2005) in which the researchers conducted semi-structured interviews with five senior, well-respected physics faculty members who made significant efforts in their teaching. Although these instructors held beliefs about teaching, learning and instructional goals that are largely consistent with reform-based education, it was found that their self-described instructional practices were largely traditional. Dancy and Henderson (2005) mention several common systematic forces that that are likely to impede the implementation of research-informed practices, such as students' resistance, time structure, department norms, expectation of content coverage and lack of instructor time. Some of these forces are also relevant in teaching science in the Israeli system, in which the major factor affecting instruction in high school is the matriculation exams taken by the students. Therefore, despite the fact that the constructivist view of learning has been placed at the center of teachers' pre-service and in-service programs for at least two decades, teachers often regard reform-based instruction as an idealistic view of education rather than a clear schooling practice. The significant diversity of the teachers, as well as the cases in which the teachers highly evaluate their students but show moderate or low self-confidence in their own abilities to teach higher-order thinking, indicate that many teachers are confused or embarrassed about reform-based instruction. Further work is therefore required in teachers' pre-service and in-service training to make the fostering of higher-order thinking a common ingredient in science teaching.

To get closer to introducing advanced instruction into the science class, we adopt Pogrow's (1996) approach that educational change requires highly specific, systematic and structured methodologies with supporting materials; common suggestions about comprehensive reforms, on the other hand, are less significant. Introducing elements of constructivist pedagogy combined with specific steps aimed at fostering higher-order thinking into class could be a realistic aim for teachers. Yerushalmi and Eylon (2001), for example, describe a program for teachers' professional development that focused on the question of "How can we promote self-monitoring by students in physics problem-solving?" The program stressed the use of strategies to guide students' problem-solving and consisted of problem-solving steps ranging from qualitative to quantitative.

The current study confirms Zohar's (2006) claim that teachers know very little about meta-strategic knowledge on fostering thinking in the classroom. This author emphasizes that it is not enough to apply a specific higher-level instruction, but rather the teachers must recognize matters such as what higher-order thinking skills are and how to develop them in teaching science.

The four-stage model to infuse the teaching of thinking by teaching a common content (Swartz and Parks, 1994) presented earlier (Figure 1) can be very useful in this discussion. According to this model, in order to foster students' thinking skills by teaching a specific content, a teacher needs to: *Introduce* a specific teaching-learning strategy applied in the class to the students; *Engage* them significantly in learning in the suggested way; Encourage them to *Reflect* on their learning; and Teach them how to *Transfer* the problem-solving approach they have experienced to other related contexts. Similarly, Blank (2000) proposed a model of critical thinking in science called the *Metacognitive Learning Cycle* (MLC), which emphasizes the systematic use of discussions and reflection to promote explicit metacognitive understanding of critical thinking and problem-solving. The MLC consists of four interrelated steps, which include the concepts of *Introduction*, *Application, Assessment and Exploration.*

We summarize this paper by noting two examples of approaches to foster thinking in the science class to emphasize that the notion of reforming science education must be translated into well-defined instructional strategies that teachers can infuse into teaching the common curriculum.

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Pre-Service Elementary School Teachers' Learning Styles and Attitudes towards Mathematics

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The purpose of this study was to investigate the differences of pre-service elementary school teachers' attitudes towards mathematics according to their learning styles. Two hundreds eighty one pre-service elementary school teachers were involved in this study. The researchers employed two types of instruments, Learning Style Inventory and Scale of Mathematics Attitude Questionnaire, to collect the data. The learning style inventory was designed to detect the participants' learning styles, Divergent, Assimilator, Convergent, and Accommodator, and the scale of mathematics attitude questionnaire was used to find the participants' attitudes towards mathematics. After the collection of the data, the researchers run the one-way ANOVA to show the attitude differences based on the learning styles. The study concluded that there were statistically significant differences found between the attitudes of learners, convergent and assimilator, and that the convergent learners had more positive attitudes towards mathematics than the assimilator learners.

Keywords: Learning Styles, Attitudes; Mathematics, Pre-Service Elementary School Teacher.

INTRODUCTION

Students' low success level in mathematics has been a worry for a long time in many countries. There are a lot of factors affecting success in mathematics. One of these factors is students' mathematical anxiety, in other words, their mathematical fear. One of the reasons for mathematical anxiety is attitude towards mathematics (Baloğlu, 2001). Students that have high mathematics anxiety also have negative attitudes towards their success are low in mathematics (Biller, 1996). It is determined that individuals' attitudes towards mathematics may effect their careers in the mathematical sciences in the future. Since families' beliefs about mathematics may also effect their children's beliefs, families have responsibilities to their children's positive beliefs (Shoffner, & Vacc, 1999). It is clear that the encouraged students have affirmative attitudes towards mathematics (Hartog, & Brosnan, 1994). In order to make the attitudes affirmative, a great number of factors should be considered. Grouws & Cebulla (2000) state that the use of concrete materials for a long time, especially in the primary education period, is positively related to increasing students' mathematics success and developing positive attitudes towards mathematics. It is fact that decreasing students' prejudices about mathematics will be effective in developing affirmative attitudes. In addition being from different ethnic groups, nations, and sexes effect on the attitudes towards mathematics (Tocci & Engelhard, 1991; Strutchens, 1995; Odell & Schumacher, 1998). Is learning style one of the factors which affect the attitudes towards mathematics? In other words, do pre-service elementary school teachers' attitudes towards mathematics differ according to their learning styles? Since little research has been done in the area of learning style and attitudes towards mathematics of pre-

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service elementary school teachers, this research was undertaken to add that body of knowledge.

Due to the implementation of traditional instruction, many students find it difficult to adapt to learning environments that, in some situations, have conflicted with the students' values, attitude, and belief systems (Jones, Reichard & Mokhtari, 2003; Dede, 2006). Learning style research has indicated that students succeed academically in learning environments that match their learning styles (McCarthy, 1987; Kolb, 1984). In some of the research done (Peker, 2003a), it is found that the students' attitudes towards mathematics show differences according to the learning styles. Is this case valid for the candidate teachers of the future? If this is so, we, the instructors in universities, who educate them, have important roles and responsibilities. In this research, the difference in attitudes towards mathematics among pre-service elementary school teachers according to learning styles was investigated. Kolb's and McCarthy's learning styles are taken into consideration. It is stated that Kolb's and McCarthy's learning styles are similar. This similarity is given in table 1 (Peker, Mirasyedioğlu & Aydın, 2004, p.74). It is believed that the learning model most applicable to learning mathematics is Kolb's model of experiential learning (Knisley, 2002). In this model, perceiving and processing of knowledge is critically important. Student learning styles can help us understand students' difficulties in perceiving and processing mathematical concepts. This is in line with the claim of Knisley (2002) stated that teachers and educators should consider students learning styles in their teaching mathematics.

If learners are to be effective they need ability in four different areas: Concrete experience, reflective observation, abstract conceptualization, and active experimentation. That is, they must be able to involve themselves fully, openly, and without bias in new experiences for concrete experience. They must be able to reflect on and view these experiences from many perspectives for reflective observation. They must be able to create concepts that integrate their observations into logically sound theories for abstract conceptualization. They must be able to use these theories to make decisions and solve problems for active experimentation (Kolb, 1984). In Kolb's model, a student's learning style is determined according to whether the student's prefers of perceiving information from the concrete to the abstract, and whether the student's prefers of processing information active experimentation to reflective observation. These preferences result in a classification scheme of the student's learning styles. But the student may have discovered that no single mode entirely describes his/her learning style. This is because each person's learning style is a combination of the four basic learning abilities. (Kolb, 1984; 1985). Kolb identified four different learners as follows: Divergent learners (diverger), assimilator learners (assimilator), convergent learners (converger), accommodator learners (accommodator) [See figure 1]. Divergent learners learn by combining concrete experience with reflective observation. They can view concrete situations from various viewpoints. Assimilator learners learn by combining abstract conceptualization with reflective observation. They thrive putting the information in logical form. Convergent learners learn by combining abstract conceptualization with active experimentation. They take abstract ideas and actively experiment to find practical uses for the information by finding solutions to the problems. Accommodator learners learn by combining concrete experience with active experimentation. They take concrete experiences mixed with active experimentation in a hands-on experience.

These learning styles are not absolute, and all learners, regardless of preference, can function in all four learning styles when necessary (Kolb, 1984). Listed below (figure 2) are the strengths of the four learning style types (Kolb, 1984; 1985; Baker, Dixon & Kolb, 1985).

Table 1. The Similarity of Kolb's and McCarthy's Learning Styles

Kolb's Learning Styles	*McCarthy's Learning Styles*
Diverger	Imaginative learner
Assimilator	Analytic learner
Converger	Common sense learner
Accommodator	Dynamic learner

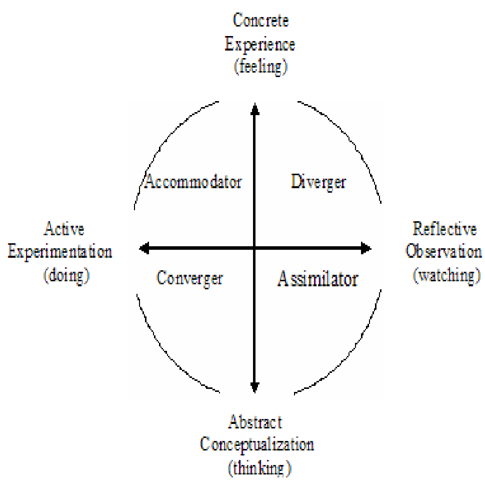

Figure 1. Elements of Kolb's Learning Styles (Kolb, 1984).

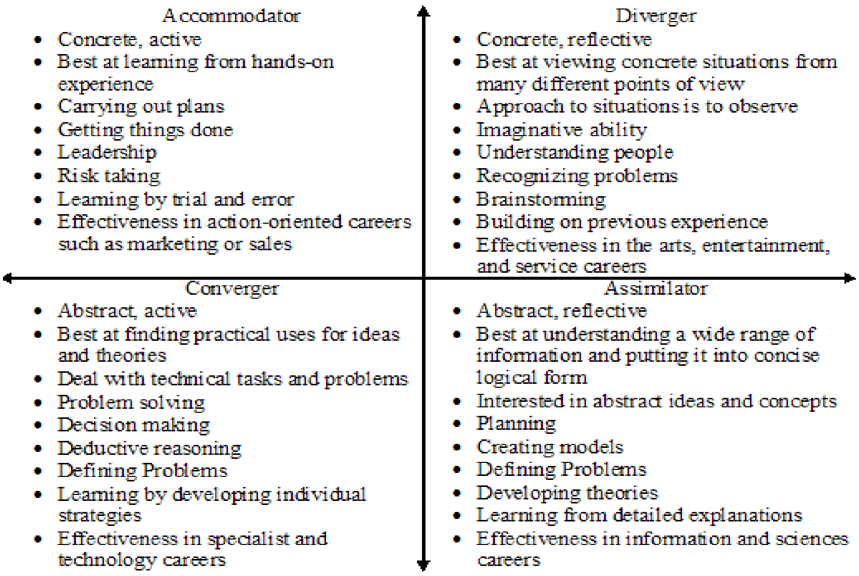

Figure 2. The strengths of the four learning style types

According to Kolb, "A major function of education is to shape students' attitudes and orientations towards learning— to instill positive attitudes towards learning and a thirst for knowledge, and to develop effective learning skills" (Kolb, 1984, p.85).

The purpose of this study is to investigate the differences of pre-service elementary school teachers' attitudes towards mathematics according to their learning styles. Namely, the main problem of the research is the question of whether pre-service elementary school teachers' attitudes show differences according to their learning styles. Since little research has been done in the area of learning styles and attitudes towards mathematics among pre-service elementary school teachers, this research is undertaken to add to this area. Besides, this study would help teacher educators know better their students learning preferences and attitudes towards mathematics.

METHODS

Participants

The research involved 281 pre-service elementary school teachers who have been enrolled in Elementary Teacher Education at the Faculty of Education in two Universities in Turkey. The pre-service teachers are students, that is, pre-service teachers enrolled in teacher education programs. 54.4 % of the pre-service elementary school teachers were female, and 45.6 % of the pre-service teachers were male.

Instruments

Two instruments were used to obtain the data: The Learning Style Inventory and the Scale of Mathematics Attitude. Learning Style Inventory which had been developed by Kolb (1985) in order to determine pre-service elementary school teachers' learning styles, and had been adapted in Turkish by Aşkar & Akkoyunlu (1993), was used. The Learning Style Inventory (LSI) describes the ways people learn and how people deal with ideas and day-to-day situations in their life. The LSI is a 12 item questionnaire in which respondents attempt to describe their learning style. Each item asks respondents to rank order four sentence endings that correspond to the four learning modes— concrete experience, reflective observation, abstract conceptualization, and active experimentation (see, Kolb, 1985). Norms of Learning Styles Inventory were applied for determining pre-service elementary school teachers' learning styles. The Scale of Mathematics Attitude, which was developed by Aşkar (1986), was used to determine pre-service elementary school teachers' attitudes towards mathematics. The Scale of Mathematics Attitude consists of twenty statements, 10 positive and 10 negative, such as "I like studying mathematics", "I suffer when I go to mathematics classroom", "mathematics is less-liked course among others", "mathematics is an enjoyable course", and so forth. The internal consistency coefficient (Cronbach Alpha) of Mathematics Attitude scale was .95.

Procedure

Unlimited time was allowed for each testing session, with most pre-service teachers finishing the scale of Mathematics Attitude within 10, the LSI within 15 minute. Statistical Package for Social Science (SPSS) was used to analyze the data. While the answers given to the negative items in the Scale of Mathematics Attitude are 5=just suitable, 4=suitable, 3=undecided, 2=unsuitable, 1=just unsuitable, they are inverted at grading and reconsidered as 1=just suitable, 2=suitable, 3=undecided, 4=unsuitable, 5=just unsuitable. The highest point of attitude is identified as 100, while the lowest is 20 for 20 items. While calculating points of pre-service elementary school teachers' attitudes towards mathematics, the total points according to the criteria determined above at the 20-item scale are considered. Norms of Learning Styles Inventory were applied for determining pre-service teachers' learning styles and the evaluation was done by taking the percentage and frequency for the distribution of learning styles. The One-Way ANOVA procedure produces a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. In addition to determining that differences exist among the means, you may want to know which means differ. Hence, One-Way-ANOVA was carried out at the analysis of the difference of pre-service teachers' attitudes towards mathematics according to their learning styles.

RESULTS

In the following findings appeared by the result of obtained data analysis is presented as tables and interpretations are done according to the relevant tables.

Learning Styles of Pre-service Elementary School Teachers

The distribution of learning styles of pre-service elementary school teachers is given in Table 2. When the percentage distribution of pre-service elementary school teachers whose learning styles are determined, it is seen that more than the half of the students (55.5 %) are assimilator learners, and more than the quarter (28.1 %) are convergent learners. Divergent learners and accommodator learners are a little group. In the research done by Peker (2003a) among the tenth grade students who have mathematics lesson the distribution of the learning styles are as follows, 13.9 % are divergent learners, 54.2 % are assimilator learners, 26.1 % are convergent learners, 5.8 % are accommodator learners. Another research conducted by Peker & Aydın (2003) in Anatolian High School and High School of Science on tenth grade students, it is defined that 10.9 % are divergent learners, 54.5 % of the students are assimilator learners, 29.4 % of the students are convergent learners, 5.2 % of the students are accommodator learners. In another research done for examining the pre-service mathematics teachers' learning styles, it is seen that nearly more than half of the pre-service teachers were assimilator learners (58.8 %), 1/3 of the students were convergent learners (31 %). Divergent (5.9 %) and accommodator (4.3 %) learners were so low at rate (Peker, Mirasyedioğlu & Aydın, 2004). Peker (2005) determined that more than half of the primary mathematic teacher education students were assimilator learners (65.8 %), quarter of them were convergent learners (25.8 %), 5.2 % of them were divergent learners, 3.2 % of them were accommodator learners. It is seen that the findings in our research show similarity with the findings in the other researches.

Table 2. The Percents and Frequency of Pre-service Elementary School Teachers' Learning Styles

	f	%
Divergent Learners	32	11.4
Assimilator Learners	156	55.5
Convergent Learners	79	28.1
Accommodator Learners	14	5.0
Total	281	100

The Differences of Pre-service Elementary School Teachers' Attitudes towards Mathematics According to Their Learning Styles

The findings obtained by making One-Way-ANOVA are given in the table 3 and table 4. When table 3 is examined, it is seen that the arithmetical mean of the assimilator learners' points of attitudes towards mathematics is the lowest ($\bar{x}$ =78.53). The convergent learners' is the highest ($\bar{x}$ =87.10). The findings of One-Way-ANOVA showing the difference between pre-service elementary school teachers' attitude points according to their learning styles are given in table 4.

When table 4 is examined, it is seen that pre-service elementary school teachers' points of attitudes towards mathematics show a significant difference according to their learning styles. Namely, pre-service teachers' attitudes towards mathematics change according to their learning styles. Pre-service teachers' learning styles are categorized in to four items: divergent learners, assimilator learners, convergent learners, accommodator learners. The result of ANOVA shows that there is a significant difference in pre-service teachers' attitudes towards mathematics according to the learning style variant. The means of attitude points according to pre-service teachers' learning styles was examined. The results of the Tukey-HSD multi-comparison test, which was applied, in order to designate significant differences according to the learning styles, are between the groups which were investigated. There was a significant difference between convergent learners' and assimilator learners' attitude points. It is seen that according to table 3 this difference is in favor of convergent learners. It is revealed that convergent learners have more affirmative attitudes towards mathematics than the assimilator learners. According to the research done by

Table 3. The Descriptive for Pre-service Elementary Teachers' Attitude Points Related to Learning Styles

	N	$\overline{X}$	*SD*
Divergent Learners	32	80.25	11.542
Assimilator Learners	156	78.53	14.061
Convergent Learners	79	87.10	10.700
Accommodator Learners	14	85.00	11.482
Total	281	81.46	13.296

Table 4. One-Way ANOVA Results for the Difference of Pre-service Elementary Teachers' Attitude Points According to Their Learning Styles

	Sum of Squares	**df**	Mean Squares	F	p
Between Groups	4079.607	**3**	1359.869		
Within Groups	45422.087	**277**	163.979	8.293	.000***
Total	49501.694	**280**			

***p<.001

Peker (2003a), the existence of the relationship between learning styles and the students' attitudes towards mathematics lesson, among high school tenth grade students was examined. Significant differences were found between divergent learners and assimilator learners' attitudes and between divergent learners and convergent learners' attitudes. It was defined that this difference was for the assimilator and convergent learners.

DISCUSSION AND CONCLUSIONS

At the end of the research, it is seen that 11.4% of pre-service elementary school teachers are divergent learners, 55.5% of them are assimilator learners, 28.1% of them are convergent learners, and 5% of them are accommodator learners. Findings of research showed that pre-service elementary school teachers are mostly from the assimilator learners. In Turkey, where traditional instruction is generally applied, it is seen that learning styles appropriate to this instruction method (namely, that which is geared towards assimilator learners and convergent learners) takes too much place (Peker, 2003a).

The analysis of One-Way ANOVA about the attitudes of pre-service elementary school teachers towards mathematics demonstrated that there was a statistically significant difference found among learning styles [$F_{(3\text{-}277)}=8.293$, $p<.001$]. These differences were between assimilator learners and convergent learners. It also found that the difference was in favor of convergent learners. It is thought that such a result is revealed because convergent learners find the traditional instruction more appropriate to themselves than the others do. In the procedure of functional view, it can be seen as natural that convergent learners have more affirmative attitudes. This result supports the findings of Peker (2005) and Peker, Mirasyedioğlu and Yalın (2003), According to Peker (2005), convergent learners were the most successful ones among pre-service elementary mathematics teachers. In addition, Peker, Mirasyedioğlu and Yalın (2003) showed that assimilator and convergent 10th graders instructed with learning preferences of assimilator and convergent performed better in mathematics classroom than their peers who were divergent and accommodators. In other words, this current study documented that students given an instruction based on their learning styles and preferences showed better performance and positive attitudes towards mathematics than students given an instruction designed not on their learning styles and preferences.

As a result, one of the factors which affect the attitudes towards mathematics is learning style. Students in the classroom have more than one learning style (Peker, 2003b). The students who have other learning styles expect instruction appropriate to themselves. Students are capable of functioning in all four learning styles, but the preferred learning style of a student varies from topic to topic and concept to concept. If this is so, then what can be done about this? One of the factors effecting students' mathematics achievement is their attitudes towards mathematics, and one of the factors effecting students' attitudes towards mathematics is learning style. Teachers must know about learning styles and their students' particular learning styles. Teachers must apply to their students' lesson plans considering the learning styles.

Like many researchers (Stice, 1987; Wilkerson & White, 1988; Morris & McCarthy, 1990; McCarthy, 1990; Blair & Judah, 1990; Harb, Durrant & Terry, 1993; Knisley, 2002) we hope that learning cycle (or 4 MAT system) constructed according to different learning styles will improve mathematics achievement and attitudes towards mathematics among the students. The students can find all the features of four types and also the difference between their successes depending on learning styles can be eliminated by applying 4 MAT system by McCarthy. The 4 MAT system was prepared by considering all four types. Therefore, there will be a learning covering for all the learning styles. The main responsibility belongs to the teachers and to the educators of the teachers. Teachers must know that learning style affects success and all the teachers and candidates must be aware of all learning styles.

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The Effects of Mathematics Anxiety on Matriculation Students as Related to Motivation and Achievement

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The study investigated the effects of mathematics anxiety on matriculation students as related to motivation and achievement. Subjects included 88 students who were at the end of their second semester of study. Anxiety and motivation were measured using the Fennema-Sherman Math Anxiety Scale (MAS) and Effectance Motivation Scale (EMS) respectively. The instrument used to measure achievement was the Mathematics Achievement Test (MAT). The ANOVA results showed that the mean achievement scores and motivation scores of low, moderate and high anxiety groups were significantly different. Findings also revealed a low (r=-0.32) but significant ($p < 0.05$) negative correlation between mathematics anxiety and achievement and also a strong (r=-0.72) significant ($p<0.05$) negative correlation between mathematics anxiety and motivation. The study also revealed a significant low positive correlation (r=0.31) between motivation and achievement
Keywords: Mathematics Anxiety, Motivation, Achievement, Matriculation Students

INTRODUCTION

Mathematics anxiety is prevalent among the college students population (Betz 1978). Studies by Rahmah (1999), Ahmad Sukri et al. (1996) and Jasmani Bidin et al. (2005) found that a majority of Malaysian students have moderate level of mathematics anxiety. Lazarus (1974) believed that the roots of mathematics anxiety are in the elementary and secondary grades. In a similar vein, Jackson and Leffingwell (1999) have linked mathematics anxiety to prior experience with formal instruction in mathematics at the elementary and secondary level. They found that 16% of the students surveyed had their first negative experience with mathematics instruction as early as grades 3 and 4. This is cause for concern, considering that matriculation students may bring these negative feelings to their university studies.

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A review of current research suggests that low achievers in mathematics frequently accompany the incidence of mathematics anxiety. Ma (1999) found that the relationship between mathematics anxiety and mathematics achievement is significant. It was also found that once maths anxiety takes shape, its relationship with maths achievement is consistent across grade levels. Satake and Amato (1995) and Hardfield et al. (1992) also reported similar findings. A high level of anxiety is associated with a lower level of achievement (Quilter & Harper, 1988). Other than achievement, Tapia (2004) reported that students having little or no math anxiety scored significantly higher in motivation than students with some or high math anxiety, and students with some math anxiety scored significantly higher than students with high math anxiety. Bretscher et al. (1989) found that students who were involved in learning because wanted to be, scored significantly higher than their counterparts. They further contended that effectance motivation was a predictor of mathematics achievement. This influence is understandable since students with high motivation usually enjoy doing mathematics, stick at problems until they are solved and become absorbed in their mathematical problem solving activities.

Levine (1995) described math anxiety as involving feelings of anxiety and tension that interfere with doing mathematical operations. Math anxiety existed around a set of circumstances in which students suffered from fears that were based upon years of painful experiences with mathematics (Miller & Mitchell, 1994). Maths anxiety has been defined as the feeling of tension, helplessness, mental disorganisation and dread one has when required to manipulate numbers and shapes and the solving of mathematical problems (Ashcraft & Faust, 1994). Fennema and Sherman (1976) described math anxiety as involving strong feelings of fear and apprehension when faced with the possibility of dealing with a math problem.

Norwood (1994) emphasized that math anxiety did not appear to have single cause, but was, in fact, the result of many different factors such as truancy, poor self image, poor coping skills, teacher attitude and emphasis on learning maths through drill without understanding. However, Greenwood (1984) further stated that the principal cause of mathematics anxiety has been in teaching methodologies. He said math classes did not encouraged reasoning and understanding. The problems with math anxiety would not go away until teachers applied the problem solving process to the teaching of arithmetics and mathematics (Geenwood, 1984). Butterworth (1999) believes that a lack of understanding is the cause of anxiety and avoidance and that understanding based learning is more effective than drill and practice. A lack of confidence when working in mathematical situations is described by Stuart (2000) as the cause of maths anxiety. Highly maths anxious individuals will be less fluent in computation, less knowledgeable about mathematics, and less likely to have discovered special strategies and relationships within the mathematics domain (Ashcraft & Faust, 1994). In order to reduce mathematics anxiety and increase achievement, Miller and Mitchell (1994) suggested that teacher should create a positive learning environment, free from tension and possible causes of embarassment or humiliation.

RATIONALE OF STUDY

One of the aims of matriculation education was to further develop students' knowledge, competency and interest in the subject area. In a study by Rokiah and Mazlina (1998) on first year engineering students from matriculation, it was found that students had a negative attitudes towards mathematics. From my own teaching experience, some students do well during mathematics lesson and assignment yet fail to perform well in examination. Although there are many diverse reasons for the poor performance in mathematics, one prevalent variable worth considering is mathematics anxiety. Since little research has been done locally in the area of mathematics anxiety of matriculation students, this study was undertaken to add to that body of knowledge.

PURPOSE

The purpose of this study was to investigate whether there was a statistical difference between matriculation students' motivation and achievement when they were classified according to the math anxiety levels. Further, this study also sought to find out whether there was a significant correlation between (a) mathematics anxiety and motivation, and (b) mathematics anxiety and achievement.

METHODOLOGY

The study involved 88 students (73 females and 15 males). The participants were overwelmingly female, therefore no attempt was made to differentiate results by gender. Students were informed that their participations in the study were completely voluntary and would not influence their grade in the course. Three instruments were used to obtain the data: the Mathematics Anxiety Scale (MAS), Effectance Motivation Scale (EMS) and the Mathematics Achievement Test (MAT). The MAS and the EMS is a 12-item instrument, six worded positively and six worded negatively (Fennema & Sherman, 1976). The instrument uses a Likert scale with a range of strongly agree to strongly disagree. A total score is calculated by assigning a value of 1 (strongly disagree) to 5 (strongly agree) to each item and then adding the values. Possible scores range from 12 to 60. It is important to know that a low score on the MAS indicates a high level of mathematics anxiety, therefore the sign was reversed so that high scores would indicate high mathematics anxiety. According to Fennema and Sherman (1976), both the Math Anxiety Scale and Effectance Motivation Scale have a split-half reliability of 0.89 and 0.87 respectively. The instrument used for measuring mathematics achievement was the Mathematics Achievement Test (MAT). The MAT is a 12 questions open ended test with a 2 hour time limit.

Matriculation students' math anxiety scores were used to assign them into three groups: low math anxiety group, moderate anxiety group and high math anxiety group. The classification of the students was made by using the percentiles of the anxiety scores. Students whose scores fell between 33% and 67% were considered the moderate group. Low and high anxiety groups consisted of the students whose scores were in the lower 33% and in the upper 33% of the distribution, respectively. One way ANOVA tests and Tukey's HSD (Honestly Significant Difference) tests were used to compare the mean EMS and MAT scores of the different math anxiety groups. The Pearson product correlation coefficients of the participants' EMS and MAT scores and math anxiety scores were calculated to explain the possible relationships between these variables.

RESULTS

The number of students in each anxiety group and the mean scores for dependent variables are reported in Table 1.

The ANOVA results as shown in Table 2, revealed that the mean achievement scores of low, moderate and high anxiety groups were significantly different, $F(2,85)=3.75, p<0.05$. According to the Tukey's HSD tests, the mean differences in achievement test between the low and high anxiety groups were found to be statistically significant. On the other hand, the comparison of the mean scores of low and moderate anxiety and between moderate and high anxiety groups provided insignificant results at 0.05 significance level.

For motivation, as shown in Table 3, ANOVA results show that the mean motivation scores of low, moderate and high anxiety groups were also significantly different, $F(2,85)= 24.97, p<0.05$. According to the Tukey's HSD tests, the mean differences between the low and moderate anxiety groups, between the low and high anxiety groups and between moderate and high anxiety groups were found to be statistically significant. Findings also revealed a low ($r=-0.32$) but significant ($p < 0.05$) negative correlation between mathematics anxiety and achievement and also a strong ($r=-0.72$) significant ($p<0.05$) negative correlation between mathematics anxiety and motivation. The study also revealed a significant low positive correlation ($r=0.31$) between motivation and achievement.

DISCUSSION

The results indicated that matriculation students with high mathematics anxiety scored significantly lower in achievement. Numerous authors have suggested that higher achieving students are more apt to be less anxious (Betz, 1978; Hembree, 1990; Skiba, 1990). The data analysis also indicated that the effect of math anxiety on motivation was significant. Students with low math anxiety scoring significantly higher than students with moderate or high math anxiety and students with moderate anxiety scoring significantly higher than students with high math anxiety. These results concurred with the findings of Tapia (2004). The results also indicated that there was a relationship between mathematics anxiety and achievement. This indicates that as math anxiety scores increase, achievement scores decrease. This finding is consistent with the studies of Betz (1978), Ma (1999) and Woodard (2004), which revealed a negative relationship between these two variables. Although the magnitude of the correlations calculated is not very high, teacher should be aware of the needs and the capabilities of the students with different mathematics anxiety levels when designing teaching strategies for them. There could be other variables that have significantly influenced the students achievement that were not identified and explored in this study. A strong correlation between mathematics anxiety and motivation is not surprising. This would indicate that students with high anxiety will be less

Table 1: Comparisons of Mean by Level of Math Anxiety

Math Anxiety Group	Mean (Achievement)	SD	Mean (Motivation)	SD	n
High	38.10		42.55		29
Moderate	49.33		46.83		30
Low	55.69		51.62		29
Total	47.73		47.00		88

Table 2: Results of the ANOVA for Mathematics Achievement Scores

Source of Variation	Degree of Freedom	Mean Squares	F	Sig
Between Groups	2	2300.95	3.75	0.028
Within Groups	85	614.04		

Table 3: Results of the ANOVA for Motivation Scores

Source of Variation	Degree of Freedom	Mean Squares	F	Sig
Between Groups	2	596.92	24.97	0.000
Within Groups	85	23.91		

motivated in doing things related to mathematics. The significant low positive correlation between motivation and achievement showed that all the variables were interrelated with one another. The results of this study provide evidence that mathematics anxiety has an important effect in mathematics education that cannot be ignored. Therefore, teacher should be thinking on how to reduce students' anxieties by finding a better ways to teach mathematics.

IMPLICATIONS

Teachers need to be aware of the effects of anxiety on students' achievement and motivation. They should make an effort to lessen anxiety on these students. Teachers should develop teaching strategies that help highly anxious students. Woodard (2004) suggested the following techniques: (a) Create an environment in which students do not feel threatened and allow them to relax. (b) Use cooperative grouping. It helps students to understand that others have the same problems as they do. (c) Teach at a slow pace. It can help students better comprehend the material being taught. (d) Provide extra tuition sessions so that they are not left behind academically. With all these efforts it can be a positive force in reducing mathematics anxiety. Mathematics teacher should show their students a sincere, caring attitude to help them overcome mathematics anxiety.

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Science and Mathematics Teachers' Experiences, Needs, and Expectations Regarding Professional Development

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High quality teachers are essential to improving the teaching and learning of mathematics and science, necessitating effective professional development (PD) and learning environments for teachers. However, many PD programs for science and mathematics teachers fall short because they fail to consider teacher background, experience, knowledge, beliefs, and needs (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). To develop more effective PD systems, it is necessary to assess and identify teachers' PD needs, expectations, experiences and constraints. In this manuscript, we describe the findings from a study that examined the PD experiences, needs, expectations, and constraints of middle and high school science and mathematics teachers in one state in the U.S. We examine similarities and differences between science and mathematics teachers and among teachers from urban, suburban and rural schools. The findings from this study suggest that mathematics and science teachers participate in a minimal amount of PD and that a number of factors contribute to this reality. Furthermore, science and mathematics teachers do not experience effective PD learning environments described by Bransford, Brown & Cocking (2000) and there is a mismatch between teachers' PD needs and experiences.

Keywords: Mathematics and Science Teachers, Professional Development, Teacher Expectations

INTRODUCTION

To enhance science and mathematics learning in schools across the world, teachers need extensive opportunities to further develop knowledge and skills in both content and teaching in effective professional development (PD) settings (NRC, 1996; NCTM, 1991). This requires the design of effective learning environments for teachers (Bransford, Brown, & Cocking, 2000), including the use of successful PD strategies (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). The National Research Council's (NRC) publication, How People Learn, provides a four-perspective framework for designing effective learning environments (Bransford, Brown, & Cocking, 2000) for teachers:

Community-Centered: Values the search for meaning and understanding, builds collaborative relationships, and enhances participation in educational research and practice.

Knowledge-Centered: Focuses on the content that will help teachers develop an understanding of the discipline, including an emphasis on sense making.

Learner-Centered: Pays careful attention to the knowledge, skills, attitudes, and beliefs that teachers bring to the educational setting.

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Assessment-Centered: Continuously monitors and assesses teachers' thinking and understanding and provides feedback and opportunities for revision.

Therefore, PD must consider teachers as learners and build on participants' knowledge, skills, and beliefs; focus on knowledge and practice; provide opportunities for feedback, revision, and success; and require interactions with others (Bransford, Brown, & Cocking, 2000). However, many PD programs for science and mathematics teachers fall short of accomplishing this design because they fail to consider teacher background, experience, knowledge, beliefs, and needs (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). As a result, PD design has not given sufficient attention to the learner-centered or assessment-centered perspectives necessary for effective learning environments for science and mathematics teachers. Moreover, to create a more coherent PD system, attention to the learner-centered and assessment-centered perspectives should be considered for individual teachers, schools, districts as well as at the state level as argued by Corcoran (1995):

Historically, state policymakers have paid little attention to the form, content or quality of professional development. Such matters have been left to the discretion of local boards of education and district administrators. However, if today's teachers are to be adequately prepared to meet the new challenges they are facing, this laissez-faire approach to professional development must come to an end. The needs are too urgent and resources too scarce to simply continue or expand today's inefficient and ineffectual arrangements. (p. 1)

In some cases, effective and coherent PD for science and mathematics teachers in the U.S. has been designed and implemented at the school or district level (e.g., Elmore, 2002), especially in the cases of the districts receiving federal grants (e.g., National Science Foundation Local Systemic Change, Teacher Enhancement, or Mathematics and Science Partnership grants). However, these opportunities have been limited to a relatively small number of U.S. districts. Alternatively, individual science and mathematics teachers have pursued PD opportunities offered by higher education institutions, regional PD centers, and professional organizations such as the National Science Teachers Association (NSTA) and the National Council of Teachers of Mathematics (NCTM). Again, these opportunities have been limited to a relatively small number of teachers. Most U.S. school districts do not have the necessary resources to design, implement, and fund the PD that is required to improve the teaching and learning of science and mathematics. Therefore, in the U.S. it is necessary for most school districts to draw on and coordinate with other state resources such as government agencies and higher education institutions to develop a coherent PD system as Desimone, Porter, Birman, Garet, & Yoon (2002) proposed:

One method of designing and developing a program of professional development is to align the activities, pedagogy, and curriculum with standards and assessments adopted by the state or district and to coordinate funding with other programs in the state and district to develop a coherent professional development reform strategy. (p. 1269)

It is necessary to assess and identify the PD needs, expectations, experiences and constraints within states in order to develop more effective PD systems and reduce obstacles. This examination also needs to consider issues related to differentiation among teachers. For example, more experienced teachers have different professional needs than novice teachers. PD needs in rural and urban settings vary; many schools within a state do not have ready access to higher education institutions or regional PD centers due to their remote location.

Purpose of the Study

The purpose of the current study was to examine, on a state-wide basis, the PD experiences, needs, expectations, and constraints of middle and high school science and mathematics teachers. The research questions that guided the study were:

- How do science and mathematics teachers perceive their PD experiences?
- What do they perceive as their PD needs?
- What are their expectations for effective PD?
- What constrains them from participating in PD?
- How do the experiences, needs, expectations, or constraints differ for science and mathematics teachers and across subgroups?

Literature Review

Professional development is an intensive, ongoing, and systemic process that aims to enhance teaching, learning, and school environments (Fenstermacher & Berliner, 1985; Elmore, 2002). Researchers have argued that effective PD is critical to enhancing teacher and student learning as well as the organizational structures of school environments (e.g., see research conducted by Fullan; Sparks; Loucks-Horsley; Hall; Hord; Guskey; Lieberman; & Smilie). As a result, a number of researchers have investigated and documented effective PD at the district and school levels (Elmore, 2002). A consensus view of how PD should be designed and implemented exists (Bransford, Brown, & Cocking, 2000; Elmore, 2002; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). For example, Kennedy (1998) noted that PD experiences focused on subject matter knowledge and knowledge of students were

Table 1. Sample by County Size and Subject

County Size	Science	Mathematics	Mathematics/Science
Large (>100,000)	57	49	6
Medium (50,000 - 100,000)	13	16	4
Small (<50,000)	49	53	3
Total	119	118	13

more likely to have a greater impact on student learning than PD focused on teaching behaviors.

Researchers have also examined teachers' views and expectations regarding PD. For example, Park Rogers et al., (2007) found that both teachers and PD facilitators considered classroom application, teachers as learners, collegiality and collaboration as the important characteristics of PD. When Wilson and Berne (1999) observed PD and interviewed participants, teachers reported that they enjoyed PD that was relevant to their practice. In addition, teachers' beliefs, background, social influences, and practical circumstances shaped their reactions to PD (Wilson & Berne, 1999).

The typical PD experience for science and mathematics teachers is not aligned with teacher expectations or essential characteristics of effective PD identified in the literature. A number of factors influence this reality. First, the investment in PD has been insufficient; schools spend only 1-3% of their operating budgets on PD (Bransford, Brown, & Cocking, 2000). In addition, Randi & Zeichner (2004) argue:

Not all districts spend professional development funds wisely. One study, for example, conducted a cross-case analysis of professional development spending in seven elementary schools in a large urban district. Schools within the district varied widely in their levels of professional development funding, depending on school performance, availability of discretionary funds, and staff preferences (Fermanich, 2002). Other research found that even when districts allocate considerable funds for professional development, most of the investments are spent on district-controlled activities, typically in ineffective ways and for unclear purposes (Corcoran, 1995). (p. 197)

Second, science and mathematics teachers participate in a limited amount of PD. For example, from a national survey of 5,765 teachers, Weiss et al., (2001) reported that over 50% of science and mathematics teachers had participated in less than four days of subject-related PD in the previous three years. Third, typical approaches and formats to PD are antithetical to research on effective teacher learning (Bransford, Brown, & Cocking, 2000). Teachers do not have opportunities to determine the content or format of school-mandated PD (Bransford, Brown, & Cocking, 2000). The workshop is the most common teacher reported form of PD (Weiss, Banilower, McMahon, & Smith, 2001) and typical "one-shot" workshops deal with decontextualized information and often do not resonate with teachers' perceived needs (Bransford, Brown, & Cocking, 2000; Wilson & Berne, 1999). A National Center for Education Statistics study (U.S. Department of Education, 2001) surveyed 5,253 public school teachers in 50 states and the District of Columbia and found that teachers most frequently reported participating in PD related to state or district curriculum and performance standards at the district level. Furthermore, when teachers participate in PD, most of these experiences are disjointed and disconnected from classroom practice (Garet, Porter, Desimone, Birman, & Yoon, 2001). Finally, teachers often regard PD as having little impact on their responsibilities, and therefore, meaningless and a waste of time (Guskey, 2000). It is not surprising that less than a third of a national sample of teachers who participated in PD indicated that they changed their teaching practice as a result (Weiss et al., 2001). Ball and Cohen summarized, "Teacher learning has traditionally been a patchwork of opportunities—formal and informal, mandatory and voluntary, serendipitous and planned—stitched together into a fragmented and incoherent 'curriculum'" (as cited in Wilson & Berne, 1999, p. 174).

As demonstrated above, typical PD structures for science and mathematics teachers in the U.S. are problematic and have a limited impact on teacher practices or student learning (Weiss, Banilower, McMahon, & Smith, 2001). This suggests that there are obstacles that hinder the design and implementation of effective PD. Zimmerman and May (2003) surveyed principals from 450 schools in Ohio to identify obstacles to effective PD. Principals identified lack of time, lack of money, limited perceptions of teachers' roles as professionals, lack of both internal and external support for teachers, and difficulty of finding substitute teachers as the most common barriers to PD.

The PD research and policy literature clearly outlines problems with the current PD system for science and mathematics teachers in the U.S. Coordinated efforts to improve PD will require a state-level analysis related to teacher workforce as well as to PD resources and learning environments. The current study, building on prior research efforts, was designed to better understand the state-level PD context to assist future efforts at improving PD for science and mathematics teachers.

METHODOLOGY

Instrument

We designed a PD survey, using existing items, such as those available from Horizon Research, Inc. (2003) and creating new items, to collect data about science and mathematics teachers' experiences, needs, and expectations regarding PD. The survey consisted of 10 questions, including Likert scale, constructed response, and open-ended items, as well as a demographics section about school setting, teacher education, and teaching experience. The full survey is available at http://www.teach-math-or-science.org/docs/ PD_inventory_Summary.pdf.

Data Collection and Analyses

We mailed the survey to a stratified random sample of 1000 science and mathematics teachers, grades 6-12 from the state database of all science and mathematics teachers in the state of Missouri (N=7150). We stratified the sample by subject (science, mathematics, and both), grade level (middle or secondary), and county size (small, medium, and large). Every teacher in the sample was sent a letter describing the study, a letter concerning human subjects consent in addition to the survey including a return stamped envelope. We sent two follow up mailings to non-respondents. Surveys were coded to enable the team to ascertain the corresponding respondent within the subgroups. A total of 241 teachers across all subgroups returned the surveys (see Table 1).

Using the population size of 7150 Missouri science and mathematics teachers, we determined the confidence level of our results using the following equation:

$$n = \frac{N.z_{\alpha}^{2}.p.q}{[e^{2}(N-1)+z_{\alpha}^{2}.p.q]}$$

Setting $z\alpha=1.96$ for $\alpha=0.05$. Assuming a worst case law probability percentage of $p=q=0.5$, our level of confidence in the results was 0.062.

Data analyses included quantitative and qualitative methods. Quantitative analyses involved comparing different groups of teachers for differences in the frequency of their responses. We calculated chi-squared values from the contingency tables derived from these frequencies. To determine significance in the differences observed between science and mathematics teacher responses regarding teaching and learning, we carried out two different analyses. First, we paired science and mathematics teacher responses for each sub-item and calculated the $\chi 2$ statistic using 2x2 contingency tables. Then we compared teacher priorities in terms of their PD needs by pairing off each of the different ranges of teaching experience and calculating Spearman's rank correlation (rs) for each of the pairings, considering the rank for each particular item by the percentage of teachers selecting it.

Qualitative analysis involved coding data from the open-ended items into thematic categories. The open-ended questions asked the respondents to determine the characteristics of effective and ineffective PD, and then asked them to create their ideal PD. We began the analysis process by reading open-ended responses in the survey for comments related to teachers' PD experiences, needs, and expectations. We coded the data into thematic categories, which required several rounds of reading data, coding phrases, discussing possible categories and themes, and refining the definitions of each category. After the saturation of coding, we coded the remaining data using the list of categories we had developed. Next, we developed a frequency chart that included the number of comments for each coding category. This synthesis helped us to see which categories were discussed more frequently. We also compared the categories across years of teaching experience among the respondents. Then, we developed a set of assertions about teachers' PD expectations and returned to the data to find specific examples that supported our assertions. Finally, we compared and made connections between quantitative and qualitative data in order to answer the research questions.

RESULTS

The results are presented in three sections that reflect the research questions in relation to teacher PD experiences, needs, and expectations.

Teacher Professional Development Experiences

Table 2 shows the number of hours respondents reported they spent in PD activities within the last 12 months and the last three years. Teachers were asked to include attendance at professional meetings, workshops, and conferences, as well as job-embedded PD, but not to include formal courses for which they received college credit or time spent providing PD for other teachers. Fifty-seven percent of the teachers reported

Table 2.Time Spent in Professional Development within the Last 12 Months and 3 Years

	Percentage of Respondents	
Hours	12 months	3 years
	n = 236	n = 235
None	7	3
Less than 6	21	4
6-15	29	17
17-35	27	22
More than 35	13	50

spending 15 or fewer hours in PD within the last 12 months and 50% of the teachers reported spending less than 35 hours during the preceding 3-year period.

Table 3 summarizes the types of PD activities in which respondents reported involvement within the last three years. The most common type of PD activity that the science and mathematics teachers reported was reading professional literature. The least common type of PD activity the teachers reported was collaboration with other teachers using telecommunications.

When we compared the PD activities of urban, rural, and suburban teachers, we found four significant differences (see Table 4). Urban and suburban teachers reported more frequent opportunities to observe other teachers teaching, meet in study groups, read the professional literature, and serve as a mentor or peer coach than did their colleagues in rural settings.

We also asked teachers to report on the types of PD leadership activities that they had undertaken over the previous 12 months (see Table 5). The most common type of leadership activity that the science and mathematics teachers reported was serving on a school or district science/mathematics curriculum committee. The least common type of leadership activity reported was receiving a grant or award for science/mathematics teaching.

Table 3. Professional Development Activities within Last 3 Years

Activity	Percent of Respondents n = 241
Read professional literature	87
Attended a workshop on science/math teaching	74
Met with a local group of teachers on a regular basis to study/discuss science/math teaching issues	58
Observed other teachers teaching science/math as part of your own professional development (formal or informal)	58
Completed a college/university science/math course	43
Completed a college/university course in the teaching of science/math	35
Served as a mentor and/or peer coach in science/math teaching, as part of a formal arrangement that is recognized or supported by the school district not including supervision of student teachers	27
Collaborated on science/math teaching issues with a group of teachers at a distance using telecommunications	13

Table 4. Professional Development Activities within the Last 3 Years by School Setting

	Percentage respondents			χ^2
	Urban n=33	Sub urban n=80	Rural n=124	
Read professional literature	93.75	97.44	81.97	**12.36
Observed other teachers teaching as part of your own professional development	90.91	72.50	40.65	** 36.87
Attended a workshop on science/math teaching	84.85	73.75	71.54	2.41
Met with local teachers on a regular basis to study/discuss science/math teaching issues	68.75	71.25	46.77	**13.70
Completed College or University science/math course	45.45	42.50	41.94	0.13
Completed College or University teaching course in science/math	42.42	31.25	36.29	1.36
Attended a science/math teaching conference	38.71	54.43	56.56	3.21
Served as a mentor and/or peer coach in science/math teaching, as part of a formal arrangement that is recognized and supported by the school or district	33.33	37.97	22.13	*6.18
Collaborated on science/math teaching issues with a group of teachers at a distance using telecommunications	21.21	13.75	12.10	1.81

* $p < 0.05$

Table 5. Professional Development Leadership Activities within the Last 12 Months

Activity	Percent of Respondents n = 241
Served on a school or district science/math curriculum committee	63
Served on a school or district science/math textbook selection committee	46
Facilitated professional development in science or mathematics teaching	45
Facilitated professional development in science or mathematics subject matter	44
Mentored another teacher as part of a formal arrangement that is recognized or supported by the school or district, not including supervision of student teachers	34
Received local, state, or national grants or awards for science/math teaching	14

Table 6. Science and Mathematics Teachers' Perceived Professional Development Needs for Pedagogy

Topic	Percent of Respondents		X^2
	Science n=122	Math n=119	
Developing critical thinking in science/math	68.0	73.1	0.747
Using technology to teach science/math	63.1	68.9	0.901
Connecting science/math to the real world	55.8	60.5	0.562
Inquiry or problem-based strategies in science/math	55.7	67.2	3.356
How students learn particular topics in science/math	50.8	63.9	*4.189
Developing conceptual understanding in science/math	48.4	47.1	0.041
Writing in science/math	41.8	44.5	0.184
Questioning and classroom discussion techniques	41.0	47.1	0.902
Using the State standards to design instruction	38.5	49.6	2.988
Inquiry or problem-based science/math curriculum	37.7	57.1	**9.131
Involving parents in their children's science/math education	36.9	42.0	0.664
Designing instruction for gifted students in science/math	36.1	34.5	0.069
Designing instruction for special education in science/math	36.1	36.1	0.000
Assessing student learning in science/math	33.6	38.7	0.666
Co-operative/collaborative learning in science/math	31.2	44.5	*4.596
Classroom management in science/math	27.9	33.6	0.934
Involving girls or minorities in science/math	25.4	22.7	0.244
Designing instruction for ESL students in science/math	23.0	13.5	3.647

* $p < 0.05$ ** $p < 0.01$

Teacher Professional Development Needs

Table 6 summarizes the perceived needs of science and mathematics teachers for PD about various pedagogy topics. The top six perceived needs were the same for both science and mathematics teachers and the order of these needs was almost identical. Likewise, the bottom three needs were the same for both groups. Respondents noted a greater need for PD about critical thinking, strategies related to inquiry or problem-based approaches, student learning, making connections with the real world, and the use of technology in teaching both science and mathematics. Addressing the needs of English as a Second language (ESL) students and involving girls or minorities were reported as lower needs for PD.

Table 6 also presents a $\chi 2$ comparison between science and mathematics teacher respondents. We found no significant difference between science and mathematics teachers except for three topics: how students learn particular topics in science/mathematics, inquiry or problem-based science/mathematics curriculum, and co-operative/collaborative learning in science/mathematics. In these three cases, mathematics teachers reported a greater need for PD than did science teachers.

We also compared perceived needs in terms of years of teaching experience for science teachers (Table 7) and mathematics teachers (Table 8). Using a Spearman's rank correlation index, we found significant correlations across all levels of teaching experience related to the ranking of perceived needs for PD. In the case of science teachers, those with 0-2 years of experience only show significant correlation in their ranking of needs

Table 7.Ranking Comparison for Professional Development Needs by Teaching Experience: Science Teachers [a]

Years of teaching experience	Years of teaching experience						
	0-2	3-6	6-10	11-15	16-20	21-25	26+
0-2	-	0.416	*0.490	*0.482	0.399	0.260	0.437
3-6		-	**0.772	*0.533	**0.577	**0.935	**0.678
6-10			-	*0.454	**0.609	**0.839	**0.653
11-15				-	0.414	0.446	0.367
16-20					-	**0.602	**0.703
21-25						-	**0.748
26+							-

a. Spearman's Rank Correlation index (r_s), * $p < 0.05$, ** $p < 0.01$

Table 8. Ranking Comparison for Professional Development Needs by Teaching Experience: Mathematics Teachers [a]

Year of Experience	Years of teaching experience						
	0-2	3-6	6-10	11-15	16-20	21-25	26+
0-2	-	*0.467	*0.503	**0.761	*0.569	*0.462	**0.638
3-6		-	**0.892	**0.644	**0.728	**0.609	**0.692
6-10			-	**0.728	**0.645	**0.661	**0.832
11-15				-	**0.572	**0.648	**0.704
16-20					-	**0.682	**0.65
21-25						-	**0.692
26+							-

a. Spearman's Rank Correlation index (r_s), * $p < 0.05$, ** $p < 0.01$

Table 9. Science Teachers' Perceived Professional Development Needs in Science

Topic	Percent Respondents (n=122)
Electricity and magnetism (Physics)	55.7
Energy and chemical change (Chemistry)	50.8
Climate and weather (Earth Science)	49.2
Modern Physics (Physics)	46.7
Genetics and evolution (Biology)	45.9
Earth's features and physical processes (Earth Science)	45.1
Chemical reactions (Chemistry)	41.8
Structure of matter and chemical bonding (Chemistry)	40.2
The solar system and the universe (Earth Science)	40.2
Light and sound (Physics)	38.5
Forces and motion (Physics)	35.3
Energy (Physics)	35.3
Plant biology (Biology)	32.8
Interactions of living things/ecology (Biology)	32.0
Properties and states of matter (Chemistry)	30.3
Structure and function of human systems (Biology)	26.2
Animal behavior (Biology)	19.7
Others (Chemistry)	12.3
Others (Biology)	8.2
Others (Earth Science)	7.4
Others (Physics)	5.7

with those in the 6-10 years of experience and 11-15 years of experience groups. Regarding science teachers with 0-2 years of experience, the most significant difference in our findings was the fact that addressing the needs of ESL students and involving girls and minorities were ranked among their top 5 perceived needs. In the case of mathematics, correlation was less between those teachers with 0-2 years of experience and the other groups.

Tables 9 and 10 summarize teachers PD needs in terms of specific science and mathematics content topics. Science teachers ranked physics, chemistry and earth sciences topics higher than biology topics, except for genetics and evolution which ranked 5th with 45.9% of the teachers selecting it. The top-ranked topics where: electricity and magnetism (55.7%), energy and chemical change (50.8%), climate and weather (49.2%) and modern physics (46.7%). Mathematics teachers wanted PD about the following topics: technology in support of mathematics (60.5%), topics from discrete mathematics (54.6%), probability (51.3%), statistics (45.4%) and patterns and relationships (43.7%).

Teachers' needs for PD can also be discerned by their perceptions of constraints to participating in PD. Constraints that limit participation in PD as reported by respondents in different school settings (urban, suburban and rural) are detailed in Table 11. We ranked the constraints according to a weighted index derived from individual teacher ratings. The most constraining factor reported was time conflict, which ranked among the top two factors for respondents in all school settings. The least constraining factor reported was the availability of substitutes, ranking in the bottom two factors for respondents in all school settings. When we removed these two issues from the analysis, we found no significant correlation by school setting (using Spearman's index). Location of PD was considered more of constraint for rural teachers, while lack of interest in the available PD topics was considered more constraining by teachers in suburban settings. The perceived value given by the district to PD was a more important issue for teachers in urban settings.

Teacher Professional Development Expectations

To understand teachers' expectations for PD, we analyzed 215 responses to two open-ended items about the characteristics of effective and ineffective PD and 191 responses to an open-ended item that asked them to design an ideal PD experience in terms of length, location, topics, delivery formats, participants, and facilitators. When designing their ideal PD, respondents took into account their previous experiences with effective and ineffective PD. We found a great amount of similarity across the responses regardless of teachers' subject matter, school setting, or years of experience as we discuss below.

Professional Development Topics

The teachers identified both science and mathematics content topics and pedagogy topics. The most frequently mentioned topics were:

- Subject specific topics (e.g., biology, chemistry, electricity, algebra) that are aligned with state standards and tests
- Instructional strategies (e.g., inquiry, cooperative learning, motivation techniques, critical thinking)
- Technology integration
- Classroom management
- Assessment
- Lab/hands-on activities
- State standards and standardized tests

Some differences appeared in preferred topics in relation to years of teaching experience. Teachers with 0-5 years of experience mentioned both subject-specific topics and instructional strategies with equal frequency. Although some of the teachers with six or more years of experience mentioned content knowledge as part of their ideal PD, the majority of them expected the PD to address instructional strategies and activities that they could use with their students. Technology integration was another topic raised more often by the experienced teachers than the beginning teachers. Additionally, this topic was raised more frequently by mathematics teachers than science teachers. The more experienced teachers also mentioned an expectation that PD would help them improve their teaching in order to increase students' standardized test scores or to meet the state standards. None of the beginning teachers mentioned standards or testing, and only 3 of 37 respondents with 3-5 years experience did.

Effective PD Delivery

Teachers noted that the PD effectiveness was related to its relevance, delivery style, and opportunities to network with other teachers. These views held regardless of years of teaching experience or subject (science or mathematics). Respondents indicated that PD was most effective when it was relevant and useful in their classrooms. They described relevance as meeting one or more of the following criteria:

PD topic is focused on the content and grade level they teach.

PD participants include those that teach the same content they teach.

PD is aligned with state, district, and grade level curricular goals.

Table 10. Mathematics Teachers' Perceived Professional Development Needs in Mathematics

Topic	Percent Respondents(n=119)
Technology in support of mathematics	60.5
Topics from discrete mathematics	54.6
Probability	51.3
Statistics	45.4
Patterns & relationships	43.7
Geometry and spatial sense	40.3
Data collection and analysis	39.5
Numeration and number theory	38.7
Algebra	33.6
Functions and pre-calculus	31.9
Measurement	28.6
Calculus	26.9
Pre-algebra	26.1
Mathematical structures	25.2
Estimation	24.4
Computation	17.6
Others	6.7

Table 11. Perceived Constraints to Teacher Participation in Professional Development

	Urban		Suburban		Rural	
Issue	Rank	Index [a]	Rank	Index [a]	Rank	Index [a]
Cost	1	0.408	1	0.407	2	0.269
Family responsibilities	2	0.308	7	0.161	5	0.199
Lack of financial support from school/district	3	0.272	8	0.152	1	0.354
Lack of interest in PD topics available	4	0.198	2	0.225	6	0.178
Lack of relevance to job	5	0.173	10	0.069	9	0.085
Location of PD not convenient	6	0.161	3	0.216	4	0.229
Low value placed on PD by school/district	7	0.148	5	0.181	3	0.250
Reluctance to release from classroom	8	0.111	11	0.054	12	0.051
Time conflicts	9	0.099	4	0.196	7	0.167
Unavailability of substitutes	10	0.086	6	0.171	8	0.108
Unawareness of available PD	11	0.037	9	0.152	10	0.063
Other	12	0.025	12	0.034	11	0.057

a. Calculated by percentage teachers selecting an issue and weighted importance combined.

PD is not overly theory-laden, but focuses on classroom-based practice.

The ideas presented are practical for the classroom setting.

They will learn something or have a product that they can "use tomorrow in class."

Respondents commented frequently that PD effectiveness depended, in part, on delivery style. In particular respondents mentioned:

PD should be well organized and well structured, including efficient use of time.

PD should be well focused and preferably focused on a few big ideas.

PD should be convenient in terms of location and schedule.

These characteristics of effectiveness in delivery were mentioned by both science and mathematics teachers of all levels of experience. One additional criterion mentioned by a few of the more experienced teachers in regard to delivery characteristics was that they did not want PD forced on them by district or state mandates. Most likely the beginning teacher respondents had not yet experienced problems with mandated PD given their strong incoming need for continuing education.

Respondents wanted to be engaged as learners. They preferred interactive PD experiences. Most of the teachers preferred PD providers to present the activities and instructional strategies that the teachers could use with their own students as the following responses illustrate.

Give us (teachers) activities the students would be doing. The facilitator has to remember several of us have 30+ students in a room. We need activities to do w/ large groups and students of low to med. ability. (6-10 years experience)

Hands-on active learning-model good teaching / instructional strategies. Not just "cute" activities. (6-10 years teaching experience)

Half sit & listen, half get up & practice. Time could be given to actually develop strategies with my fellow teachers on how to improve my instruction in the classroom. (6-10 years teaching experience)

At the same time, teachers want to be considered as adult learners, not as students as the following responses demonstrate.

Tell me how to set it up or use it-I hate having to do what the kids would do. Give me the information and treat me professionally. (16-20 years experience)

Do not make participants do activities that are designed for young students—it loses relevance. (6-10 years experience)

I like to just listen and see/hear how the lesson/topic is taught. I also like to see student work if there are activities/projects involved. (6-10 years experience)

Respondents valued PD experiences in which interaction with peers was an explicit feature. They mentioned two ways in which networking with other teachers was valuable. First, they appreciated opportunities to get ideas from other teachers about how to implement innovations in their classrooms. Second, they wanted time to share situations and problems they faced in their own classrooms with other teachers in order to find practical solutions. The following response illustrates these ideas:

I think a discussion session among teachers teaching the same courses would be ideal. We could share learning strategies, homework collection ideas, activities, etc. (26+ years teaching experience)

These delivery formats for effective PD were mentioned by teachers from every experience group. Additionally, respondents with more than two years of experience made three other comments about PD effectiveness. First, they wanted PD that focused on new ideas, rather than rehashing topics they had previously learned. This desire most likely stemmed from their more extensive experience with teaching and PD. Second, the more experienced teachers found that PD was most effective when it was sustained over time rather than a "one shot deal." These teachers wanted ongoing, job-embedded PD. They did not want their time wasted, but they were willing to invest in PD over the long term as long as the content was new and relevant. Third, a few of the experienced teachers mentioned that effective PD included learning about assessment of student performance and ultimately resulted in improved student achievement.

Participants and Facilitators

Although most respondents preferred to attend PD with teachers from similar grades and subjects, some mentioned that PD should occasionally include participants from different fields (e.g., combining science and mathematics teachers, or teachers and administrators). Respondents believed that these individuals should have similar interests and be willing to share their experiences and expertise. Some respondents remarked that ideal PD is not mandated from above, but involves willing participants.

Age-specific teachers, administrators that would be interested. Content-specific teachers for one day and cross-content science teachers for additional viewpoints. (0-2 years teaching experience)

Volunteers (teachers that want new ideas). Forced professional development leads to lots of unhappy people (3-5 years experience)

Teachers held high expectations for PD facilitators. That is, they wanted facilitators who were knowledgeable, motivating, interesting, and credible (in touch with classrooms), and who treated them in a professional manner. The majority of respondents preferred experienced teachers who had been successful in classroom teaching and improving student achievement to facilitate the PD. Moreover, they valued facilitators with experience in their school district or in a similar school setting.

Teachers that use these things and can tell you how to get started, trouble shoot, etc. (21-25 years teaching experience)

A teacher who taught in a disadvantaged district for many years and had success with student achievement. (0-2 years experience)

Top teachers in subject area. College professors aren't really connected and [don't] know what goes on in HS-MS. (26+ years experience)

Some of the more experienced teachers put a premium on facilitators who were knowledgeable and understood classroom teaching at a particular grade level, regardless of an individual's current position. These respondents expected experienced teachers, university professors, and other experts to be ideal PD providers.

Middle school science teachers who have successfully used the activities being presented or college instructors who work with middle school science. (26+ years teaching experience)

The person should have "lived" this situation with 1st hand knowledge & experiences. (26+ years experience)

Someone who has realistic experience with teaching mathematics to middle school age people. (21-25 years experience)

The respondents to this needs assessment were consistent in their ideas about the characteristics that contribute to effective PD. They wanted 1) to learn both science/mathematics content and pedagogy that is aligned to standards and relevant to their classrooms, 2) to be engaged both as learners and as teachers, 3) to have opportunities to interact with other teachers in meaningful ways, and 4) to have facilitators who are organized, knowledgeable, and who understand the exigencies of schools and classrooms.

CONCLUSIONS

The findings from this study suggest that mathematics and science teachers participate in a minimal amount of PD and that a number of factors contribute to this reality (e.g., location of PD opportunities). Over the past three years only 50% of the teachers participated in a total of more than 35 hours of PD activities (including reading professional literature). This is similar to the results from the 2000 National Survey of Science and Mathematics Education (Weiss, Banilower, McMahon, & Smith, 2001) where 17–23% of grade 5–8 teachers and 31–45% of grade 9–12 teachers reported participating in more than 35 hours of professional development in the last three years. A study of the National Science Foundation-funded Local Systemic Change (LSC) PD Initiative suggests that this minimal amount of PD is insufficient for improving the teaching and learning of science and mathematics. Teachers who participated in 60 or more hours of LSC PD were more likely to report an impact on their content preparedness than teachers with fewer than 60 hours (Shimkus & Banilower, 2004). Furthermore, Bowes and Banilower (2004) found that lessons were more likely to be rated highly for actively involving all students, engaging students intellectually, and creating a climate of respect and rigor when taught by teachers with higher levels of LSC PD.

Science and mathematics teachers who responded to our survey also indicated that they do not experience effective PD learning environments described by Bransford, Brown & Cocking (2000):

Community-Centered: The PD experiences have not provided opportunities for teachers to build collaborative relationships with colleagues, and to enhance participation in educational research and practice.

Knowledge-Centered: PD experiences have not focused on the necessary science/mathematics content nor have they been designed to enhance the teaching and learning of science and mathematics.

Learner-Centered: PD experiences have not built on the knowledge, skills, attitudes, and beliefs that teachers bring to the educational setting.

Assessment-Centered: PD experiences have not involved a process of assessing teachers' thinking and understanding, providing feedback, or opportunities for revision.

Our data also indicate that rural teachers have significantly less opportunities to meet with other science and mathematics teachers and to observe other teachers teach science or mathematics. This would be explained by the fact that in many cases teachers in rural communities have sole responsibilities for teaching specific courses.

Teachers preferred PD that was specific to their grade level, content, and classroom practice. This suggests that PD needs to be tied to specific grade levels or courses, as well as to instruction and student thinking. Appleton (2005) indicated that teachers, both novice and experienced, use activities that work as a central role in the development of their knowledge. This supports our finding that teachers expected relevant and useful classroom ideas as part of PD. The relevance of classroom ideas is also related to teacher experience. In some cases, beginning teachers expressed different PD needs than did more experienced teachers. This suggests that, for example, high school biology teachers with less than two years of experience might need PD opportunities with more experienced biology teachers, as well as opportunities for PD with other novice teachers.

IMPLICATIONS

The results from this study as well as others (Weiss, Banilower, McMahon, & Smith, 2001) indicate that there is a mismatch between teachers' perceptions of their PD needs and their PD experiences. In order to organize successful PD that improves teaching practice in large numbers of classrooms (Corcoran, 1995; Elmore, 2002), understanding and addressing teacher PD expectations, experiences, needs, and constraints is essential. This suggests government agencies, organizations, and school districts responsible for funding, designing and facilitating PD must:

Seek input from teachers regarding PD through surveys, focus groups, or other mechanisms.

Work together to consider the recommendations that have been identified in the PD research and policy literature (e.g., Ball & Cohen, 1999; Corcoran, 1995; National Staff Development Council, 2005).

Invest more resources in preparing and supporting PD facilitators, especially those who have successful classroom experience.

Consider the PD needs of all teachers, especially those who do not have regular access to effective PD opportunities.

In Missouri, 3,293 of the 7,150 mathematics and science teachers (46%) teach in counties with populations of less than 100,000. Structures need to be created to support the professional growth of this large, isolated group of teachers. Most U.S. school districts and likely many school systems throughout the world do not have the necessary resources to design, implement, and fund the PD that is required to improve the teaching and learning of science and mathematics. Therefore, it is necessary for most school districts to draw on and coordinate with other state resources such as government agencies and higher education institutions to develop a coherent PD system. This would require designing and facilitating PD in regions throughout a state in coordination with school districts so that teachers can be released from teaching responsibilities in order to participate. For example, an ongoing series of PD could be designed to meet the needs of high school biology teachers within a certain region of a state. This focused PD would have the potential to address the four perspectives of effective learning environments identified by Bransford, Brown & Cocking (2000), teachers' expectations for effective PD identified in this study, and prior recommendations identified in the PD research and policy literature.

In addition to implications for policy and practice, the findings from this study suggest implications for future research efforts. Research is needed to more carefully examine PD design and implementation as it relates to specific groups of teachers (e.g., level of experience, content area, grade level, type of school) and the four perspectives of effective learning environments outlined by Bransford, Brown, and Cocking (2000). In addition, more research efforts need to investigate PD practices at the state, regional, national, and global levels as we work toward a more coherent PD system for mathematics and science teachers.

The current political and economic context in the U.S. that led to the National Academies' publication, Rising Above the Gathering Storm (Committee on Science, Engineering, and Public Policy, 2006), indicates the critical importance of science and mathematics in contributing to prosperity. High quality teachers are essential to achieving this vision, necessitating high quality PD. This national situation is reminiscent of the post-Sputnik era, when large federal investments were made to improve science and mathematics education in the U.S. This time around we need to consider carefully how to best use our resources to reach our goals. Collaboration at the state-wide level across groups with responsibility for PD—state agencies, institutions of higher education, professional organizations, and school districts—is essential. This collaboration must begin with recognizing the PD experiences, needs, and expectations of science and mathematics teachers in order to design effective PD learning environments for teachers.

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The Effect of the Teaching Practice on Pre-service Elementary Teachers' Science Teaching Efficacy and Classroom Management Beliefs

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The purpose of this study was to investigate the effect of the teaching practice on pre-service elementary teachers' science teaching efficacy and classroom management beliefs. The subjects were 185 pre-service elementary teachers from two different universities in Izmir. In this study, Science Teaching Efficacy Belief Instrument (STEBI-B) and the Attitudes and Beliefs on Classroom Control (ABCC) instruments were utilized to collect data. Results of the study indicated that almost all pre-service elementary teachers had high self-efficacy beliefs regarding science teaching. In addition, teaching experience did not affect pre-service elementary teachers' science teaching efficacy beliefs. However, pre-service elementary teachers' classroom management beliefs tended to change with the teaching practice. While pre-service teachers' beliefs related to instructional management decrease with teaching practice, their People Management beliefs increase with teaching practice.

Keywords: Pre-Service Elementary Teachers, Science Teaching Efficacy Beliefs and Classroom Management Beliefs

INTRODUCTION

Most educational researches have revealed that most of the elementary teachers have some problems in teaching some subjects. Especially, both pre-service and inservice teachers perceive science as a difficult subject and feel themselves inadequately prepared to teach science in elementary schools. In addition, they lack the confidence to teach science and their self-efficacy regarding to science teaching is very low (Schoeneberger & Russell, 1986; Enochs & Riggs, 1990, Riggs, 1991, Mulholland & Wallace, 2000, Appleton, 2003; Mulholland, Dorman, & Odgers, 2004). Elementary teachers' attitudes and beliefs about teaching and learning and the pedagogical knowledge garnered from classes and fieldwork play a critical role in shaping their patterns of instructional behavior (Thompson, 1992; Tobin, Tippins, & Gallard, 1994, as cited in Plourde, 2002). The role of teacher efficacy in teaching and learning has been an interest for researchers and practitioners since 1970's. Teacher efficacy has been associated with significant variables such as students' motivation and achievement, teachers' adoption of innovations, teachers' classroom management strategies and time spent in teaching certain subjects (Berman, et al., 1977; Bandura, 1977; as cited in Tschannen Moran, Hoy & Hoy, 1998, Hoy, 2000; Bıkmaz, 2004). Teacher efficacy also has positive impacts on teachers' classroom management beliefs and practices (Good, 1981; Bezzina & Butcher, 1990; Ross, 1994; Soodak & Podell, 1994). Classroom management is the aspect of the teaching

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and learning and it seems to be the most common concern of both pre-service and experienced teachers (Johns, MacNaughton, & Karabinus, 1989; Gee, 2001; Weinstein, 1996; Smith, 2000; as cited in, Sokal, Smith, & Mowat, 2003). Successful classroom management is essential for effective instruction and a teacher's belief in his or her ability to positively facilitate student learning may affect classroom management behavior (Henson, 2001). Although classroom management and effective instruction are interrelated with each other, many studies indicated that both pre-service and inservice elementary teachers perceive a lack of connection between the information provided in teacher preparation programs and the real classroom environement (Laut, 1999). Moreover, teachers thought that they were inadequately prepared in handling classroom management and it is a distinctive factor in causing stress (Silvestri, 2001, Youseff, 2003). Furthermore, teachers who self-define their teaching experiences as failures attribute their experiences to a lack of preparation by their teacher education programs.

The development of teacher efficacy and classroom management beliefs among pre-service teachers has been investigated by the many researchers, because once these beliefs are established, they would show resistance to change (Ginns, Tulip, Watters, & Lucas, 1995; Fortman & Pontius, 2000; Lorna, Neelam, & Kyesha, 2002). Pintrich (1990) suggested that teachers' beliefs would ultimately prove to be the most valuable psychological construct to teacher education. There is some evidence that teaching practice affects the classroom management and efficacy beliefs of teachers. Teaching practice provides an opportunity to gather information about pre-service teachers' personal capabilities for teaching.and to be tested their beliefs (Katrina, 2004). Although pre-service teachers take theoretical courses about teaching and learning in their education classes, many pre-service teachers may be tarnished when confronted with the realities and complexities of the teaching task. Goodland (1990) comments of the need for teacher educators to realize the likely discrepancy between the ideas of the methods course and the reality of the classroom. In this study, it is aimed to investigate the effect of the teaching practice on pre-service elementary teachers' science teaching efficacy and classroom management beliefs.

Concept of Teacher Efficacy

The teacher efficacy concept has been based on social learning theory of Bandura and his construct of self-efficacy. Bandura (1997) defined perceived self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p.3). Self-efficacy beliefs provide the foundation for human motivation, well-being and personal accomplishment. This is because unless people believe that their actions can produce the outcomes they desire, they have little incentive to act or to persevere in the face of difficulties (Pajares, 2002). In the Bandura's theory, behavior is based on two sources; outcome expectations and self-efficacy expectations. According to Bandura, outcome expectancy is a given behavior that will lead to certain outcomes. However, self-efficacy expectation defined as a conviction that one can successfully execute the behavior required to produce the outcomes (Savran & Çakıroğlu, 2003). Studies related to measuring of teacher efficacy were started in 1966 by Rotter. Rotter (1966) defined two efficacy items in the teacher efficacy questionnaire: Rand item 1 and Rand item 2. Rand item 1 focused on teachers' beliefs about the power of external factors compared to the influence of teachers and schools and this item was labeled as general teaching efficacy (GTE) which corresponded to Bandura's outcome expectancy. Rand item 2 was more specific and individual than a belief about what teachers in general could accomplish and it was labeled as personal teaching efficacy (PTE) which corresponded to Bandura's self-efficacy expectation (Tschannen Moran, Hoy& Hoy, 1998). Researchers were interested in developing more reliable and comprehensive instruments to measure teachers' efficacy. These instruments are Teachers Locus of Control (TLC) developed by Rose and Medway (1981), Responsibility for Student Achievement (RSA) developed by Guskey (1981) and Webb Scale (WS) developed by Ashton, Olejnik, Crocker, & McAuliffe, (1982). Following these works, Gibson and Dembo developed a broader and more reliable teacher efficacy measurement, which is beginning with the formulation of the Rand studies but bringing to bear the conceptual underpinnings of Bandura. Results of the factor analyses, Gibson and Dembo found same two dimensions of teacher efficacy; one of them is personal teaching efficacy assumed to reflect self-efficacy and the other is general teaching efficacy assumed to capture outcome expectancy (Gibson & Dembo, 1984).

Studies related to measuring teacher efficacy in science teaching and learning have been conducted by some researchers. Riggs and Enochs (1990) developed a questionnaire based on Gibson and Dembo's Teacher Efficacy Scale to measure efficacy of teaching science, which was called Science Teaching Efficacy Belief Instrument (STEBI). Gibson and Dembo developed two useful tools for monitoring teachers' personal science teaching self-efficacy at various stages of their career: Science Teaching Efficacy Belief Instrument-A (STEBI-A) and Science Teaching Efficacy Belief Instrument-B (STEBI-B). STEBI-A is aimed to reveal elementary teachers' self-efficacy beliefs and STEBI-B was designed for pre-service teachers (Ginns & Watters, 1999)

Teachers' Classroom Management Beliefs

Classroom management is the essential factor that deeply affects effective teaching-learning environments and students' achievement. By reviewing literature, it was perceived that some investigators (Smith & Misra, 1992; Colvin, Sugai, & Patching, 1993; Kohn, 1994; Ellis & Karr-Kidwell, 1995; Tauber, 1995, Ellis et al. 1996) seem to consider classroom discipline and classroom management as being synonymous (Youseff, 2003). However, discipline typically refers to structures and rules for student behaviour and efforts to ensure that students compy with those rules (Martin & Yin, 1997; Martin, Yin & Baldwin, 1998; Martin & Shoho, 1999). Classroom management, on the other hand, is defined as a broader, umbrella term that describes all teacher efforts to oversea the activities of the classroom including learning, social interaction, and student behavior (Wolfgang & Glickman, 1980, 1986; Lemlech, 1988; Wolfe, 1988; MacNaughton & Karabinus, 1989; Weinstein & Mignano, 1993; Burden, 1995; Johns, Weinstein, 1996; as cited in Martin, Yin, & Baldwin; 1998). Brophy (1988) defined classroom management as "the actions taken to create and maintain a learning environment conductive to attainment of the goals instruction-arranging the physical environment of the classroom, establishing rules and procedures, maintaining attention to lessons and engagement in academic activities" (p.2). According to Martin and Baldwin (1993), classroom management includes three extensive dimensions; first one is the person dimension which is related to teachers' perceptions of the students as persons and teachers' beliefs about what they can do to help students in developing as individuals. Instruction is the second dimension that includes what teacher can do for enabling students to learn use of time, physical design of the classroom and maintenance of classroom routines etc. The last one, discipline, entails those behaviors that teachers use to set standards for behavior and to enforce those standards (Laut, 1999).

Glickman & Tamashiro (1980) and Wolfgang (1995) examined teachers' beliefs regarding classroom management and discipline and, they put forward three approaches based on child development. These approaches show a continuum from high teacher control to low teacher control. Low teacher control represents noninterventionist models of classroom management. The noninterventionist presupposes that the child has an inner drive that needs to find its expression in the real world. This model focuses on what an individual child does to modify his or her own environment. High teacher control demonstrates interventionist models that emphasize what the outer environment does to the human organism to cause it to develop in its particular way. This approach focuses on environment's effects on the individual. Moderate levels of teacher control are indicative of an interactionist model of classroom management and presuppose that internal and external forces are constantly interacting. Interactionalists focus on what the individual does to modify the external environment, as well as what the environment in return does to shape the individual (Martin, Yin, & Baldwin, 1998; Laut, 1999; Sokal, Smith & Mowat, 2003).

Classroom management is the one of the most important issues in educational settings and it is needed to investigate the teachers' classroom management beliefs and practices. Researchers attempt to capture multi dimensional aspects of classroom management and for this reason developed some scales. Martin and Baldwin (1993) suggest, "research efforts to explore the effects of classroom management are limited by the quality of instruments presently available to measure teacher perceptions and beliefs" (p. 5). The first instrument to measure teachers' disciplinary approaches and choices is the Pupil Control Ideology (PCI) developed by the Willower, Eidell, & Hoy in 1967. This instrument, based on ideological continuum, is custodial at one extreme and humanistic at the other. Another instrument related to classroom management is the Beliefs on Discipline Inventory (BDI) and it was developed by Wolfgang and Glickman in 1980 (Youssef, 2003). Finally, Martin and Baldwin (1993) developed the Inventory of Classroom Management Styles (ICMS) that addresses the broader concept of classroom management. This instrument was redesigned and recalled as the Attitudes and Beliefs on Classroom Control (ABCC) by Martin, Yin, & Baldwin (1998). ABCC instrument was designed to measure various aspects of teachers' beliefs and attitudes toward classroom management practices. This instrument is based on the three approaches of the classroom management and consists of 26 items and 3 independent dimensions, which are *instructional management*, *people management* and *behavior management*. According to Martin, Yin & Baldwin (1998), instructional management dimension "includes aspects such as monitoring seatwork, structuring daily routines, and allocating materials" (p.7). The second dimension, people management, "pertains to what teachers believe about students as persons and what teachers do to develop the teacher-student relationship" and the behavior management dimension "focuses on preplanned means of preventing misbehavior rather than the teacher's reaction to it" (p.8)

Purpose of the Study

The main aim of the study was to investigate the effect of the teaching practice on pre-service elementary teachers' science teaching self-efficacy and classroom management beliefs.

Research Questions

The research questions for this study as follows:

1. Is there any significant difference between male and female pre-service elementary teachers with regard to their self-efficacy and classroom management beliefs?
2. Is there any significant difference among pre-service elementary teachers who graduated from different types of secondary schools with regard to their self-efficacy and classroom management beliefs?
3. Is there any significant difference between self-efficacy beliefs of pre-service elementary teachers before and after teaching practicum?
4. Is there any significant difference between classroom management beliefs of pre-service elementary teachers before and after teaching practice?

METHOD

Subjects

The subjects of this study were 185 pre-service teachers who were enrolled in two different state universities in Izmir. 42 of pre-service elementary teachers were from Ege University (7 males and 35 females), 143 of them were from Dokuz Eylul University (41 males and 102 females), and the whole were seniors being ready to be teachers in elementary schools.

Instruments

In this study, two instruments were used: Science Teaching Efficacy Belief Instrument (STEBI-B) and The Attitudes and Beliefs On Classroom Control (ABCC) Inventory. A one-group pretest-posttest design was utilized in this study. The STEBI-B and ABCC were administered to pre-service teachers before and after their teaching practice. Researchers visited the classrooms to apply instruments to the students in both two universities.

The Science Teaching Efficacy Belief Instrument (STEBI-B) was developed by Enochs and Riggs in 1990 to measure pre-service elementary teacher's self-efficacy beliefs toward science teaching. According to the Enochs and Riggs (1990), STEBI-B consists of 23 items in a five- point Likert type scale ranging from strongly agree to strongly disagree and has two subscales; *Personal Science Teaching Efficacy* (PSTE) including 13 items and *Science Teaching Outcome Expectancy* (STOE) including 10 items. This instrument is a valid and reliable tool for studying and the items in the self-efficacy subscale and outcome expectancy subscale had high reliability (0.89, 0.76). This instrument was adapted to Turkish by Tekkaya, Çakıroğlu, & Özkan (2002) and it was found that Turkish version of this instrument is valid and reliable. In this study, a factor analysis was conducted to confirm the original factor structure of the instrument developed by Enochs and Riggs. Two items (items 13 and 22) were deleted from instrument because factor loadings were lower than 0.3. Finally, Turkish version of STEBI-B consists of 21 items and PSTE subscale includes 12 items, STOE subscale includes 9 items. Reliability coefficient was calculated as 0.86 for the whole instrument and as 0.80 and 0.72 for the PSTE and STOE subscales respectively

The Attitudes and Beliefs on Classroom Control (ABCC) inventory is designed to measure teachers' perceptions of their classroom management beliefs and practices. The ABCC Inventory consists of 26 Likert Format statements with a response scale that consists of four categories for each item in the Inventory (Martin & Shoho, 2000). The categories are defined as *Describes Me Very Well*, *Describes Me Usually, Describes Me Somewhat*, and *Describes Me Not At All*. Within this inventory, classroom management was defined as a multi-faceted construct that includes three broad dimensions: Instructional Management (α=0.82), People Management (α=0.69), and Behavior Management (α=0.69) (Matin, Yin & Baldwin, 1998). Each subscale was derived to assess a continuum of control ranging from interventionist to interactionalist to non-interventionist (Martin & Baldwin, 1993; Martin, Baldwin & Yin, 1995; Martin, Yin & Baldwin, 1997, 1998; Martin & Shoho, 1999, 2000). Higher scores indicate a more interventionist (controlling) approach while lower scores are indicative of a less controlling ideology in that dimension of classroom management style. According to Martin, Yin and Baldwin (1998), ABCC Inventory is a reliable and valid instrument that is useful in the empirical examination of classroom styles.

The ABCC was adapted to Turkish by Savran (2002). It was found that Turkish version of this instrument was valid and reliable. It includes two subscales: the instructional management and the people management. In this study, 26 items of the ABCC instrument were subjected to principal component analysis (PCA) to find underlying structures of the instrument. Principal component analysis revealed the presence of seven factors with eigenvalues exceeding 1. An inspection of the screeplot revealed a clear break after the second factor. To aid in the interpretation of these factors, Varimax rotation was performed. In the two factors structure, three items (items 6, 7 and 17) were deleted from instrument because item-total correlation coefficients were lower than 0.2. Final instrument includes two factors: instructional management factor consists 12 items and explains 13.87 per cent of the variance; people management factor consists of 11 items and explains 19.78 per cent of the variance. Behavior management subscale, which is the third factor in the original inventory, was failed to be included in the Turkish form. In order to determine reliability of the ABCC instrument, Cronbach alpha coefficient was calculated and it was found that Cronbach alpha of the whole instrument was 0.75. Reliability coefficients of the Instructional Management subscale and the People Management subscale were found to be 0.74 and 0.78, respectively.

RESULTS

Descriptive statistics were conducted to analyze the pre-service teachers' STEBI-B and ABCC scores. As seen in Table 1, the means of pre and post-PSTE scores on STEBI-B for the whole pre-service teachers were 46.16 and 46.31 respectively. Possible minimum score is 12 and maximum score is 60 for the PSTE subscale. These descriptive results can be interpreted as preservice elementary teachers have high personal science teaching efficacy that they have necessary skills to teach science effectively. Pre-service teachers' mean scores for pre-STOE and post-STOE were 32.81 and 32.39 respectively. STOE subscale includes 9 items and minimum score is 9 and maximum score is 45 for this scale. With regard to subjects' mean scores on the STOE subscale, it can be interpreted that pre-service teachers have high level of science teaching outcome expectancy which student learning can be influenced by given effective instruction. The means of pre and post-Instructional Management subscale on ABBC for the whole sample were found to be 36.07 and 34.83. Instructional management subscale includes 12 item and thus the possible minimum score is 12 (less controlling) and the maximum score is 48 (most controlling). Results indicate that preservice elementary teachers have high scores indicating more controlling, interventionist approach. Pre and post-People Management subscale mean scores of pre-service teachers were 34.51 and 35.26 respectively. For the People Management subscale, the possible minimum score is 11 and maximum score is 44. Results showed that preservice elementary teachers also tend to be more interventionist on this scale.

An independent t-test was used to determine if there was any significant difference between male and female pre-service elementary teachers with regard to their self-efficacy and classroom management beliefs before and after teaching practice. As seen in Table 2, there was no

Table 1. Descriptive Statistics of STEBI-B and ABCC Scores

Variable	N	Minimum	Maximum	Mean	Sp
Pre-PSTE	185	24,00	60,00	46,16	6.26
Post-PSTE	185	26,00	60,00	46,31	6.31
Pre-STOE	185	21,00	44,00	32,81	4.33
Post-STOE	185	18,00	45,00	32,39	4.69
Pre-Instructional Management	185	25,00	46,00	36,07	3.85
Post-Instructional Management	185	16,00	45,00	34,83	4.06
Pre-People Management	185	21,00	44,00	34,51	3.98
Post-People Management	185	23,00	44,00	35,26	3.89

Table 2. t-Tests: Males –Females Regarding STEBI-B and ABCC

Subscale	Gender	N	Mean	SD	df	p
Pre-PSTE	Female	137	45,95	6,42	183	.451
	Male	48	46,75	5,81		
Post-PSTE	Female	137	46,21	6,37	183	.712
	Male	48	46,60	6,21		
Pre-STOE	Female	137	32,73	4,37	183	.662
	Male	48	33,04	4,28		
Post-STOE	Female	137	32,10	4,79	183	.152
	Male	48	33,23	4,31		
Pre-Instructional Management	Female	137	35,89	4,01	183	.285
	Male	48	36,58	3,34		
Post-Instructional Management	Female	137	34,66	3,86	183	.342
	Male	48	35,31	4,58		
Pre-People Management	Female	137	34,63	4,05	183	.465
	Male	48	34,14	3,78		
Post-People Management	Female	137	35,46	3,91	183	.215
	Male	48	34,67	3,58		

significant difference between the mean scores of males and females' science teaching efficacy and classroom management beliefs (p>.05).

A one-way between groups analysis of variance was conducted to explore the different types of secondary schools on pre-service elementary teachers' self efficacy and classroom management beliefs. There was no significant difference between the mean scores of pre-service elementary teachers who graduated from different types of secondary schools with regard to their science teaching efficacy and classroom management beliefs (p>.05) (Table 3).

A paired-samples t-test was conducted to evaluate the impact of the teaching practice on self efficacy and classroom management beliefs of pre-service elementary teachers. As seen in Table 4, mean scores on STEBI-B for PSTE subscale changed from 46.16 to 46.31, indicating an increase of 0.15. There was no statistically significant difference between the pre-test (before teaching practice) and post-test (after teaching practice) means on the PSTE sub-scale. Mean scores on STEBI-B for STOE changed from 32,80 to 32,39, indicating a decrease of 0.41. There was no statistically significant difference between pre-test and post-test means of STOE (p>.05). However, there was a statistically significant difference in ABCC scores of the each subscales before teaching practice to after teaching practice (p<.05).Mean scores of Instructional Management subscale changed from 36.07 to 34.83, a indicating decrease of 1,24 and mean scores of People Management subscale changed from 34.51 to 35.26, indicating an increase of 0.25.

DISCUSSION

Classroom management and teacher efficacy beliefs of pre-service teachers have been shown to be the most common concern of the educational studies (Weinstein & Mignano, 1993; MacNaughton & Karabinus, 1989; Weinstein, 1996; Smith, 2000; Gee, 2001). These beliefs that pre-service teachers have about how to manage their classes and how effectively they might be are interrelated with each other. These beliefs also affect teachers' perceived success before entering the teaching

Table 3. ANOVA Tests: Different Types of Secondary Schools Regarding STEBI and ABCC

Variable	Source	Sum of Squares	df	Mean Square	F	p
Personal Science Teaching Efficacy	Between Groups	226,060	6	37,677	,938	.469
	Within Groups	7111,657	177	40,179		
	Total	7337,717	183			
Science Teaching Outcome Expectancy	Between Groups	65,045	6	10,841	,483	.821
	Within Groups	3975,384	177	22,460		
	Total	4040,429	183			
Instructional Management	Between Groups	75,316	6	12,553	,420	.865
	Within Groups	2944,424	177	16,635		
	Total	3019,739	183			
People Management	Between Groups	176,662	6	29,444	2,057	.061
	Within Groups	2533,289	177	14,312		
	Total	2709,951	183			

Table 4. Paired Sample t-Test (Two-Tailed) Results for STEBI and ABCC

Variable	*Tests*	*N*	*Mean*	*SD*	*t*	*df*	*p*
Personal Science Teaching Efficacy	Pre-test	185	46,16	6,2620	-,311	184	.756
	Post-test	185	46,31	6,3150			
Science Teaching Outcome Expectancy	Pre-test	185	32,80	4,3357	1,112	184	.267
	Post-test	185	32,39	4,6893			
Instructional Management	Pre-test	185	36,07	3,8519	3,437	184	.001*
	Post-test	185	34,83	4,0565			
People Management	Pre-test	185	34,51	3,9783	-2,550	184	.012*
	Post-test	185	35,26	3,8388			

* p<0.05

field. The most important factor, which affects or change pre-service teachers' believes is the teaching practice experience. Teaching practice is the event in a pre-service teacher's educational career that warrants the application of that theoretical knowledge and transforms the "pre-service teacher" to "real teachers" (Katrina, 2004). This experience give opportunities for pre-service teachers to apply their content and pedagogical knowledge with children and to further develop personal teaching philosophies (Plourde, 2002).

In this study**,** the effects of the teaching practice on pre-service elementary teachers' science teaching efficacy and classroom management beliefs were examined. Firstly, the differences between the science teaching efficacy and classroom management beliefs of pre-service elementary teachers with regard to gender were investigated. Results revealed no significant differences in both self-efficacy and classroom management scores between males and females pre-service teachers. These findings are consistent with the other studies conducted in Turkey (Celep, 2001; Savran, 2002; Gencer & Çakıroğlu, 2007). However, there is no consistency among the results of the other studies in this field. In terms of science teaching efficacy beliefs, some researchers found that female teachers had lower science teaching self-efficacy beliefs than their male counterparts before teaching practice. However, after teaching practice, there was no statistically significant difference in preservice male and female teachers' self-efficacy beliefs. According to these researchers, methods courses in teacher education programs focus on preservice teachers' own experiences with science and past education inequities and female teachers need support to change their beliefs about self-efficacy regarding teaching science. (Riggs, 1991**;** Brandon, 2000; Howes, 2002; Kiviet & Mji, 2003; Mulholland et al., 2004).Studies related to classroom management regarding gender revealed that males scored significantly higher (more interventionist) on each subscales of the ABCC. That is males are more controlling, authoritarian, interrupting, impolite, assertive, aggressive and dominant than their female counterparts (Martin & Yin, 1997).

In this study, when it was examined whether or not the effects of pre-service elementary teachers graduating from different types of high school with regard to their science teaching efficacy and classroom management beliefs, it was found that this variable did not affect these beliefs. This could be explained as these pre-service teachers were senior, and for this reason, it has been a long time since they had their high school experiences. That means, pre-service elementary teachers' self-efficacy and classroom management beliefs were influenced by experiences from undergraduate courses.

The analyzing of the effects of the teaching practice on pre-service elementary teachers' self-efficacy and classroom management beliefs, teachers put forth very interesting results for consideration. As seen from the analyses, there were no significant differences between PSTE and STOE mean scores of pre-service teachers both before and after teaching practice. Results seem to indicate that teaching practice did not affect their science teaching efficacy beliefs. Similar to this study, Gencer & Çakıroğlu (2007) found that completing teaching practice course and additional educational courses were not a significant factor on preservice teachers' self-efficacy beliefs. According to Ginns and Watters (1999), the lack of significant difference in PSTE scores could be attributed to preservice teachers' beliefs and attitudes regarding the teaching of science which were set firmly prior to entry into preservice program as a result of their science-related experiences in elementary and high schools (Plourde, 2002). On the other hand, Tosun (2000) indicated that the lack of change in outcome expectancy scores is related to Bandura's (1977) four sources of efficacy information (performance accomplishment, vicarious experience, verbal persuasion, emotional arousal). Bandura (1981) suggested the need for successful mastery experiences to enhance self-efficacy. The results suggest that a lack of performance accomplishment in prior science coursework may have translated into little change in outcome expectancy. However, research conducted in this area to date indicates that teaching practice experiences affect preservice teachers' efficacy beliefs either positively or negatively. Studies related to STEBI-B reported mixed results in terms of significant changes in the two subscales, self-efficacy (PSTE) and outcome expectancy (STOE) (Ginns, Tulip, Watters & Lucas, 1995; Plourde, 2002; Bleicher & Lindgren, 2005). For example, Wingfield et al. (2000) found significant changes in both self-efficacy and outcome expectancy. Cantrell, Young, and Moore (2003), Schoon and Boone (1998), and Tosun (2000) found significant changes in self-efficacy, but not in outcome expectancy. However, Ginns, Tulip, Watters & Lucas (1995) and Plourde (2002) found significant changes only in outcome expectancy. Tschannen-Moran and Woolfolk Hoy (2001) argued that discrepancies in these findings could be related to the way efficacy was measured. Hoy and Woolfolk (1990) postulated that a significant phase of socialization begins when students enter the actual world of teaching as practice teaching. The suggestions of Ashton and Webb (1986) that perceived efficacy may be high for certain tasks when students enter the teacher education program, but decrease as students encounter difficulties with the task. Perhaps increase with successful experiences, and decrease again if additional complexity is added to the task may, in part, account for the results (Ginns et al., 1995)

Statistical analyses related to preservice teachers' classroom management beliefs changes before and after teaching practice revealed that there was a statistically significant difference on both Instructional Management and People Management subscales of the ABCC inventory with regard to teaching experience. While pre-service teachers' beliefs related to instructional management decrease with teaching practice, their People Management beliefs increase with teaching practice. Pre-service students' instructional management beliefs partially tend to shift interventionist to interactionist approach. However, their people management beliefs became more interventionist through the teaching experience.

These findings suggest that pre-service teachers' educational experiences during their teaching practice affect their attitudes toward classroom management. This is also consistent with the other studies that how teaching practice experiences affect the pre-service teachers beliefs. Research has demonstrated that effective classroom instruction in teacher education programs can alter students' views about classroom management (Hollingsworth, 1989). More often, however, student teachers begin their traditional teacher education programs with well-defined ideas about classroom management and these ideas remain unchanged during the course of their training (Zeichner & Tabachnick, 1981; O'Loughlin, 1991; Tatto, 1996). Ironically, changes occur when these teachers are hired for their first teaching positions (Celep, 1997; Laut, 1999). At this point, their attitudes usually become more interventionist.

According to Sokal, Smith, & Mowat (2003), it is unclear exactly where on the continuum that the transition between interactionist and interventionist attitudes becomes problematic. Moreover, studies resulted in student teachers become more interventionist in one component of classroom management and less so in another create more questions. When designing teacher education programs, which types of classroom management beliefs should be the focused are still unanswered.

CONCLUSION

This study is only a step to understand pre-service elementary teachers' science teaching efficacy and classroom management beliefs. In order to analyze and understand the modification in teacher's beliefs, longitudinal studies that preservice teachers can be observed through the 4-years teacher education programs must be conducted. In addition, future studies using qualitative methods would enhance our understanding of pre-service teachers' potential differences in students' interpretation of experiences as well as differences among experiences themselves self-efficacy and classroom management beliefs. The findings of this study can help to develop and improve teacher education programs and pre-service teaching practices. Teacher education programs must be designed to bridge the gap between theory and practice and to better prepare these teachers. In order to enhance pre-service teachers' science teaching efficacy beliefs, they are encouraged to observe and involve variety of science experiences during their field experiences. It is no doubt that, field experiences provided the pre-service teacher a number of new experiences in the classroom. Hence, field experiences are needed to include efficient lesson planning and effective classroom management. A better understanding of the self-efficacy and classroom management beliefs of pre-service teachers will facilitate the process of university level instruction.

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Turkish Primary Students' Perceptions about Scientist and What Factors Affecting the Image of the Scientists

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Students' views of science and scientists have been widely studied. The purpose of this study is to analyze image of scientist from drawn picture of scientists using The Draw-a-Scientist Test (DAST) by 5th grade students and to analyze where this image comes from students' minds in changing Turkish educational perspective. Two hundred eighty seven students from sixteen different primary schools, located in the same city, participated in this study. Like previous studies, the findings generally showed that scientists are male, Caucasians, elderly-aged, working indoors with chemistry. On the contrary, the image of scientists, having glasses and facial hair and/or crazy hair, wearing lab coats, and doing dangerous and secrecy things decreased but smiling scientists and indicator of technology increased in young Turkish students' drawings. Eventually, stereotypical images of the scientist are a slightly lesser than revealed in previous studies. The impact of science teachers and textbooks has shaped what a scientist is and what a scientist does to young students' minds. Notwithstanding, the influence of media (movies, magazines, television, etc.) has been pointed to as not significant source of information by students.

Keywords: The Draw-a-Scientist Test (DAST), Scientist, Science Teaching

INTRODUCTION

Students come into classroom with their own knowledge and they reformulate their existing knowledge, either valid or invalid or incomplete, only if new information is connected to knowledge in their mind. Otherwise memorized information that has not been connected with the students' prior knowledge will be quickly forgotten. Besides, science is no longer presented as a mystery tour or a magic show. Now science is all around us. The contemporary teaching science at school tends to be active and hands-on, and teaches children a great deal about their world In fact, the more opportunities kids ask questions, make observations, and learn through hands-on experiences, the more easily they learn and connect to the real world (Bransford, et.al 2000; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Erduran, Ardac, & Yakmaci-Guzel, 2006; Halat, 2007; Turkmen, & Pedersen, 2005). These accepted two facts caused to Turkish Ministry of National Education to revised Turkish science education curriculum in 2004. The revised programs began in the 2005-2006 academic year. Turkish perspective of teaching science was totally changed to be "doing science" rather than just reading about it. The purpose of this science curriculum is to prepare students to be scientifically literate citizens who are able to use scientific facts in their daily life. New instructional materials were designed for a student-centered (constructivist theory) learning crucially important for implementation of lifelong learning strategies. The main approach in the new science curriculum was to make our students "think like a scientist". Teachers would use a "student as scientist" metaphor for students' activities in the classroom and when conducting an investigation and encourage them by asking "how would

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a scientist find out? In addition, science textbooks were written by paying attention to history and nature of science. Many students come across to stories about scientists and inventors. These stories in the science textbooks tended to emphasize positive characters of scientists, such as curiosity, hardworking, persistency, and encourage students to follow these examples. The purpose of mentioning of scientists in textbooks was to show their achievement and contributions to mankind.

Scientists are often symbolized in visual and verbal images in TV, fictions, and textbooks. Whether inside or outside school, students develop their own images of scientists, which can be very stable and resistant to change. Investigating their images of scientists has significant implications for understanding students' perceptions of scientists. The Draw-a-Scientist Test (DAST) is a useful tool for exploring students' perceptions of scientists by providing symbolic indications of students' basic beliefs. Several studies using the Draw-a-Scientist Tests have assessed students' images of scientists over the last two decades.

The DAST was originally developed by David W. Chambers (1983) in order to learn the person's image of a scientist. In his study, 4807 children, who are from kindergarten to K-5, participated in the DAST. Drawings were analyzed for some indicators of the image He used 7 major indicator, such as lab coat, eyeglasses, and facial growth of hair. He was able to show that views of scientists varied by age and grade level, and that children held stereotypical views of scientists from these indicators. The Draw-a-Scientist-Test revised prompt (DAST-R) was recommended and tested by Symington and Spurling (1990), because they realized that students draws represent what they perceived to be the public stereotype of a scientist instead of their own perception of a scientist. To remedy this problem, Symington and Spurling added "Do a drawing which tells what you know about scientists and their work" section. They compared drawings done by students given both sets of prompts. The drawings showed enough differences that the DAST prompt is critically examined for what it actually is asking the students to draw.

After creating DAST by Chambers, many researchers started to use DAST to gauge various factors in students, including career goals, perceptions of scientists at the elementary through high school level, and perception of technology in 1990's. Each of these studies has shown that students possess interesting stereotypic images of scientists. The typical finding was that students have drawn white men who wear a white coat and work alone in a laboratory. Scientist was elderly or middle aged and wears glasses. This has been interpreted as showing strong confirmation of a stereotype of the scientist (Chambers 1983; Finson, Beaver & Cramond 1995; Fort & Varney 1989; Huber & Burton 1995; Mead & Metraux, 1957; Hadden & Johnstone, 1983; Rubin, & Cohen, 2003; Schibeci & Sorenson 1983; Solomon 1993; Tuckey, 1992). These stereotypical images of the scientist seemed to be common worldwide. Despite, there have been few studies reporting the image of the scientist from non-western countries. In this study, the more comprehensive data from 5th grade Turkish students to identify their image of scientist and highlight to their vision of most effective sources about scientist's image were attempted to provide.

RESEARCH QUESTION/DESIGN

Sample

Fifth grade students were concentrated in this study, because they were the first source of impacted subject group by changing of Turkish education perspective. Two hundred eighty seven (287) 5th grade students, who 120 were boys and 167 girls from 16 different primary schools located in the same city, participated in the data collection procedure. All the students attending this study had taken first time science and technology course.

Instrument

The whole study was carried out in two parts. First part of questionnaire was the DAST. In this part, each student was given a piece of paper with the following instruction: Could you draw a picture of a scientist? (Try to draw one in the rectangular box below) When you are finished, Could you please explain What Scientist is Doing?

The second part of questionnaire regarding source of scientist image was adapted by Pedersen and Turkmen (2005) and a little changed for this study. For the current study, second part consisted of 3 sections identifying "Where Students Receive Information about Scientist," including 15 questions, and "The Most Frequent Way Students Study/Learn about Scientist," including 7 questions.

The questionnaire was administered by the class teacher in one of his/her lessons. The teachers were asked not to give any further directions to students and no time limit was set for drawing the pictures. All teachers reported that students completed the task in 20 minutes or less. The reliability of the instrument is documented at .81.

DATA COLLECTION and ANALYZING

At the end of the 2006 fall semester, the questionnaire was conducted to attempt to ascertain information about the image of scientists and source of

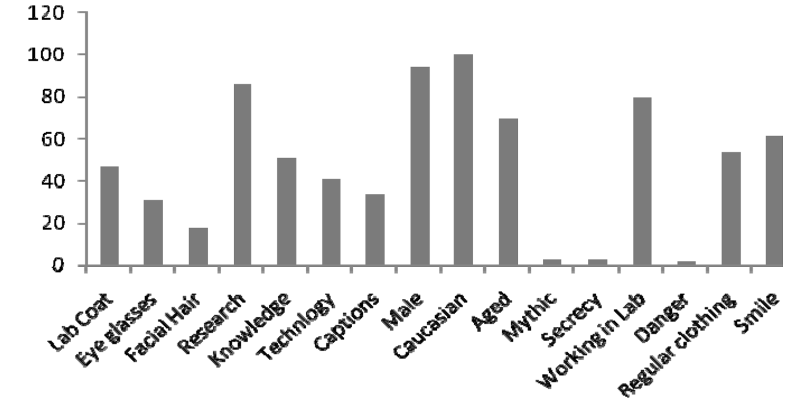

Figure 1. DAST Percentages

scientist image. The student's drawings of scientists were collected and analyzed using the DAST-C. Each drawing was rated for specific stereotypic images and additional information obtained from the student narratives.

In the previous studies, general opinion would readily find a scientist depicted as a white male, middle-aged or older, wearing a lab coat and glasses and featuring some type of facial hair (Barman, 1996-1997-1999; Bodzin, & Gehringer, 2001; Chambers 1983; Finson, 2002-2003; Finson, Pedersen, & Thomas, 2006; Flick, 1990; Fort & Varney 1989; Finson, Beaver, & Cramond 1995; Fung, 2002; Huber & Burton 1995; Kahle, 1992; Moseley, & Norris, 1999; Odell, Hewitt, Bowman, & Boone, 1993; Pedersen, & Thomas, 1999; Rosenthal, 1993; Ryder, Leach, & Driver, 1999; Schibeci & Sorensen, 1983; Song, & Kim, 1999; Symington, & Spurling, 1990; Thomas, & Pedersen, 1998; Thomas, Pedersen, & Finson, 2001). In this study, the students perceived scientists as being males (94.1%) who are old-aged (69.7%), do their work in some type of laboratory (79.8 %), and wearing lab coat (46.7 %). Indicator of symbols of research (86.1%) were laboratory equipment, including test tubes, various types of flasks, beakers and burners with flames and symbols of knowledge (51.2%), drawn books, shelves or stationery, were almost same percentage in previous studies.

On the other hand, some images of scientists were interestingly found opposite of former studies, such as, regular clothing (blue-jeans and T-shirts) (53.3%), smiling (61%). Turkish 5th grade students were not agreed that facial hair (17.4%), eyeglasses (30.7%), relevant captions (33.5%) including time machines; infra-red eyeglasses; and special watches, mythic stereotypes (2.5%), indications of secrecy (2.4%), and indications of danger (1.7%) are not stereotyped image of scientist.

Ethnic minority representation was practically *nonexistent*. One possible explanation is all Turks are Caucasian and students probably have never seen any black or Hispanic or Asian people. Undoubtedly, students did not depict any minority people as a scientist. Another interesting feature was the computers (40.8 %) in the drawings. This could be reflecting an increasing usage of computers in science lessons.

Another interesting result was that nearly all scientists were in a laboratory and were behind or by the side of a table but very few were outside. Moreover, scientists stood alone in an environment (generally laboratory) surrounded by objects of research (86.1 % percent) or objects of knowledge (51.2 %); barely included other people. In this sense, teachers failed to teach science is a collaborative endeavour and many of today's investigations are team based (Figure 1).

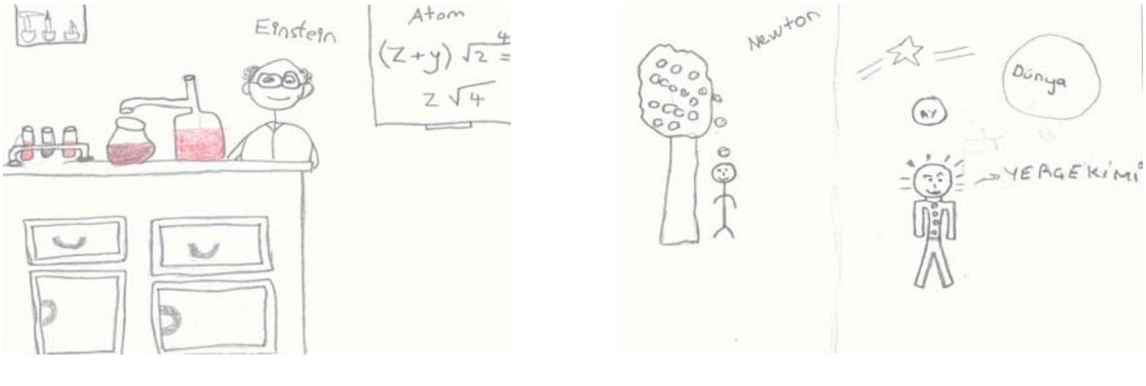

Figure 2. Examples of students' sketches of scientists, Einstein and Newton.

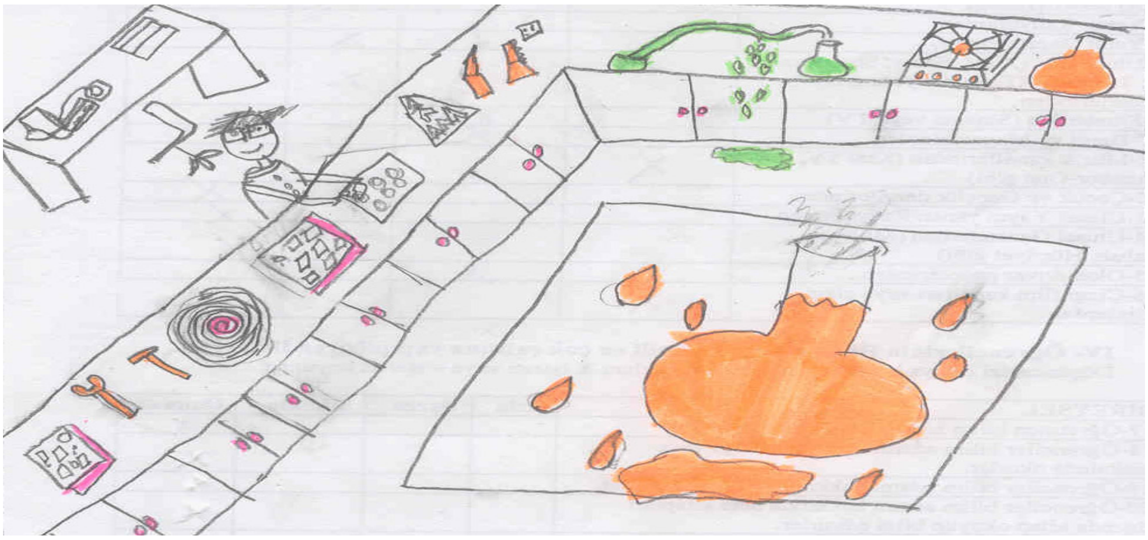

Figure 3. Male scientist is working in the chemistry lab.

In many cases, it was noted that most of the students pay close attention scientists' contributions to the well-known of mankind, such as Newton, Einstein, and Graham Bell (Figure 2). The usual stereotype of the 'brainy' scientist with a large forehead was largely absent. However, white men were sometimes drawn with a bald head and hair at the sides. Most probably, this could be an adaptation of the Albert Einstein. In few cases, there were some images having smoking chemicals, blowing, and dissections. There were one image of bombs/blowing up some planets, three Frankenstein, two where one person and one animal were being injected with dangerous chemicals, and three featured dissections. Although there were the negative images of scientist, they were not many. The negative image of scientists might be coming from such popular movie characters and/or cartoon characters, such as "Norman Osborn (Green Goblin)" from Spiderman movie, "Dr. Lex Luthor" from Superman movie, "Dr Frankenstein" from many Frankenstein movies, and "Dr Moreau" from the Island of Dr. Moreau movie. These scientists were mad, evil, godless, amoral, arrogant, impersonal or inhuman in the movies. These characters have contributed more or less unattractive vision of the scientist. These fictional representations of the scientist were reflections of the response to the role of science and technology in the social context and were drawn by boys mainly, and were massively of males. On the contrary, there were also very few positive statements, like "A scientist is trying to found a cure for Bird Flu (Avian influenza) and AIDS."

Besides, the majority of scientists were drawn as chemistry-based scientists. One possible explanation might be it is easier to draw beakers, funnels, pipettes, and test tubes than common physics apparatus, such as balance, magnifiers, and electrical supplies, and biology apparatus, such as dissecting instruments, model of DNA/RNA, and torso. (Fig. 3)

In the second part of questionnaire, 5th grade students were asked based on items listed on the instrument where they obtain most of their information about scientist. Most of their sources of information came from the *teachers* (61.3 %) and *parents* (40.5 %). Moreover, they thought that friends (37.6 %) were also important sources of information about scientist. *Media* (41.8 %) was somewhat important source. One of the possible reasons is that Turkish media do not have responsibility to educate our children. Often the media present an exaggerated science stories and treating controversial theories as facts and scientists as superior beings who live in a world apart (Table 1).

Five grade students responding to this instrument were also asked to indicate which media sources they used to gather information about scientists. Although media was somewhat important sources, music channels (34.8 %), local radios (36.6 %), and local (39.1 %) and national (40.1 %) newspapers were ranked in important or very important categories in media. On the contrary, respondents indicated that movies (42.4 %), national magazines (61.3 %), school events TV (47.4 %) were not important sources of information about scientists. These results showed that most of Turkish 5th grade students believed movies, TV programs, and magazines were not a trustable source of information about scientists. One of the possible reasons is that these sources do not represent realistic and educational news to people in their broadcastings and editions (Table 2).

The students' responses about their insights regarding how they most frequently studied about scientist indicated that "Students read about scientists in textbooks" and "A teacher talks about scientists in class." have the highest and "Students participate in field trips related to scientists" has the lowest mean scores. In contrast, statements of "Students write papers about scientist" (31.1 %) and "Students participate in field trips related to scientists" (50.3 %) were seen as the least likely manner (never) and "Students read about scientists in an article or journal," "Students read about scientists in books (other than textbooks)," and "Students complete projects on scientists" were ranked in "sometimes" manner by which 5th grade students learn about scientists. These results were very similar with She's (1995) findings, which suggested that Taiwanese students' images of scientists were influenced to a considerable degree by the content of science textbooks, this study illustrated the possible impact of the curriculum (Table 3).

In general the results of this study indicate that boys and girls are seeing scientists in realistic ways and science as an exclusively male preserve. There was no statistically difference between male and female students' "DAST" and "source of information about scientists" mean scores. But some boys tended to see scientists do something weird and magical things in science and girls in this study did not see science as an exclusively male preserve as much as boys'.

CONCLUSION and DISCUSSION

Undoubtedly, the image of scientists is a part of science. It is essential responsibility for teachers, science educators, and curriculum developers involved in developing science curriculum materials to know what students' perception is about science. It also helps students' understanding and use of science in their lives.

Table 1. Where 5th Grade Students Receive Information about Scientist: Individuals

Questions	Mean	Standard Deviation	Not Important	Somewhat Important	Important	Very Important
B1: Media	2,5958	,94816	12.9 %	41.8%	39.7 %	5.6 %
B2: Friends	2,5401	,95216	19.8 %	29.6 %	37.6 %	13.0 %
B3: Parents	2,9861	1,05105	13.9 %	13.9 %	31.7 %	40.5 %
B4: Teachers	3,3380	,98984	10.1 %	7.3 %	21.3 %	61.3 %

Table 2. Where 5th Grade Students Receive Information about Scientist: Media

Questions	Mean	Standard Deviation	Not Important	Somewhat Important	Important	Very Important
BM5: Local TV News	2,26	,868	20.2 %	40.8 %	31.4 %	7.6 %
BM6: Local Radio	2,73	,937	10.5 %	29.3 %	36.6 %	23.6 %
BM7: Local Newspaper	3,01	,998	11.5 %	14.6 %	34.8 %	39.1 %
BM8: National TV News	2,29	1,00	25.1 %	34.1 %	26.5 %	14.3 %
BM9: Movies	1,89	,971	42.5 %	35.1 %	12.5 %	9.9 %
BM10: National Magazines	1,67	,980	61.3 %	17.8 %	12.9 %	8.0 %
BM11: MTV and other music channels	2,56	,954	14.9 %	31.7 %	34.8 %	18.6 %
BM12: Teen Magazines	2,56	,947	12.9 %	37.3 %	30.3 %	19.5 %
BM13: National Public Radios	3,01	,951	7.7 %	21.6 %	32.8 %	37.9 %
BM14: National Newspapers	2,58	,945	15.3 %	27.5 %	40.1 %	17.1 %
BM15: School Events TV	1,86	,988	47.4 %	27.9 %	15.7 %	9.0 %

Table 3. The Most Frequent Way Students K-12 Students Study/Learn About Scientist

Questions	Mean	S.D	Never	Sometimes	Frequently	Always
C16: A teacher talks about scientists in class.	2,90	,903	2.8 %	31.9 %	26.5 %	38.8 %
C17: Students read about scientists in an article or journal.	2,40	,821	19.8 %	41.9 %	26.5 %	11.8 %
C18: Students write papers about scientist.	2,48	,896	31.1 %	26.0 %	26.5 %	16.4 %
C19: Students read about scientists in books (other than textbooks).	2,79	,968	8.7 %	32.8 %	28.6 %	29.9 %
C20: Students read about scientists in textbooks.	2,96	,905	3.5 %	32.4 %	28.6 %	35.5 %
C21: Students complete projects on scientists.	2,37	,910	25.7 %	35.3 %	25.1 %	13.9 %
C22: Students participate in field trips related to scientists.	1,92	,807	50.3 %	33.3 %	10.1 %	6.3 %

Many researchers and educators believed that the less stereotypical the image of scientists one holds, the more probable s/he will have positive attitudes toward science and subsequently consider entering a profession in the sciences (Bodzin & Gehringer, 2001; Flick, 1990; MacCorquodale, 1984; Matkins, 1996; Rosenthal 1993). Hence, information about students' perceptions of scientist is vital tool to evaluate science curriculum.

The perception of scientists being male, Caucasians, elderly-aged, working indoors with chemistry was seen a prevalent in previous research using DAST to explore students' image of scientists. Although the results of study resemble the findings of previous research, the elements of those scientists having glasses and facial hair, wearing lab coats, with crazy hair and doing dangerous and secrecy things decreased. Eventually, indicator of technology and smiling face increased in young Turkish students' drawings. Even, a number of students view scientists as realistic people rather than as mythical creatures.

What factors influence all these perceptions have been inferred by various researchers? Most of them stated that the impact of classroom activities with the influence of today's media and literature (Evans, 1992) shapes students' attitudes toward science and role of scientists in our society (Talsma, 1997). Notwithstanding, the influence of media (movies, magazines, television, etc.) has been pointed to as not significant source of information by students in this study. Thus, if teachers got our students to be curious about the natural world around them and encouraged them to develop their own theories about why something is the way it is, through drawing, or creating structure of their idea, or a way of thinking at an early ages, this would lead them to have science-related hobbies and jobs as they grow up.

IMPLICATIONS of STUDY

Teachers in the primary schools play a central role in sharing and creating perceptions and stereotypes about science and scientists. A clear evaluation of students' views of scientists can pinpoint misconceptions at early ages. These misconceptions can be got rid of students' minds using student-centered learning style. To get rid of negative images of scientists, teachers, science educators, and curriculum developers need to be encouraged to use the special features in science textbooks that highlight science careers, depict scientists as everyday people. They should get students meet with scientists because at that age it is considered the critical time of influence. Scientists can come to the classroom and students can ask them to talk about their lives not just their science. Even, they can get helpful from students' parents having a science background and from university academicisons.

While the DAST is simple method, readers should be cautious about this conclusion because the DAST only provided us with a one dimensional snapshot of students' mental representations about scientists and do not necessarily reflects what students believe. Hence, it would be useful to include interviews for deeper understanding of students' constructs after the drawing activity. Although some students added comments and captions on their drawings, it is not enough evidence for what students believe and probably it difficult to express their views simply through drawing.

The information obtained in this study has been limited to a few schools in the west of Turkey. The other researchers should be encouraged to use the similar research to gain insights about how students in different parts of Turkey perceive scientist and its relevancy to them. These data would provide valuable feedback to teachers regarding whether students are developing a realistic perception about scientist and its usefulness to them. This information could serve as an evaluation tool for teachers to assess the effectiveness of their science instruction.

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Correlations Among Jamaican 12th-Graders' Five Variables and Performance in Genetics

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This study was aimed at finding out if the level of performance of selected Jamaican Grade 12 students on an achievement test on the concept of genetics was satisfactory; if there were statistically significant differences in their performance on the concept linked to their gender, self-esteem, cognitive abilities in biology, school-type and socioeconomic background (SEB); and if there were significant correlations among the five variables and the students' performance. The sample (n = 357, 102 males and 255 females) was chosen from two all-boys' schools, four all-girls' schools, and 13 mixed schools in rural and urban Jamaica. The results indicated that the students' level of performance (mean = 22.81 or 45.62%) was unsatisfactory; there were statistically significant differences in the students' performance on the genetics test based on their self-esteem, cognitive abilities in biology and school-type in favour of students with a high self-esteem, high cognitive abilities, and students in the coeducational schools respectively; there was a positive, statistically significant but weak relationship between the students' (a) self-esteem, (b) cognitive abilities, and (c) school type and their performance on the genetics test.

Keywords: Correlations, Gender, Genetics Achievement Test, School-type, Socioeconomic Background

INTRODUCTION

In 1999, the Caribbean Examinations Council (CXC) - the regional body which examines Caribbean 11th-graders on all school subjects - got the approval of the UK's National Academic Recognition Information Centre to offer the Caribbean Advanced Proficiency Examinations (CAPE) to replace the GCE advanced level examinations that UK's examinations boards had been conducting in the Caribbean. The CAPE was instituted to offer Caribbean students the opportunities to sit examinations that Caribbean educators set with a view to improving the students' pass rate. But, the fact that 954 (69%) of the 1383 Jamaican students who wrote the CXC CAPE in biology from 1999 to 2003 got the passing Grades 1-5, while 429(31%) of them obtained Grades 6-7 and failed the examinations is a cause for concern.

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One of the justifications for this study was that genetics is one of many biology concepts in the CAPE biology curriculum that present students with high cognitive challenges. Indeed, some studies have shown that many students perceived genetics to be difficult to learn (Longden, 1978; Woolley, 1979), while ample evidence indicated that many students performed poorly on genetics tests (Walker, Mertens & Hendrix, 1979). Yet, genetics is widely recognised as the conceptual foundation for the understanding of biology itself (Deadman & Kelly, 1978). A review of the reports on candidates' work in the CAPE in biology since 1999 revealed that many candidates did not perform well on questions set on genetics although the topic is taught fully in Grades 10 and 11. We considered it worthwhile to explore the possible links among selected Jamaican

12th-grade CAPE students' gender, self-esteem, cognitive abilities in biology, school-type and socioeconomic background (SEB) and their performance on a test on genetics. This was because it has been shown in many studies that these five variables did contribute to students' poor performance in science generally, but the topic of this study had not been investigated in previous studies. We also conjectured that the five variables were likely to be significantly correlated to the participants' performance on the genetics test in this study, although the findings of previous studies on the five variables were conflicting.

The findings of many of the international studies conducted between the 1970s and 1990s showed that gender differences in high school students' performance in mathematics and science achievement tests were in the males' favour (Forrest, 1992; Third International Mathematics and Science Study, TIMSS, 1997). But recent evidence from Northern Ireland revealed that boys received lower grades than girls in all science subjects at both the "O" and "A" levels (Millar, 1999). Many local studies' findings on gender differences in students' performance in biology are also inconclusive. For example, while no gender differences in high school students' performance in biology had been documented in some studies (e.g., Greenfield, 1996), Jegede and Okebukola (1991) reported that male Nigerian 10th-graders significantly outperformed their female counterparts in biology. Moreover, whereas Soyibo and Ishola (1986) found no significant gender differences in selected Nigerian 11th-graders' performance in genetics, Woolley (1979) reported that male British "A"-level students performed significantly better in genetics than their female peers.

The positive evaluation that individuals make and maintain about themselves is termed self-esteem, while the evaluated beliefs which individuals have about themselves are referred to as self-concept (Cooper-Smith, 1967). In this study, self-concept and self-esteem are considered as synonyms. The findings of several studies have revealed that students with a high self-esteem performed significantly better in science than their classmates with a low self-esteem (Brookover, LePere, Hamilton & Erickson, 1965; Ugwu & Soyibo, 2004). However, Soyibo and Pinnock (2005) recorded no significant self-esteem differences in Jamaican 11th-graders' performance in respiration.

Whereas many researchers have demonstrated that students' cognitive ability is a most valuable asset in their learning of science and mathematics (Bennet, Seashore & Wesman, 1966; Soyibo & Pinnock, 2005), research findings on the link between students' cognitive ability and performance in genetics are mixed. Lawson and Thompson (1988) contended that students' solutions and interpretations of genetic problems required formal level operations such as combinatorial, proportional and probabilistic reasoning. But, Smith and Sims (1992) asserted that combinatorial, proportional and probabilistic reasoning was not demanded in students' solutions of typical genetic problems.

Whilst some researchers have reported that students in mixed schools significantly outperformed students in boys' and girls' schools in biology (Clayton-Johnson & Soyibo, 2004), several studies have shown that girls' schools performed better in many school subjects including science than boys' and mixed schools (e.g., Forrest, 1992). While some research findings have shown that boys in all-boys' schools statistically significantly outscored students in all-girls' and mixed schools in biology (e.g., Soyibo & Pinnock, 2005), Field (1998) found no significant school-type differences in high school students' biology performance. Nevertheless, Soyibo and Ishola (1986) reported that Nigerian 11th-graders in a mixed high school significantly outperformed their counterparts in all-boys', and all-girls' schools on a genetics test.

Again, the findings of many studies on the relationship between students' SEB and their academic achievement are mixed. Several research findings have demonstrated that students from a high SEB significantly outperformed their peers from a low SEB in science (Field, 1998; Flemming & Malone, 1983; Ugwu & Soyibo, 2004). But, a few studies' findings indicated no significant SEB differences in students' science performance (Blair-Walters & Soyibo, 2004; Houtz, 1995). Whereas, Clayton-Johnson and Soyibo (2004) reported that some Jamaican 11th-graders from a high SEB performed significantly better in biology than their peers from a low SEB, Soyibo and Pinnock (2005) reported the absence of significant SEB differences in the biology performance of some Jamaican 11th-graders.

PURPOSE OF THE STUDY

Based on the foregoing review of cognate literature, this investigation was aimed at finding out if the level of performance of some Jamaican 12th-grade CAPE biology students on a genetics achievement test (GAT) was satisfactory; if there were significant differences in their performance based on their gender, self-esteem, cognitive abilities in biology, school-type, and SEB; and if any significant relationships existed among the five independent variables and the students' performance on the GAT.

METHODOLOGY

Research Design

We used an *ex post facto* research design because the five independent variables (the differences in the students' gender, self-esteem, cognitive abilities in biology, school-type, and SEB) had existed already and the observations were made on their possible relationships with the dependent variable (the students' performance on the GAT) (Weirsma, 1995).

Sample

The sample consisted of 357 12th-grade students (102 males and 255 females) conveniently selected from 2 out of the 3 all-boys' schools (52 students), and 4 out of the 7 all-girls' schools (109 students), and 13 coeducational schools (196 students) offering the CAPE in rural and urban areas of Jamaica in the 2003/2004 academic year. The participants - who were chosen from 14 traditional high schools, 3 nontraditional high schools and 2 community colleges - represented 56% of Jamaican 12th-graders ($N = 641$) enrolled for the CAPE in biology in the 2003/2004 academic year. See Table 3 for the detailed composition of the study's sample.

In this study, the traditional high schools were the long-established, "academic-oriented" high schools, while the nontraditional schools, and (now called 'new secondary schools') were founded in the 1970s as junior secondary schools. The two types of schools had similar curricula but the weaker students were placed in the latter. However, the selected schools in this study had trained biology teachers with a BSc degree in biology. The community colleges were post-secondary institutions that offered pre-university programmes (e.g., CAPE and A-level subjects), and professional certificate and diploma programmes.

Instrumentation

The two instruments we utilised to collect data were: the Cooper-Smith (1967) Self-Esteem Scale (CSSES) – used to measure the students' self-esteem and the Genetics Achievement Test (GAT) – employed to assess the students' knowledge of genetics. In Section A were the students' demographic variables, while the GAT and self-esteem scale were in Sections B and C; and the three sections were combined as one instrument.

The CSSES adopted for this study is a commercially produced self-report inventory with 26 statements that describe how the respondents felt. Students responded to each statement that best described them by inserting a tick under the column "Like me" or "Unlike me." There were 10 positive and 16 negative statements. A score of 5 was given to the respondent who chose each positively-worded item, whereas zero was given for a negative response. For the negatively-worded items, the scoring was reversed. The maximum score on the CSSES was 130. The reported test-retest reliability coefficient of the CSSES ranged from .70 (after 3 years) to .88 (more than 5 weeks) (Rublin, 1978), while Soyibo and Pinnock (2005) recorded a Cronbach alpha coefficient of .81 with Jamaican 11th-graders.

The students' raw scores on the CSSES ranged between 10 and 130; their mean was 97, while their standard deviation was 25. Based on their scores, the students were grouped into three categories: high self-esteem (scores between 122 and 130 - i.e. one standard deviation above the sample mean 97 + 25); average self-esteem (scores between 72 and 121- i.e. one standard deviation below the mean and 121); and low self-esteem (scores between 10 and 71).

The GAT consisted of five structured questions which one of the authors set using the CXC (2003) CAPE unit 1, paper 1 biology examination as a guide. The questions were based on the genetics contents and ten specific objectives prescribed for the CXC (2002) CAPE biology.

Displayed in Table 1 are the major contents that the five questions set on the GAT covered. In preparing the test, a table of specifications was constructed to ensure that each of the main questions contained items that tested the students' knowledge, comprehension and application levels on Bloom's (1956) taxonomy of educational objectives in the cognitive domain. Each question was allotted 10 marks, and the maximum score was 50. Multiple-choice items were not used because the CXC does not offer such items to its CAPE candidates. Two university senior lecturers (a PhD holder in biology, and the other a PhD holder in biology education with expertise in test construction), the 19 biology teachers in the sampled schools (each with a BSc in biology and more than three years of teaching A-level biology), validated the GAT items. There was a 100% agreement among the validators on the four validation criteria given to them. The inter-rater reliability coefficient calculated on the scores that one of the authors and an independent marker gave on ten randomly selected scripts of the students' answers on the GAT was .99. This implies that the two markers were very consistent in their use of the prepared marking scheme in grading the students' answer scripts.

Table 1. Main contents of the items on the genetics achievement test

Question number	Main content tested
1	Mitosis and meiosis
1	Gametogenesis
2	DNA and RNA
3	Chi-square
2 & 4	Gene and chromosome mutations
4 & 5	Genetic variation

Procedures

On request, the principals of the participating schools permitted us to administer the instruments to students in their schools. On the days the instruments were administered, the biology teachers and one of the authors supervised the students for 90 minutes under examination conditions. To group the students into cognitive abilities in biology, we used their final mock biology examination scores obtained from their teachers as follows: high cognitive ability - 70% and above; average cognitive ability - 50% - 69%; and low cognitive ability - below 50%.

RESULTS AND DISCUSSION

The first purpose of this study was to find out if the level of performance of some Jamaican 12th-grade CAPE biology students on the genetics achievement test (GAT) was satisfactory or not. In this study, students who scored 70% and above were considered to have attained a 'satisfactory' or "acceptable standard". The students' mean 22.81 (45.62%) is regarded as "unsatisfactory" because it is far below 60% which the CXC considers as the minimum pass mark in the CAPE in biology; and we regard 70% as the minimum "satisfactory" pass mark.

Table 2. Frequency distribution, mean and standard deviation on the genetics achievement test

Score	Frequency	Percentage	Mean	SD
2	2	0.56	22.81	10.19
3-24	179	50.14		
25-29	72	20.17		
30-35	54	15.13		
36-	48	13.44		
4346	2	0.56		
Total	357	100.00		

n = 357 Maximum score = 50

Table 3. Means and standard deviations on the genetics achievement test based on the five independent variables

Variables	*n*	Mean	SD
Gender			
Male	102	20.18	10.44
Female	255	23.86	9.91
Self-Esteem			
High	31	28.29	9.96
Average	282	22.70	9.99
Low	44	19.64	10.23
Cognitive abilities			
High	23	34.91	5.37
Average	155	27.27	9.11
Low	179	17.39	8.14
School-type			
All-boys	52	14.15	7.45
All-girls	109	21.89	11.31
Coeducational	196	25.61	8.70
Socioeconomic background			
High	227	22.02	10.01
Low	130	24.18	10.38

Evident from Table 2 is that (a) 102 (29%) of the students scored 60% and above, while only 50 (14%) of them scored 70% and above. The students' poor performance (a) is consistent with CXC's (1999-2003) CAPE biology examiners' reports which showed that since 1999 many candidates did not perform well on the questions set on genetics; and (b) receives an indirect support from some previous researchers (Walker, Mertens & Hendrix, 1979; Woolley, 1979) who reported that many post-secondary school students performed poorly on genetics tests because they perceived genetics to be a difficult concept to understand.

The second purpose of the study was to find out if there were significant differences in the students' performance based on their gender, self-esteem, cognitive abilities in biology, school-type, and SEB. Exhibited in Table 3 are the means and standard deviations of the students based on the five variables.

Table 3 shows that (a) the mean of the females is slightly higher than that of the males; (b) the mean of students with a high self-esteem is appreciably higher than that of their counterparts with an average and a low self-esteem; (c) the mean of students with a high cognitive ability in biology is much higher than that of their peers with average and low cognitive abilities; (d) the mean of students in the coeducational schools is higher than the means of students in the all-girls' and all-boys' schools; and (e) the mean of students from a high SEB is slightly lower than that of students from a low SEB. The standard deviations are fairly high in all cases implying that there were relatively wide variations in the GAT scores of the high and low scorers based on the variables.

To determine if there were statistically significant differences in the students' GAT means, linked to the five independent variables, a five-way factorial analysis of variance (ANOVA) was computed.

Implicit in Table 4 are that there are statistically significant differences in the students' performance on the GAT associated with their self-esteem, cognitive abilities in biology and school-type, whereas there are no significant gender and SEB differences in the their performance. The data in Table 3 suggest that the differences are in favour of students (a) with a high self-esteem, (b) with high cognitive abilities in biology, and (c) students in the coeducational schools. Hence, the numerical differences in the students' means in Table 3 based on gender and SEB were likely to have occurred by chance. The Scheffe *post-hoc* tests on the main effects of self-esteem, cognitive abilities in biology and school-type were applied. The Scheffe tests confirmed that the conceptual knowledge of genetics of students (a) with a high self-esteem was significantly better than that of students with an average and a low self-esteem respectively: [F (2) = 6.859, p < .001]; (b) with a high cognitive ability in biology was significantly better than that of students with average and low cognitive abilities respectively: [F (2) = 82.296, p = .001]; (c) in the coeducational schools was statistically significantly better than that of students in the all-girls', and all-boys' schools respectively: [F (2), 31.157, p < .001].

We anticipated the first finding that students who exhibited a high self-esteem would statistically significantly outperform those with average and low self-esteem on the GAT. This was because, as stated earlier, whereas it had been shown in several studies that students with a high self-esteem performed significantly better in science than their classmates with a low self-esteem (Brookover *et al*., 1965; Ugwu & Soyibo, 2004), Soyibo and Pinnock (2005) reported no significant self-esteem differences in high school students' performance in biology. But, we could not find any studies in which the association between students' self-esteem and their performance in genetics had been investigated.

Table 4 results - showing that there are significant cognitive abilities' differences in the students' performance on GAT - are not surprising. This was because, Walker, Mertens and Hendrix (1979) reported a positive correlation between students' reasoning ability and problem-solving ability in genetics. In addition, Esiobu and Soyibo (1995), showed that Nigerian10th-graders with high cognitive ability in biology significantly outperformed their peers with average and low abilities in ecology and genetics tests.

The finding that students in the coeducational schools performed significantly better than those in the all-girls' and all-boys' schools was expected (Soyibo & Ishola, 1986 in respect of Nigerian 11th-graders' performance in genetics). However, this study's finding conflicts with several previous studies' findings indicating that girls' schools performed better in many school subjects including science than boys' and mixed schools (Forrest, 1992; Blair-Walters & Soyibo, 2004), and few research findings that boys in all-boys' schools significantly outscored students in all-girls' and mixed schools in biology (e.g., Soyibo & Pinnock, 2005).

We did not expect the absence of statistically significant gender differences in the students' performance on the GAT recorded in this study. This was because Woolley (1979) reported significant gender differences in British "A"-level students' performance on the genetics component of his study in favour of the males. Nonetheless, this study's finding receives some indirect support from Soyibo and Ishola's (1986) and Esiobu and Soyibo's (1995) findings that there were no significant gender differences in selected Nigerian 11th and 10th-graders' performance in genetics respectively.

We anticipated the data in Table 4 showing that there is no significant SEB difference in the students' performance on the GAT. This was because, whereas Clayton-Johnson and Soyibo (2004) reported the existence of statistically significant SEB differences in the biology performance of selected Jamaican 11th-graders in favour of students from a high SEB, Soyibo and Pinnock (2005) reported the absence of significant SEB differences in the biology performance of some Jamaican 11th-graders.

The third purpose of this study was to find out if any significant relationships existed among the five independent variables and the students' performance on the GAT.

Table 4. Five-way factorial analysis of variance in the genetics achievement test scores of students

Source of variation	SS	df	MS	*F*
Gender	16.495	1	16.495	.263
Self-esteem	1222.330	2	611.165	9.744*
Cognitive abilities	7729.688	2	3864.844	61.619*
School-type	1833.486	2	916.743	14.616*
Socioeconomic background	182.676	1	182.676	2.912
Model	15102.578	8	1887.822	30.098
Residual	21837.086	348	62.722	
Total	36929.664	356	103.735	

* p < .001

Table 5. Point-biserial correlation coefficients linking students' genetics achievement test scores to five variables

	Gender	Self-esteem	Abilities	School-type	SEB
GAT scores	.16**	.22***	.56***	.20***	.10*

* p < .05 **p < .01 ***p < .001

Point-biserial correlation test was used because the five independent variables are nominal or categorical variables and two of them (gender and SEB) show genuine dichotomies, while the remaining three had three categories (Guilford & Fruchter, 1978, p. 308). In Table 5 are the results.

Table 5 indicates that there is a positive, statistically significant but weak relationship between the students' (a) gender, (b) self-esteem, (c) school-type, and (d) SEB and their performance on the GAT, whilst the relationship between their cognitive abilities in biology and their performance on the GAT is considered as "substantial reliability" (Miller, 1991). The findings regarding self-esteem, cognitive abilities and school-type confirm the data in Table 4, while the findings in respect of gender and SEB are inconsistent with the results in Table 4. Moreover, the weak relationships and the "substantial reliability" suggest that there were other factors apart from the students' self-esteem, cognitive abilities and school-type which could have accounted for the significant variations in the students' performance on the GAT that were not explored in this study.

CONCLUSIONS AND IMPLICATIONS

We considered the overall performance of the students (mean = 22.81 or 45.62%) as unsatisfactory because it is much less than the official 60% pass mark of the CXC in the CAPE in biology. Implicit in this study's finding is that the majority of the students lacked a sound conceptual knowledge of genetics and that their performance and that of their counterparts on genetics questions in internal and external examinations is likely to be poor.

Students with a high self-esteem and a high cognitive ability in biology performed significantly better than their counterparts with (a) an average self-esteem, and (b) a low self-esteem, and (c) an average cognitive ability, and (d) a low cognitive ability respectively. But a close look at Table 2 indicates that the mean (28.29 or 56.58%) of students with a high self-esteem (n = 31 or 8%) and the mean (34.91 or 69.82%) of students with a high cognitive ability (n = 23 or 6%) are less than the 70% which we consider as the minimum "satisfactory" grade in this study. Hence, Jamaican 12th-grade CAPE teachers need to (a) improve their students' basic mathematical knowledge that they need in the solutions of genetics numerical problems; and (b) use a variety of activity-oriented instructional strategies to improve their students' knowledge of and performance in genetics, regardless of the differences in their self-esteem and cognitive abilities in biology. This is because, based on our teaching experience, many A-level biology teachers tend to use the lecture method to teach the subconcepts of genetics and many of the teachers and their students have a poor knowledge of mathematics.

We did not obtain any empirical data to explain why the students in the coeducational schools significantly outperformed their counterparts in the all-girls' and all-boys' schools. To assist Jamaican male and female 12th-graders in single-sex schools to perform as well as their peers in mixed schools, their biology teachers need to motivate them to learn the subject meaningfully by varying their instructional strategies. Other variables that could have contributed to the significant differences in the students' GAT performance - which should be identified and investigated in future studies on the topic - include: the differences in the students' learning styles and cognitive abilities in mathematics, subject preference, their teachers' teaching experience, mathematical background and teaching styles.

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A Conversation with Sandra Abell: Science Teacher Learning

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The conversation between Sandra Abell and Patricia Friedrichsen took place at the University of Missouri, U.S., on December 19, 2007. The purpose of this dialogue was to reflect on Dr. Abell's career in science education and her research on science teacher learning. During the conversation, Sandra Abell discussed changes in research in this field, the usefulness of the pedagogical content knowledge construct, as well as directions for future research. The text includes a brief summary of Sandra Abell's career achievements, a list of our conversation topics, the transcript of the audio-taped conversation, as well as a list of Dr. Abell's selected publications.

Keywords: Science Teaching Learning, Pedagogical Content Knowledge

FOREWORD

Sandra K. Abell is the Director of the Science Education Center at the University of Missouri, U.S. Dr. Abell is a Curators' Professor of Science Education and is jointly appointed in the Department of Teaching, Learning & Curriculum and the Division of Biological Sciences. Dr. Abell received her Ph.D. in Science Education from the University of Iowa (1988); a M.A. in Talented and Gifted Education from the University of Northern Colorado-Greeley (1981); and a B.A. in Elementary Education from the University of Iowa (1977).

Dr. Abell began her career as an elementary teacher, teaching in Iowa and New Mexico (U.S.), and Iceland. Dr. Abell's elementary teaching career focused on both science teaching and multicultural, gifted and talented education. Dr. Abell's first appointment in higher education was at Purdue University, where she moved through the ranks of assistant to associate to full professor of science education (1988-2000). Dr. Abell has taught a variety of university courses, including science teaching methods courses for pre-service elementary teachers, secondary teachers, and university science teachers, as well as graduate research courses in science education. Dr. Abell has received numerous teaching awards throughout her career, including the Association for the Education of Science Teachers' (AETS, now ASTE) Award for Outstanding Science Teacher Educator (1996), the AETS Award for Innovation in Teaching Science Teachers (1997), and the AETS Outstanding Mentor Award (2005).

Figure 1. Professor Sandra K. Abell

Dr. Abell is internationally known for her research on science teacher learning. She has presented 117 papers at international and national conferences, and published 58 refereed journal articles. Dr. Abell has authored 14 book chapters and edited 3 books, including the *Handbook of Research on Science Education* (2007), which she co-edited with Norman Lederman. In recognition of her efforts to advance science education, Dr. Abell was elected as a Fellow in the American Association for the Advancement of Science (AAAS) in 2004.

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Throughout her career, Dr. Abell has been active in professional organizations, including ASTE, the National Association for Research in Science Teaching (NARST) and the National Science Teacher Association (NSTA). She has served on a variety of committees within these organizations, as well as serving on the NARST Executive Board (1995-1998) and the AETS Executive Board (1997-2000). From 1993 to1998, she served as the Associate Editor for the *Journal of Research in Science Teaching*. Most notably, Dr. Abell served as NARST President in 2000-2001.

Introduction

Sandra Abell and I attended the 2007 European Science Education Research Association Conference (ESERA) in Malmö, Sweden. The ESERA presentations were thought-provoking, helping me generate new research connections and ideas. More important to me, though, were the informal conversations that took place in the conference hallways, hotel lobbies and while enjoying smorgasbords in charming Swedish restaurants. During the conference, Fatih Taşar, the associate editor of the *Eurasian Journal of Mathematics, Science and Technology Education*, asked me to interview Sandra Abell for a new series in the journal. I was intrigued with Fatih's proposal and agreed to conduct the interview. I view this new interview series as a way to provide graduate students and novice researchers access to the types of beneficial, informal conversations that took place at ESERA. As a faculty member of the MU Science Education Center, I have worked closely with Sandra for the past five years. During this time, my conversations with Sandra have helped shape my research. Surprisingly, though, I learned some new things about my colleague during this interview, as I hope you will, too.

Conversation Topics

To guide the listener/reader in this conversation with Sandra Abell, I have provided a list of our general conversation topics:

• Sandra Abell's career pathway that led to researching science teacher learning;

• Changes in research perspectives on teacher learning, including the current U.S. policy favoring "scientifically-based" research;

• Research informing the design of science teaching methods courses, including courses for pre-service elementary teachers, secondary teachers, and university-level science teachers;

• The usefulness of the construct of pedagogical content knowledge (PCK), including advice for novice PCK researchers;

• Achieving balance between research and teaching in one's academic career, including writing tips.

In this section, I provide a verbatim transcript of the audio-taped conversation which is available on the journal's webpage.

PF: I am Pat Friedichsen at the University of Missouri-Columbia and today I am having a conversation with Sandra Abell, my colleague, about science teacher learning research. So, Sandi, tell me what experiences led you to do research in science teacher learning?

SA: Well, I started my career as an elementary school teacher and I think I received really good preparation to be an elementary school teacher at the University of Iowa. While I was an elementary school teacher I started to do professional development for other teachers and got very interested in how I could have an effect beyond my classroom. That's when I went back to school, went back to the University of Iowa for a Ph.D. I think it was just a natural for me to fall into research about science teacher learning because I had always been a teacher, always wanted to be a teacher or was a teacher, and I was very interested in what made some teachers excellent, what helped teachers become better teachers, those kinds of questions. So I think it was just a natural fit between my interest in being a teacher and my own professional development, and then wanting to study that with other teachers.

PF: I think it was a very similar reason for me as well, how I went down that path. Tell us more about your research career. Did you start out focusing on elementary science teacher learning? Kind of talk us through the path that you took.

SA: I was certainly very interested in elementary teacher learning and elementary teacher education for a big part of my career. I felt like that was where I could make sense of the world, of elementary schools and that is what I really cared about, what was going on in elementary schools. I was engaged in teaching methods courses for elementary teachers. So it seemed sort of a natural connection to have my job as a science teacher educator overlap with my interest in doing research on teacher learning. My dissertation was focused on professional development of middle school teachers. Pretty much for the first ten, twelve years of my career I focused on looking at pre-service elementary teachers and their experiences learning in methods courses and beyond method courses, their experiences learning in student teaching, and then how they developed as teachers beyond the pre-service program. Professional development types of things.

PF: Since I have known you here at the University of Missouri your research interest has been broader than that. So what caused that broadening of interest?

SA: I think the shift occurred when I moved to Missouri because my position here was different. Instead of coming here to teach elementary methods I came here to run the Science Education Center. As we looked around to see what were the biggest problems that needed our attention at that time, the shortage of qualified science teachers became a really driving force. We ended up, we being a team of people at Missouri, ended up developing some new programs for recruiting and preparing middle and secondary teachers in a kind of alternative certification setting. Then it made sense to start studying how those people learn. The other new thing that happened at that time was that I was jointly appointed in the Biology Department and the goal of the folks who hired me to do this joint appointment was that I would think about preparing graduate students in the sciences and faculty members in the sciences for being teachers. We developed new courses and we started to study teacher learning at the college level. So, I would say, yes, my research interests have broadened in terms of the scope of teacher learning and that really I am interested in science teacher learning elementary through college. But, the focus is still how people figure this really complicated thing out, the complicated thing being science teaching. How do people come to do a better job at science teaching? I think that has been the driving force for me all along.

PF: Let's take that last question and think about that from a researcher's perspective. How have perspectives changed in the field on researching teacher learning over the years? From when you started researching to today? Was your dissertation similar to the work you do now?

SA: Oh, absolutely not. Now you are making me feel old. Way back then, in the 80s when I was a student at the University of Iowa, there was still quite a bit of process-product research being done looking at teacher effectiveness in terms of teacher as a technician. If we ask teachers to do a particular strategy, will they be able to do that strategy or not? We were sort of at the end of that era, at the same time we were beginning a new era which was looking at teachers as not just the subjects of our studies, but teachers as experts. Teachers as, what Gary Fenstermacher calls the "known versus the knower"(Fenstermacher, 1994). So we used to look at teachers as something to know and we started looking at teachers as knowers. People who had something to offer to our research and that started to change the way we went about doing research from doing research on teachers to doing research with teachers. So back to my dissertation, it was a very much process-product dissertation where we had done professional development with a group of teachers and we went out to study the effect of the professional development on their teaching behaviors. We looked at: Did teachers ask more open-ended questions? Did teachers use particular kinds of assessments? It was very much we had given them this knowledge, now were they using it?

PF: Did you interview them at all or did you only observe? Was it your perspective?

SA: It was observation only. We took videotapes of them; we coded videotapes for teacher behaviors. It was very reductionist and very much "the teacher is the subject of the study." I published my dissertation, but, curious enough, I never got my dissertation bound, because somehow I knew that that was not the kind of research I wanted to do.

PF: Interesting.

SA: There was nobody at that point of time on my committee who was looking at the kind of new wave of educational research which was going on at the time – which was the whole move toward qualitative research. So I sort of had to learn some things on my own about that. When I went to Purdue where I had my first job as a professor, I started attending classes on qualitative research, both in the College of Education and in the Anthropology Department, so that I could learn more about these methods that I thought would be a better fit for the kinds of studies that I wanted to do. I wanted to look at teacher learning in some other way that was not this reductionist way.

PF: So let me ask you to reflect on the role you think you have played in science education in shifting that focus to qualitative research.

SA: I can tell you that I was on the Editorial Board of *The Journal of Research in Science Teaching* in the late 80s and early 90s. The movement toward qualitative research had sort of happened in other fields, English education for example. It was a little slower in science education and I think one of the reasons is because we were holding more to that "Scientific Ideal" (that would be a little different discussion about what is the nature of science). I think it was harder for science educators to move toward the qualitative perspective. I do remember being on the Editorial Board of JRST with Nancy Brickhouse, and Ron Good was the editor. At one point we were having a discussion about the criteria that we were using to review manuscripts. Nancy and I were basically making the argument that the review criteria were biased and not inclusive of new methodologies that were becoming available. So, Ron invited us to redo the criteria for review of those manuscripts, which Nancy and I did, and that led to a publication (does not have our names on it), but it was a publication in the journal about how the reviews would be done in the future (Good, 1993). I think it was a very important piece of work because we were influencing the way that manuscripts would be reviewed and be accepted or not accepted into the journal. I feel very proud of that work that Nancy and I did.

PF: I think that is work that younger researchers had no idea of the "behind the scene" piece that occurred.

SA: At the same time it was interesting at NARST [the National Association for Research in Science Teaching], there were groups popping up that were debating the pros and cons of this new methodology, and also groups that were trying to defend qualitative research. Certainly Ken Tobin was a leader in some of those discussions. I remember faithfully going to those discussions and trying to move the agenda forward and then I had the opportunity to become the Associate Editor of the *Journal of Research in Science Teaching* while I was at Purdue. We talked a lot about the kinds of methodologies that we would like to promote as editors and I think we even put together an editorial that talked about moving toward a mature discipline of science education research that could help young researchers feel like they did have a place in the science education community with the kinds of research that they were doing.

PF: So Sandi, now I want to ask you about this relatively new shift in policy in the United States as a call back to quantitative research as being more scientifically-based(e.g., Shavelson & Towne, 2002). What is your reaction to the current U.S. policy?

SA: A couple of years ago we put together a special session at NARST about that topic. I think that the bottom line was that that was a very limited view of educational research. I would say I am not anti-quantitative. I think that those wars are long gone. What we should be thinking about are what are the important questions that need to be asked and what are the best ways to go about answering those questions, be they qualitative, quantitative, mixed methods, what have you. I think that this view of "scientifically-based literature" is flawed on many levels. I think that it is interesting that we hold up scientific research and some time we include medical research in that, as sort of the model for our work. Yet medical research has been held up as really not having made much progress since the days of putting leeches on people's backs to solve the problem, whatever problem of the day was. So I think that we need to have a more broad view of how we can go about answering questions, in ways that will move our agendas forward-whether they are medical agendas, scientific agendas or science education agendas. It is just the problems are too big to be solved by any one methodology.

PF: I completely agree with you. We have been talking about shifts in methodologies and changes. I want to go back to science teacher learning as a construct. So, what have we learned about how teachers learn? What progress have we made in this field about what we know–how to support teacher learning?

SA: I think it is a great question and we could probably write a book about that. I think we do know quite a bit. We know a lot about, for example, science teacher subject matter knowledge. But rather than, I guess I want to evade your question for just a minute, and think instead about how our views of teacher learning have shifted to help us think about different questions to ask and the answers to those questions are moving us forward in science teacher education practice. Maybe that is the most important thing. Science teacher education research is very practical. It is not basic research; it is research that needs to be done if we are going to improve how we prepare teachers. So, I think the biggest shift in thinking from this thing I was talking about, teacher as technician, teaching people a set of skills or strategies, to thinking about teachers as knowing individuals and thinking about how, say a conceptual change approach could really affect the way we look at our research. So what happened in the 90s, is that a lot of people started to think about teacher learning in science from this conceptual change approach. We started to study what do students know when they come into programs. So instead of thinking of people as blank slates that we needed to teach particular strategies to, we started to say we know that they have been in the apprenticeship of observation of science teaching for 18-20 years, probably 15 years (Lortie, 1975). We know they have views coming in about what science teaching and learning ought to be. Now we actually have some research, some empirical data, that tell us, yes they do have these views, these pre-service teachers have these views about science teaching and learning when they come into teacher preparation programs. More importantly, those views do not match the views that are being promoted by the science teacher educators in the teacher education programs. So we have a mismatch between what we are trying to accomplish in teaching teachers and what they come to us already knowing and believing. That finding is critical for thinking about how to do teacher education. If we know they have these views, then it is going to be our job, as teacher educators, to bring those views to light, to challenge those views and then to help them to see intelligible, plausible, alternative views of science teaching and learning. I think that has led to, for example, greater use of case-based instruction in teacher education. So that students can actually see video examples or read text examples of science teachers in action, and see how those views might differ from the views they have always seen of "teachers as tellers" and "learners as listeners."

PF: I very much had this "ah ha" moment a few years ago when I went out and watched my student teachers teach a 5E [lesson] and they thought they were doing what I, we thought we were talking about the same thing (Bybee, 2002). I saw very clearly that we were not talking about the same thing.

I wanted to ask you about, you teach a rather unique course, a methods course, but, it is a college science teaching course. Now these are Ph.D. students in sciences who are interested in teaching. So their apprenticeship of observing science teachers is even longer. How has your research in science teacher learning influenced what you do in that one semester course that you have with these people, who will probably never take another methods course or another education course?

SA: I think that is an interesting question. Now I have taught methods courses for elementary, future elementary teachers, future secondary, middle and secondary teachers and these future college science teachers. I have to say that overall the same research findings are helpful in thinking about structuring those courses. In every case, we know that these people have a very limited view of what science teaching could look like and need to have some new views, some new pictures of science teaching. In the college science teaching course, we try to show them the best scientists who teach undergraduate courses on campus. We try to show them examples of folks on campus who are doing different kinds of things in order to let them see the alternative views. I would have to say, though, I think the biggest difference in teaching college science teaching folks is that we have to be aware of the constraints that they are going to face. Those constraints that they are going to face, as teachers, are very different from what a future elementary school teacher might face. They may have 300 people in a large lecture class so we have to think about what does best practice looks like in a lecture setting. We have to be realistic of what we expect these people to be able to do. For example, I think in the past science educators may have gotten a bad name for saying lecture is bad, but not giving any alternatives. The fact of the matter is that lectures could be good. So one of the things we do in the course is we try to think about what makes a good lecture. How does all of that come back to research? Since I have been here at Missouri we have been working with some college science faculty, watching them teach and watching them think about their teaching, and trying to figure out where these points of constraint are and where we can make progress. A recent study we looked at, what do college teachers think about inquiry? I think one of the findings was really very important. They have this view of inquiry like many people in science education I would say, that says what the best instruction is, is open and full inquiry where students come up with research questions and follow through on investigations. That is their view of what they should be doing.

PF: But, it is unobtainable.

SA: It is unobtainable. It is absolutely unobtainable and they have no alternative views. That finding has helped us think about what do we need to do to help these folks move toward inquiry in what we are calling achievable inquiry, in ways that work for the constraints that they face in their classroom teaching.

PF: This led to a current professional development workshop that you are doing with college faculty and we have a joint doctoral student who is studying this.

SA: That is right.

PF: Do you want to talk briefly about how that led to the next stage?

SA: I worked with several science faculty on campus who has been doing very innovative things in their instruction. One of the things they have been doing is thinking about laboratory instruction differently and trying to move away from cookbook laboratories into laboratories that emulate the work of scientists in very structured ways, not in this full and open inquiry way. My colleagues in the sciences have gotten grant funding from our National Science Foundation to take their ideas and to do professional development with other college science faculty to help them think about how they can restructure their laboratory instruction. One of the things, last year we had a summer institute for these college science faculty, as well as their graduate students. One of the ideas we introduced was the finding from our study about college science teachers' views of inquiry. We showed them the common view and we showed them our view and we called it achievable inquiry. And there was a sigh of relief through the whole audience when we talked about that idea. They realized that they, too held that unobtainable view, but the folks that were facilitating the workshop did not. Then they started to say, maybe I can change things in my instruction that will help students take more responsibility for their learning. Get them more engaged with thinking about science, but, not to the extent that it will totally disrupt the structure of the laboratory and what I am capable of doing.

PF: I think you have given some really nice examples of how research and teaching are just two sides of the same coin. I think we both feel this way of how our research informs what we do in our teaching and that they are not separate ventures that we are engaged in and that it is a package for us.

SA: I think maybe we are lucky as science teacher education researchers, because we have figured out a way to get more mileage out of the work we do. We are not always sure of when we are teaching and when we are researching, because they are happening simultaneously. Then our research is fitting back into our practice quite naturally. I think we are the lucky ones.

PF: I agree. I think it just makes a more coherent whole for me when that does work.

SA: Yes

PF: Recently you completed a major project with Norm Lederman as the co-editors of the new handbook. You authored one of the chapters in the handbook on science teacher learning and you choose to organize your chapter around the construct of pedagogical content knowledge (PCK). You spent quite a bit of time on this project so I want you to talk about PCK. So PCK is a very attractive construct to me, I will be real honest about that. So we have seen lots of people play with it and we have seen people pull away from it and now, it is coming back into popularity. From your work on that chapter, I would like you to talk to me about the advantages and the limitations of this construct. What does this construct buy us? What do we gain from this? Are there limitations with this construct?

SA: These questions are near and dear to my heart, because I just finished writing a closing piece for a special issue of the *International Journal of Science Education* that is just about PCK. I asked myself those kinds of questions. I have to admit that PCK is very attractive concept for me and it has been since I first learned about it. It helps me think about this work that I do with teacher learning and teacher education. It gives me an organizer for thinking about the goals I have for science teachers. What do I need to know about them as science teachers? How I can help them progress as science teachers? The idea that Shulman (1986) talked about, that there is special knowledge for teaching–PCK–that only teachers have. Then Magnusson and some other folks (1999) in science education took that to the next step and helped us think about what are the components of PCK? It is those components, I think, that really help us think about teaching practice and help us think about doing research. It also helped me organize that chapter in the handbook.

PF: Huge chapter.

SA: I used those components to look at the various threads of research. I think the problem with the construct right now is not the construct itself, but how it has been used or misused or only partly used in the research. I tried to talk about that in the handbook chapter, that it seems to me often in science education research, we like to invent new constructs rather than using the good constructs that we already have.

PF: Or new terms for well established terms.

SA: That is right. I think that we have not gotten to use the PCK construct to its fullest extent. I think there is a lot that we do not know about science teacher knowledge and the development of that knowledge that the PCK construct could help us with. If we are more interested in developing new terms, (you can look at the chapter to see what some of the terms might be), then we are not really making good use of the construct, the PCK construct, that exists. I think that there are some challenges in that, but, mostly, I think there are opportunities. There is lots of research that needs to be done about what science teachers or future science teachers know about learners, about curriculum, about instruction, and about assessment. When do they know those things? Is there a developmental trajectory for those kinds of knowledge? How do we, as science teacher educators, help them build those kinds of knowledge? I think the construct is very useful, but there is a lot of work that still needs to be done. Besides developing some models of teacher knowledge and teacher development of knowledge, I think we have to move beyond some of the descriptive research that we are doing. Descriptive research is really good, it is really important and I have done quite a bit of it. We do need good cases that show us examples of teacher learning. We need to move beyond, to think also about the why question. How do we explain teacher learning and how do those explanations then help us build these models for teacher learning? I think that is going to be the harder thing to get at. That is because every researcher's life is short and because, often times, we have a desire to produce studies that could lead to more quick results and some of these questions are questions that really take a long time to investigate.

PF: I agree. For me our questions need to be focused on the longitudinal. Our system in the United States of promotion and tenure does not support these long-term studies that are really going to help us answer what, I think, our questions are at this point.

SA: I think that is true. I think that is true in the United States of our doctoral programs.

PF: Yes.

SA: I have seen some European models that I think are much better models of getting doctoral students engaged in research early on, that's going to be a research program for them over five years in their doctoral programs. I think at Missouri we engage students in a lot of research early on, but, we do not necessarily help them construct a thread of research throughout their programs.

PF: I think that is partially the way we are set up for intensive course work early in the program, that there is not time.

SA: Yes, I think so.

PF: I am going to ask you about advice on two different levels. The first one is, if someone came to you and wanted to get involved and focus on PCK research, I know you give some advice in the chapter, would you like to repeat some of that? So people who are new to the field and would like to get involved in it. What are some cautions or recommendations that you would make? You talked about building on what we already know.

SA: I think that is really critical. I have been in too many presentations at too many conferences where people have not done their homework. Going back into the literature to look at the history of the ideas and how they have developed. I think in the PCK literature and science education, we have a strong foundation and we should build on that. I think I would advise a new researcher to think about moving from quantifying PCK (I do not mean that in terms of quantitative or qualitative research, but in terms of defining what PCK people have) to also thinking about the quality issue. What is the quality of teacher knowledge that people have and how do they, not only possess this knowledge, but use it to solve classroom problems? I think teacher knowledge is a very active kind of thing. We cannot look at it as a static, kind of write down what knowledge do you have at this point and time. We have to look at it in terms of how you are using that knowledge to solve practical problems of teaching and learning. I think that advice would be really important. Build on the past; make sure you understand the nature of the construct, and some of the controversies. There are some different camps if you will, about what PCK is and is not. It is probably helpful to understand those camps and then align yourself with one of those or more than one of those. Then to get beyond what we already know. Do not do yet one more study of teacher beliefs coming into a program.

PF: We know a lot about that.

SA: We know a lot about that. Now we need to move on and think about these kind of knowledge in use questions and quality questions. Eventually we need to answer the most important question of all. Does teacher knowledge making any difference in their practice and does that make it any difference in student learning? We have these hypothesized connections on those three pieces, but, we do not have a lot of empirical evidence about those connections. So I would also encourage young researchers, but, also practicing, veteran researchers, to think about moving us forward to make those links, help us know more about those links.

PF: On a practical level there are all sorts of issues and harder to get at. I think that link is critical because we are making assumptions there about the connection to student learning.

SA: To be fair to those people who are scientifically-based research policy makers, I think in the end their heart is in the right place because they are interested in having research findings that tell us something about the connection between teacher learning and student learning. I think that part of the policy is right-minded. I just do not think that the conclusion–therefore, we need more experimental studies–is necessarily correct.

PF: Now I am going to ask you to give a broader recommendation. You have been a very successful researcher and teacher. You have balanced the different components that are required of people in higher education. So what recommendations would you give for new faculty just starting out in academic positions on balancing teaching and research and some tips for research in general, beyond PCK?

SA: The balance question is interesting. I think I kind of answered it earlier when we were talking about how lucky we are to be teacher education researchers. One of the ways I have achieved balance is to make sure my research plays into my teaching and back and forth so that I am not doing two totally unrelated activities. On the other hand (probably I do not know how many people I have advised on this very basic part of balance) you have to put it into your schedule if you are going to do it. I schedule writing time; I schedule preparation time for preparing for class. I schedule exercise time. And if it gets on my schedule it will get done. If it is not on my schedule, it will not get done. I think it is very important because the teaching can be overwhelming. We could all spend our entire career improving our teaching. Yet we know we have these other parts of what it means to be a science educator, that we need to take care of, and what it means to be a person, a parent, a friend, a child, whatever it might be. We have to make sure we are addressing those things and that is only going to happen, I think it is only going to happen, if we put it into our schedules and make sure it happens.

PF: You recently talked about a writer's block that occurred in writing a chapter. This is a conversation that we had awhile back. I remember some things that you said about what you discovered helped you get through that. It was advice that I sort of held on to.

SA: I think I have given this advice to other people and maybe had not taken it myself. So it was good for me to take it myself. When students come to me and say I am in this analysis quandary and I do not know what to do next, I often send them back to the library to do more reading. I think when I got that writer's block I went back and re-read some things I thought I was pretty familiar with, as well as read some new things. I think that reading is absolutely critical. We have to always be playing our ideas off of what is out there in the literature. My reading pile is pretty big, but that is important. I think the other thing that is really critical and writing teachers will tell you this for sure. If you have a writer's block, you have to write. Even if all of you write is "I am having writer's block." When I was having that writer's block, the worst thing that I think I could have done was to stop writing and to put the writing off. Instead, I just kept going back to the piece. Even if I wrote a paragraph in the morning I was still writing. So to me reading, writing and the third piece that is absolutely critical is talking to other people. If we really do believe all of that stuff about social learning, then we have to apply it to ourselves and think about, if I go out to lunch with you, Pat, and start talking about this it is going to help me think through some of the issues I am having. I might start constructing new knowledge by talking through it. I think that collaborating with others is absolutely a critical part of my career. It is the most fun part of my career and it is the most rewarding part of my career. You learn so much by working with other people and I would not be here today having this conversation, if it had not been for the classroom teachers I have collaborated with, the other scientific education researchers I have collaborated with, the doctoral students I have collaborated with. All of those people have enriched my thinking tremendously.

PF: Sandi, I appreciate your honesty in sharing that. I would say you are a prolific writer, you have published quite a bit and then I think people think, "this is a struggle that only I am having." Then to hear someone else talk about that and then say "this is how I worked through it, this is how I was able to produce what it was I needed to write." I think that is helpful to other people to hear that and we tend to only be known by our published work, the final product, and not know so much about the process that occurred.

I would like to thank you for sitting down on a snowy December afternoon with me, and having this conversation about research and science teacher education. Again, I would like to thank you for your time.

SA: You are very welcome, it was my pleasure.

I want to thank Fatih Tasar for initiating this interview series and Sandra Abell for agreeing to participate. It is my hope that our conversation provides insights into science teacher learning research and sparks new ideas in your own research.

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Appendix: Selected Publications, Sandra K. Abell, 1992-2008

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Book Reviews

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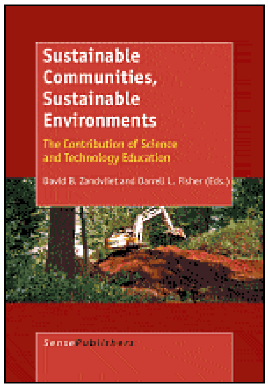
SUSTAINABLE COMMUNITIES, SUSTAINABLE ENVIRONMENTS: THE CONTRIBUTION OF SCIENCE AND TECHNOLOGY EDUCATION



By David B. Zandvlet and Darrell L. Fisher (Eds.)
2007
Sense Publisher, Rotterdam / Taipei
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The concept of the sustainability was increasingly used and evolved in past two decades, and the increasing importance has been given to this concept. However, there is still a lingering discussion about whether this concept is dealt with sufficiently or not. A good answer to this question might be the action taken by United Nations (UN). For the sake of ensuring the sustainability for now and the future, UN declared Decade of Education for Sustainable Development (UNDESD) covering the years 2005-2014 (Sato, 2006). Deriving from this importance, sustainability is now an evolving concept used for describing the broader purpose and goal for education.

The book *"Sustainable Communities, Sustainable Environments"* was basically designed for providing international perspectives by considering the fields of science and technology to teachers in different levels (primary to tertiary), teacher educators and academic researchers who are dealing with education for sustainability (EfS) and education for sustainable development (ESD).

This edited book consists of twelve chapters, each of which provides an understanding and insight into a particular view(s), practice of sustainability and research findings. As it is observed in the chapters, some of the ideas seem to be overlapping whereas the others are in opposition to other views.

Chapter I
Sustainability: An Open Question
by Siobhan Ashe, Michael Caulkins, Gillian Judson, Quirien Mulder ten Kate and David ZAndvliet

Framed ESD as an open question, this chapter is dedicated to definitional problems of sustainability and ESD. It is discussed in the chapter that even though too much definitions have been done for these concepts, there is still diversity, vagueness and unclearness showing no agreement on those definitions. Starting in 1987, endorsement efforts on sustainable development by UN General Assembly resulted in Agenda 21, Chapter 36 of which is dedicated to education for sustainable development (ESD). Continuous discussions and reform attempts by international political and economic forums point out that education would eventually be key element / cornerstone for sustainability. Despite this importance, sufficient developments pertaining to ESD were not realized. Finally, this importance was confirmed and UN dedicated 2005-2014 to Education for sustainable development. However, ESD still seems to be as a lingering discussion. In the chapter, this discussion is elaborated with the four essays written by the ones who are struggling with finding answers to "*What does ESD really mean?*"

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Chapter II

"Tweaking" Conventional Science Curriculum: Addressing Synergies between Environmental Science and a Model for Teaching Critical Thinking

by Philip L. Balcaen

In this chapter of the book, Philip L. Balcaen argues the idea of environmental issues providing a rich curricular focus of critical thinking in the sciences. He believes that a little attention has been paid for the ways of accomplishing the critical thinking that is identified as a desired outcome of the science education by most of the educators. He offers and then elaborates a model [symbolized as *(CT)²*] that provides a coherent approach to help the teachers teach critical thinking effectively within the environmental sciences instructions. In his model, he reflected his works with the science educators from several countries.

He believes the necessity of linking environmental science programs and the approach for teaching critical thinking. He summarizes three nature of environmental sciences curriculum as reasons behind this necessity, (1) kinds of complex problems, (2) interdisciplinary approach and (3) engaging for students.

The model that Philip L. Balcen elaborated includes four crucial fronts that provide an approach in order to encourage, teach and assess the qualities of the critical thinkers. These fronts indicated in the model are (1) providing critical challenges, (2) Teaching the tools, (3) regular criterion referenced assessment and (4) building communities of thinkers.

Chapter III

Ecological Education: Reconnecting with Nature to Promote Sustainable Behavior

by Susan Barker

Susan Barker basically focus upon a criticism pertaining that ecology, a science which explores the interrelationship among plants, animals and the environments, is failing to live up to its potential. She mentions about the shifting emphasis of Ecology from environmental education to economics, social and civil systems. Furthermore, she tries to explore how ecology and ecological education can be justified and developed as a crucial cornerstone for ensuring the sustainability of the earth. In the article, she argues the criticisms and the recommendations toward finding an effective way for ecological education to make connection ecology and sustainable development.

Based upon the criticisms and changing emphasis, Barker re-examines and discusses the place of ecological education in the evolving area of education for sustainable development.

Chapter IV

Developing the Scientific Imagination: A key to Sustainability?

by Sean Blenkinsop and Mark Fettes

The authors share their scientific works (project) pertaining to developing the scientific imagination with the readers. The project that they conducted is basically about determining the benefits and contributions of scientific imagination method, so called approach, used for teaching water unit of science education curricula of 4th grade in three public school districts in British Columbia. They conducted this project specifically named as *Learning for Understanding through Culturally Inclusive Imaginative Development* (LUCID) with 4th grade students in order to try to connect scientific imagination with the sustainable development. With the project, the authors also aims at connect scientific knowledge with the moral, cultural and natural worlds of people.

The authors also mention about five scenes that they followed so as to successfully realize the project. Those steps proceeded by the authors in their project are (1) A mythic framework, (2) Making sense through the body, (3) Romantic explorations and (4/5) Toward philosophical understanding. The completed project reveals that the students discovered that the science was not detached from human and natural realities.

Chapter V

Introducing Eco-Justice and the Revitalization of the Common Issues into Thinking about Environmental Education

by Chet A. Bowers

Bowers discusses how the globalization of Western techno-scientific-industrial culture is influencing the rate of changes in specific three areas which are vitally important for the future quality of life. These vital areas identified in the paper are (1) the loss of linguistic/cultural diversity that plays such an important role in maintaining biodiversity, (2) the loss of intergenerational knowledge that represents cultural alternatives to an individually-centered consumer dependent lifestyle, and (3) the further degradation of natural systems – potable water, topsoil, fisheries, climate changes, spread of toxic waste. It is emphasized in the article that Western techno-scientific-industrial culture accelerates the emergence of these life-threatened effects.

Bowers is further making a suggestion for involving faculty and students in a dialogue regarding educational reforms.

Chapter VI Controversial Socio-scientific Issues in the Science Classroom: Managing Uncertainty in Climate Change Education
By Joan M. Chambers and Patricia Rowell

In their article, Chambers and Rowell mention about how inclusion of controversial socio-scientific issues in the science classroom is recognized as an important component of science education. They discuss that including the controversial socio-scientific issues which are inherently tentative and uncertain raises concern about how this vagueness ought to be dealt with. One of the contemporary socio-scientific issue which has been perceived as controversial is climate change discussed in this chapter of the book.

In the study, they analyzed and interpreted the language of the documents pertaining to climate change education which was produced by sub-communities in the field. They tried to investigate how the reality of climate change has been addressed in the textual resources used in the schools in Alberta. The findings of their analysis of textual recourses indicate the extent to which and how discursive management of uncertainty and materials used in the school have been used for constructing the realities of climate change and appropriate actions and responses.

Chapter VII Sustainable Communities, Sustainable Environments: Industry Supported Professional Development in the Mineral Resource Sector
by Dan Churach and Di Nichols

Churach and Nichols discuss the possible positive and negative effects of technology on the desired condition, which is sustainability, in people's interaction with the environment. They argue that the ability to learn and apply people's knowledge to solve the problems depends on existence of species. The people who are in the industry sector can be actor for realizing those solutions. In the article, this point of view is supported with the findings of the several research studies done in Australia such as Western Australian Government's 2003 Youth Survey. Those research studies further indicate that teachers have been influencing the students to select a career in mining and mineral resources sector. In addition, the authors states the findings of their pilot study with 43 teachers in order to determine a shift in teachers' attitudes toward the industry as a result of personal development training. The pilot study points out that there are a strong association between teachers participating in the professional developments and a positive shift in their attitudes towards the industry.

Chapter VIII Education and Research for Sustainable Living
by Bruce Johnson

Johnson proposes the earth education model in order to make decision and take action for sustainable life, for understanding the natural system of the world and for grasping the big picture of how life works. As models of Earth Education, Johnson introduces the model programs of Earthkeepers – KEYS for 10-11 years olds, Sunship Earth for 10-12 years olds, Sunship –III for 13-14 years olds, Rangers of Earth for 10-11 years-olds and Lost Treasures for 8-9 years-olds, each of which emphasizes programmatic approach, a sense of being on a learning adventure and personal contact with the nature. Furthermore, he reports initial findings of the longitudinal project aiming to determine how understandings, perceptions, and actions develop as students to participate in the sequential earth education programs in Pennsylvania and Louisiana.

Chapter IX An Earth Systems Inquiry-Based Approach Reshapes Teachers' Beliefs about Instruction of Diverse Students
by Julie Lambert, Benjamin Lester, Okhee Lee and Aurolyn Luykx

The authors presents their research study regarding as how 5th grade teachers' beliefs changes as a result of an inquiry-based Earth system curriculum with the elementary school students who comes from different cultural and linguistic background. They describe *The Living Planet* curriculum, designed by considering one of the earth education approaches. In order to overcome the difficulties of linguistically and culturally diverse students who often left behind in science, teachers tend to use inquiry-based methods. However, while doing so, teachers do not well take into consideration students' different language and cultural backgrounds. They reported 23 teachers' in-depth perspectives and experiences which reflect implications for curriculum development and professional learning experiences for teachers teaching culturally and linguistically diverse students. Their research provides evidence that a theme like *The Living Planet* may enable the teachers to participate in culturally diverse and global communities.

Chapter X Creating Sustainable Online Learning Environments for Mature Age People
by Stephen Quinton, Darrell Fisher, Heinz Dreher and Paul Houghton

Quinton, Fisher Dreher and Houghton discuss the sustainability through the online learning environment designed for mature age people. They share a research project that aims to construct an online design model which will satisfy the preferences of mature age people.

They argue that revealing the preferences, needs and requirements of adult people will help improve the quality, variety and relevance of the learning for this group of people in the society. They also argue on new technologies and approaches for effective implementation of complex learning environment. As far as the stages of the Mature Age project are concerned, the understanding of "*one size fits all*" which basically depends on traditional approaches does not seem to work anymore. The Mature Age model enhances human capabilities, and encourages collaboration and engagement activities which provide common understanding on a determined issue.

Chapter XI Evaluating a Professional Learning in Shark Bay, Western Australia
by Rowena Scott

In this chapter, Scott reflects implications and implementations of the one of the goals of the United Nations which is "to ensure environmental sustainability, in particularly, to integrate the principles of sustainable development into policies and programs (p.131)". The author expresses her experiences and gives some examples about how one government organization has sought ways to enhance ecological literacy and integrate the principles of sustainable development into educational programs. The author describes a specific program in which primary, secondary and even university teachers attended to become well informed about local projects and actively participate with local scientist in Shark Bay as a sustainable community of fauna in World Heritage Area in Australia.

Chapter XII A *Classroom Teacher's Reflection on Learning Sustainability*
by Sandra Wooltorton

Wooltorton reflects her own teaching experiences regarding as the implementation of the aspects of the sustainability education in her own primary school classes. She identified her 2004 class and how she developed her 2005 class based upon the lessons taken from 2004 class. The project she involved points out that children tend to change their habits and actions associated with technocratic consumerism when the school culture is totally reoriented to the understanding of sustainability. She argues the ways of gaining the habits and practices for sustainable future. In this regard, she shares some examples emerging from her own experiences.

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The reviewer's main research interests are predictors of responsible environmental behavior, environmental literacy, curriculum development, analysis and evaluation, and instructional planning and evaluation.

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