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A Case Study on Science Teacher Trainees

Fen Bilgisi Öğretmen Adayları Üzerine Bir Durum Çalışması

Ceren Tekkaya, Jale Çakıroğlu ve Özlem Özkan
Middle East Technical University

Abstract

The main purposes of this study were to investigate pre-service science teachers' understanding of science concepts, their attitudes toward science teaching and their beliefs of their efficacy in science teaching. A total of 85 pre-service science teachers participated in the study. All students were sophomores who had taken various science courses during previous semesters and were still studying science. Data collection instruments included the Science Concept Test, The Science Teaching Efficacy Belief Instrument, The Science Teaching Attitude Scale, Biology/Physics/Chemistry Attitude Scales, and open ended questions. All instruments were administered to the participants at the end of the 4th semester of their university years. The findings of the study indicated that majority of the participants had misconceptions concerning fundamental science concepts. The results also revealed that they generally had positive attitudes towards science teaching, and towards three different domains of science, namely, biology, physics, and chemistry. In addition, slightly positive self-efficacy beliefs regarding science teaching were found among most of the participants.

Key Words: Teacher efficacy beliefs, attitudes, science teaching, misconceptions

Öz

Bu çalışmanın amaçları, fen bilgisi aday öğretmenlerin fen bilgisi kavramlarını anlama düzeyini, biyoloji, fizik ve kimya dersi ile fen öğretimine yönelik tutumlarını ve özyeterlilik inançlarını araştırmaktır. Çalışmaya fen bilgisi öğretmenliği programı ikinci sınıfında okuyan 85 öğretmen adayı katılmıştır. Veriler, 'Fen Kavram Testi', 'Fen Öğretimi Özyeterlilik İnanç Ölçeği', 'Fen Öğretimi Tutum Ölçeği', 'Biyoloji, Fizik ve Kimya Tutum Ölçekleri' ile açık uçlu sorulara verilen cevaplar kullanılarak elde edilmiştir. Yapılan analizler, fen bilgisi aday öğretmenlerinin fen öğretimine, biyoloji, fizik ve kimya derslerine karşı olumlu tutum geliştirdiklerini ve fen konularda birçok kavram yanılgısına sahip olduklarını göstermiştir.

Anahtar Sözcükler: Özyeterlilik inançları, tutum, fen öğretimi, kavram yanılgıları

Introduction

Developing science learning, promoting science achievement, intellectual development and positive attitudes toward science courses are among the most important goals of science education in developing countries like Turkey. To meet these aims, the role of the science teacher is considered one of the most influential factors in increasing the quality of students' learning processes and consequent outcomes. In this sense, teacher education and preparation has a special meaning in Turkey. The main purpose of a teacher education program is to provide science teachers with a good self-image, an outgoing personality, and an interest in helping their students to understand science in a meaningful way. In addition, the program also aims to equip teachers with a sound understanding of how children learn science to be confident in using

Assis. Prof. Dr. Ceren Tekkaya , Middle East Technical University, Department of Elementary Education, Ankara. Dr. Jale Çakıroğlu and Özlem Özkan, Middle East Technical University, Department of Secondary Science and Math Education, Ankara.

technology, capable in problem solving, and attentive to human rights, democracy, and ethics. However, the effectiveness of these programs has not been extensively examined (Türkmen and Bonnstetter, 1998).

Theoretical Framework

Over the past two decades, students' understandings of scientific phenomena have come to be of great interest to science educators and researchers. Studies have shown that students have a considerable number of misconceptions about various science topics. These include: the human circulatory system (Sungur, Tekkaya and Geban, 2001), ecology (Adeniyi 1985; Özkan, 2001), respiration (Tekkaya, 2001), photosynthesis (Hazel and Prosser, 1994), Newton's Law (Hydn, McWhorter, Phares and Suttles, 1994), electricity (Chambers and Andre, 1997), force (Palmer, 1997), motion (Whitelock, 1991), mass, volume and density (Hewson and Hewson, 1983), electrochemistry (Huddle, White and Rogers, 2000), and gas laws (Lin and Cheng, 2000). A number of studies have also revealed that both pre-service and in-service teachers frequently hold misconceptions about a variety of science concepts (Crawley and Arditzoglou 1988; Schoon, 1993; Atwood, R.K. and Atwood,V.A. 1996; Schoon and Boone, 1998). Many of these misconceptions are likely to have originated partly from the texts and reference books they consult for their teaching and partly from the misconceptions they too had acquired as students in high school or college (Wandersee, Mintzes and Novak, 1994). It is clear that teachers with misconceptions about science are not likely to be able to develop scientifically accurate concepts in their students. It seems to be an obvious corollary that many of the misconceptions teachers hold are likely to be transmitted to their students (Schoon, 1993).

Misconceptions do not simply signify a lack of knowledge, or factual or incorrect definitions. They represent explanations of phenomena constructed in response to prior knowledge and experience (Munson, 1994). Educators agree that the existence of these misconceptions among students leads to a serious obstacle to learning in science, since misconceptions have been shown to be pervasive, stable and often resistant to change through traditional classroom instruction (Ausubel 1968; Osborne and Wittrock 1983). Therefore, it is very important that teachers be aware of these misconceptions, correct them and be careful not to provide suitable environments to their re-occurrence.

Teachers' sense of efficacy is a construct derived from Bandura's (1986) theory of self-efficacy in which the generalized behavior of an individual is based on two factors, (a) a belief about action and outcome and (b) a personal belief about his/her own ability to cope with a task. Teacher efficacy refers to "a teacher's belief or conviction that he/she has the ability to influence how well students learn, even those who may be difficult or unmotivated" (Tschannen-Moran, Woolfolk-Hoy, Hoy, 1998, 202). Research on the efficacy of teachers suggests that behaviors such as persistence at a task, risk taking, and use of innovations may be related to degrees of efficacy (Ashton, 1984; Ashton and Webb, 1986). For example, highly efficacious teachers were more likely to use open-ended, inquiry, student-directed teaching strategies, while teachers with a low sense of efficacy were more likely to use teacher-directed teaching strategies such as lecturing and reading from the textbook. It has been demonstrated that students generally learn more from teachers with high self-efficacy than from those whose self-efficacy is low (Ashton and Webb, 1986). In fact, teachers' beliefs in their instructional efficacy are a very strong predictor of academic attainment in young children (Saklofske, Michayluk, and Randhawa, 1988).

If Bandura's theory of self-efficacy is applied to science teaching, we might predict that teachers who believe that science learning can be influenced by effective science teaching (outcome expectancy) and who believe in their own ability to effectively teach science (self-efficacy) will more regularly and effectively teach science (Riggs, 1991).

Many studies have also addressed the construct of teacher's attitudes toward science and how the construct can affect teaching (Wenner, 1993; Stevens and Wenner, 1996). Koballa and Crawley (1985) have stated that there is an interrelationship between beliefs, attitude and behavior. They illustrated this relationship with a scenario in which elementary school teachers judged their ability to teach science to be low (belief), resulting in a dislike for science teaching (attitude) that ultimately translated into teachers who avoided teaching science (behavior). It is possible to state that teachers'

attitudes towards science and science teaching are important factors affecting the quality of science taught to students.

Considering the fact that there are three important factors influencing science teaching in the classroom-teachers' understandings of science, their attitudes and beliefs toward science and science teaching (Stepans and McCormack, 1985; Wenner, 1993; Stevens and Wenner, 1996; Gooday and Wilson, 1996), this study is designed to investigate pre-service science teacher trainees' understanding of science concepts, and their attitudes and beliefs toward science teaching. This study is also interested in determining pre-service science teachers' attitudes toward three different domains of science, namely biology, chemistry and physics. In addition, their level of understanding of science topics and their degree of confidence to teach science concepts are questioned. The findings of the study might provide feedback the curriculum developers and science educators involved in the Turkish teacher education program.

Method

Subjects

The sample of the study consisted of a total of 85 pre-service science teachers (27% male, and 73% female) with a mean age of 21.5 years. All students were sophomores who had studied the various science courses during previous semesters and were still studying science. In addition, they were involved in several science laboratory courses. Therefore, they were expected to have adequate knowledge of basic science concepts and science process and skills.

Instruments

Data for this study were obtained from 5 major sources: (a) the Science Concept Test, (b) the Science Teaching Attitude Scale, (c) The Science Teaching Efficacy Belief Instrument, (d) the Biology/Physics/ Chemistry Attitude Scales, e) Responses to open ended questions. All these instruments were administered to the participants at the end of the 4th semester of their university study.

The Science Concept Test

A 33-item multiple choice test was designed by the researchers on the basis of the new Turkish science curriculum, to determine preservice science teachers' understanding of various science concepts. The items in the test included one correct answer and three distracters. The topics covered in the test were mainly: process of life, energy, force, motion, electricity, heat and temperature.

The Science Teaching Efficacy Belief Instrument

The Science Teaching Efficacy Belief Instrument (STEBI-B), was developed for pre-service teachers by Enochs and Riggs (1990). The STEBI-B is comprised of two subscales; personal science teaching efficacy beliefs (PSTE) (13 items) and science teaching outcome expectancy (STOE) (10 items). This instrument was translated into Turkish by the researchers, and the necessary adaptations were made. Reliability analysis of the Turkish version of the Personal Science Teaching Efficacy (PSTE) scale produced an alpha coefficient of 0.86 and the Science Teaching Outcome Expectancy (STOE) scale produced a Cronbach alpha coefficient of 0.79. This instrument is a 5-choice, Likert type scale ranging from 'strongly agree' to 'strongly' disagree. High scores on the first scale (PSTE), relative to other respondents, indicate a strong personal belief in one's own efficacy as a science teacher and, on the second scale (STOE), high expectations with respect to the outcomes of science teaching.

The Science Teaching Attitude Scale

This scale was developed by Thompson and Shringley (1986). It is a 21- item, five-point Likert scale, measuring pre-service science teachers' attitudes towards science teaching. Out of 21 items, 12 were worded positively and 9 were worded negatively. This scale was translated into Turkish by the researchers, and the necessary adaptations were made. The reliability of the Turkish version of the scale was found to be 0.83. The validation of the Turkish attitude scale was examined by a group of panel judges.

Biology/Physics/Chemistry Attitude Scales

Pre-service science teachers' attitudes toward biology, physics and chemistry were measured separately by

using a 15-item, 5-point Likert type scale. The reliability coefficients of the scales were found as 0.90 for biology, 0.94 for physics and 0.93 for chemistry.

Statistical Analysis

Students' responses to the Science Concept Test were analyzed using an item analysis program (ITEMAN). Other statistical analyses were carried out using SPSS/PC, the Statistical Package for Social Sciences for Personal Computers.

Results

Results of the study were grouped under the following headings:

Pre-service Science Teachers' Understanding of Science Concepts

Preservice science teachers' understanding of different science topics was determined by the Science Concept Test. The results revealed that many participants held misconceptions about fundamental science concepts. Examples of some common misconceptions are shown in Table 1.

The result of the Science Concept Test suggests that the majority of pre-service science teachers have not acquired a satisfactory understanding of basic science concepts.

Pre-service Science Teachers' Efficacy Beliefs

Analysis of the efficacy belief instrument exhibited slightly positive self-efficacy beliefs expressed by most of the pre-service science teachers regarding science teaching. For example, about 83.4% of the participants indicated a confidence in their ability to teach science effectively, while slightly less than half (47.6%) claimed to understand science concepts. However, only 29.4% of the participants maintained that they felt they knew the steps necessary to teach science concepts effectively. These data lead to a conclusion that the students are confident in their general teaching competency but harbor some doubts regarding their ability to teach science at a conceptual level. Further, respondents also seemed generally willing to assume that student learning in the content area of science is the responsibility of the teacher. Approximately 86.9% claimed that good teaching could overcome the inadequacy of a student's science background. A majority of the participants (78.5 %) indicated that students' achievements in science are directly related to their teacher's effectiveness in science teaching.

In order to see the relationship between dimensions of the efficacy beliefs instrument, the science teaching attitude scale and the science concepts test scores, a Pearson correlation analysis was computed. It was found

Table 1
Sample of misconceptions selected by respondents

Misconceptions	% of the responses selecting options
• If two balls, having same size and shape but different weights, are dropped simultaneously from the top of a building, the heavier one will hit the floor first	49.4
• Photosynthesis is the process that makes energy available for metabolism in plants	36.5
• Summer is warmer than winter, because in summer the earth is nearer the sun	60.0
• We have day and night, because the earth goes around the sun	30.6
• The temperature of water decreases when ice is added, because the ice melts lowering the temperature	55.3
• The sky is blue because particles in the air absorb blue light	45.9
• Plants respire only at night, because they do photosynthesis during day	36.5
• Energy can be cycled in an ecosystem	74.1
• Seeing depends on a visual ray going from the eye to the object that is being looked at	23.6

that participants' personal science teaching efficacy beliefs (PSTE) scores correlated significantly with their attitudes toward science teaching ($r=0.38$, $p<0.01$). This means that teachers who believe in their own ability to teach science effectively have positive attitudes toward science teaching. However, no correlation was found between science teaching outcome expectancy beliefs (STOE) and attitude toward science teaching ($p>0.05$). When the dimensions of the efficacy belief instrument (PSTE and STOE) are correlated with the science concept test scores, no statistically significant relationship among those variables is found either ($p>0.05$).

Pre-service Science Teachers' Attitudes toward Science Teaching

Overall scores revealed that pre-service science teachers have positive attitudes toward science teaching. For example, 97% of the participants believed that the teaching of scientific process is important in the science classroom. Approximately 70% of the participants claimed that they would feel comfortable teaching science. The majority of the participiants claimed that they would enjoy helping students construct science equipment (91%). About 79% indicated that they hoped to be able to excite their students about science.

Pre-service Science Teachers' Attitudes toward Biology, Chemistry and Physics

Pre-service science teachers' responses to the attitude scales revealed that they generally had positive attitudes towards biology, chemistry and physics. On the other hand, the participants' attitudes appear generally to be more favorable towards biology than towards the other subjects. For instance, 65% of the participants indicated that they enjoyed reading books related to biology. The corresponding figures for physics and chemistry were 38% and 33.4% respectively. Similarly, 72.7% of the participants indicated their willingness to learn more about biological concepts. This percentage was reduced to 61.5 for physics and 53.6 for chemistry.

The Relationship between Understanding of Science Concepts and Degree of Confidence

The pre-service science teachers were given a list of 21 topics present in the new Turkish science curriculum. They were asked to rate their level of understanding of these topics and their degree of confidence in their ability to teach the topics to their future students. A statistically significant high correlation between level of understanding and degree of confidence was found ($p<0.01$). The topics related to "living things", "energy for life" "environmental science" and "the nature of matter" were among the topics rated highly. For example, 87.4% of the pre-service science teachers indicated that they had a strong understanding of the topic of "the nature of matter" and they felt very confident in their ability to teach this topic (85.3%). The reason lies in the relatedness of these topics to their daily life, as may be understood from their responses to open-ended questions. On the other hand, they expressed relatively little understanding (57.3%) and a relative lack of confidence (51.2%) in relation to "electricity".

Conclusion

The learning of a complex subject like science is an incremental process. Understanding is sometimes incomplete at every level and it is easy to draw incorrect conclusions from incomplete models. The generation of the misconception is thus a natural and probably unavoidable part of the learning process. For this reason there is a need to identify persistent misconceptions in science subjects. One of the aims of this study was to identify pre-service science teachers' understanding of science concepts. The results indicated that many participants held several misconceptions concerning fundamental science concepts. Photosynthesis, respiration, motion, and heat and temperature were among such concepts. These concepts are basic to scientific knowledge and act as keys to the understanding of other concepts in different disciplines of science. This finding adds to the evidence that, regardless of the age of the students or the level of schooling, misconceptions are prevelent and resistant. Although most of the participants held several misconceptions, they showed a high level of understanding of science and a positive attitude toward biology, physics and chemistry. For example, 83% of the participants indicated a high level of understanding concerning concepts related to the ecosystem, but only 5.9% knew that energy could not be recycled in an ecosystem. Moreover, their responses revealed that they did not realize the important role of respiration and photosynthesis in energy flow through the ecosystem

even if they have studied these concepts from primary school years to university. These results showed that they were most probably unaware of the misconceptions they held.

Pre-service science teachers' beliefs regarding their general ability in science teaching appears strong. They express some concerns regarding conceptual understanding and teaching science at a conceptual level, however. The results of the science concept test also confirm this finding. Indeed, pre-service science teachers held many misconceptions. It also appears that they are willing to assume responsibility for students' achievements, but the question remains: are they adequately prepared to promote students' conceptual understanding and to develop positive attitudes in their future science classrooms.

Pre-service science teachers' responses to attitude scales revealed slightly more positive attitudes toward biology and physics than towards chemistry. When they were asked several open-ended questions regarding their perceptions of these subjects, they indicated that biology and physics are more related to daily life, and that they are more enjoyable, easier and more interesting when compared to chemistry. On the other hand, they mentioned that chemistry is a complex discipline that depends on memorization and includes many formulas and several abstract concepts such as atoms and molecules. According to the participiants, these concepts are not easily observable and demonstrable in the classroom. Therefore, they concluded that chemistry is a difficult dicipline to understand and to teach. Developing a positive or negative attitude toward the subject matter is strongly associated with participants' past experiences in their high school years, as understood from their reponses to open-ended questions.

Due to the vital role pre-service teachers will play in educating our younger generation, teacher training programs need to critically weigh the long-term consequences of having pre-service teachers graduate before they get the chance to explore and try to alter their misconceptions. Teachers with misconceptions about scientific ideas are not likely to be able to develop scientifically accurate conceptions in their students. These programs also need to evaluate the efficacy levels of their teacher trainees and begin to find ways to enhance their efficacy beliefs and their attitudes regarding science teaching. Only then can these programs begin to launch future teachers who are ready, willing, and able to meet the needs of their students.

Further research may focus on how pre-service science teachers' understanding of science, their attitudes towards science teaching and their self efficacy beliefs will be influenced by teacher education programs.

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