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Pre-Service Science Teachers' Mental Models about Science Teaching*

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Abstract

The main purpose of this study is to explore preservice science teachers' mental models of science teaching. Additionally it is investigated whether there is a significant correlation between their gender and grade levels in terms of mental models. The sample of this study composed of 300 (111 males and 189 females) pre-service science teachers from Turkey. As a data collection instrument "Draw a Science Teacher Test-Checklist (DASTT-C)" was used. The test was made up two sections. In the first section of the DASTT-C, the pre-service science teachers were asked to "Draw a picture of yourself as a science teacher". In the second section, they were asked to give answers to the questions "What is the science teacher doing? and what are the students doing?" regarding their drawings. The data was the coded according to the rubric and analyzed with SPSS. The results of study showed that pre-service science teachers' mental models of science teaching were in the categories of conceptual teaching (61%), exploratory or inquiry/constructivist teaching (22%), and explicit/didactic teaching (17%). There was no significant difference between male and female but there was significant difference between the grade levels in favour of senior levels with regard to their mental models of science teaching. In the light of the results, some suggestions were made for further studies.

Key Words

Belief, Mental Models, Teaching models, Pre-service Science Teachers, Draw a Science Teacher Test-Checklist.

For 20 years, researchers and program designers working in the field of teacher training have been researching what good instruction could be, and the ways in which preservice teachers learn to teach (Minor, Onwuegbuzie, Witcher, & James, 2002). They have also examined the behaviors of "successful" and "unsuccessful" teachers (Ornstein & Lasley, 2004), and they have attempted to define the factors that affect teacher behaviors in the classroom. The concept of "teacher belief" has been emphasized in order to explain the behaviors of teachers. It is reported that the beliefs teachers hold concerning the learning-teaching process shape their teaching practices (Levitt, 2001; Lumpe, Haney, & Czerniak, 2000; Pajares, 1992).

The Beliefs of Teachers

The belief system of an individual is composed of beliefs, attitudes and values. This system, which affects an individual's perception, has a structure which becomes stronger as it is employed over

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time, and it displays a resistance to change (Pajares, 1992). Nespor (1987) argues that belief is a strong determinant in the formation of behavior; and behavior is effective in the process of decision making, organizing missions and solving high-level problems. Calderhead (1996) evaluated teacher beliefs under five headings: beliefs about (*i*) learners and learning (*ii*) teaching, (*iii*) learning to teach, (*iv*) one's self and one's role, and (*v*) the subject matter. These beliefs are related to each other and they play an important role in teacher-student interaction.

The previous experiences of an individual may affect their beliefs. According to researchers who support this view, the previous education experiences of teachers and preservice teachers affect their beliefs about teaching and their class practices (Appleton & Asoko 1996; Davies & Rogers 2000; Hart, 2002; Ornstein & Lasley, 2004; Tobin, Tippins, & Gallard 1994). Similarly, Duru (2006) and Mellado (1998) argue that the teacher roles that preservice teachers had previously encountered significantly helped to shape their beliefs concerning learning and teaching. Based on this view, it can be said that preservice teachers start their education in teacher training program with certain preconceived beliefs toward teaching (Minor et al., 2002).

Teacher training programs affect preservice teachers' beliefs. The duration of the program and the preservice teachers' experiences in the field are shaped their beliefs (Doyle, 1997). Similarly, Nuangchalerm and Prachagool (2010) state that field experiences are effective on teachers in deciding teaching methods, understanding the subject content and developing a point of view about professional practices. Doyle analyzed the effects of the curriculum on preservice teachers' beliefs about teaching and suggested that preservice teachers show a transition from the role of transferring information directly to the role of guidance. In this case, it is necessary to efficiently apply systematic inquiry, reflective practice and assessment strategies in curriculums in order to strengthen preservice teachers' beliefs about learning and teaching (Sandholtz, 2011).

Mental Models of Preservice Teachers about Science Teaching

As it is thought that there is a strong link between belief and behavior, it is impossible to isolate teacher beliefs about science teaching from their practices for teaching (Minogue, 2010). Thomas, Pedrsen, and Finson (2001) stated that there is a high-level relation between preservice teacher beliefs about science teaching and their mental models which reflect their behaviors. Mental models enable us (*i*) to understand the belief system that an individual acquires via observation, instruction or inference, (*ii*) to observe the similarity between an individual's mental model and the physical world, (*iii*) to understand the individual and to predict his/her behaviors (Norman, 1983). Mental models can be used in order to determine preservice science teacher belief systems concerning science teaching and to predict their classroom practices in the future. Thomas et al. grouped preservice teachers' mental models for teaching based on three models.

Explicit Teaching Model: The teacher employs didactic methods in order to transfer the information. Teacher presents the information; displays models and gives corrective feedback (Whyte & Ellis, 2003). In these classrooms, students are expected to remember and repeat the information given by the teacher (Billings, 2001). The learning environment is organized in a way which facilitates the conveyance of information for and by the teacher (Thomas et al., 2001). In the demonstration of this kind of teaching, the teacher is generally in front of the class, he/she is standing among the students, students are taking notes and they sometimes ask permission to speak. In this type of class, it is evident that the teacher conducts the lesson using the chalkboard and/or teaching chart; the students focus on the blackboard and books; and they study using only paper and pencils (Whyte & Ellis).

Conceptual Teaching Model: This kind of instruction is applied by teachers who use both didactic methods and who try to adopt constructivist learning approaches. The subject and concept to be taught are at the center of it, and activities -such as inquiry, discovery and problem solving- are designed to assist the learning of the concept (Whyte & Ellis, 2003). The teacher is the guide in this model. The teacher chooses the subject; introduces the unit to his/her students and presents them the necessary basis for inquiry. In this instruction method, based on laboratory and activity, students discover new information and construct their knowledge (Martin, 1997). In demonstrations of this kind of instruction environment, students conduct activities in small groups; there are conversation bubbles which reflect the interaction between the students, and the teacher can closely observe the students. Students are simultaneously given routine tasks. Teachers may intervene in student work by giving the students instructions (Whyte & Ellis).

Exploratory Teaching Model: The teacher gives particular importance to student interests and deci-

sions. Non-routine activities are determined; these are based on the student questions (Whyte & Ellis, 2003). The teacher takes the part of a researcher in the classroom along with his/her students. In this model, where students are cognitively active, discovery is the basic concept (Martin, 1997). Discussions of the subjects and individual or group projects are remarkable in these classrooms. Besides the practices in the classroom environment, there are also frequently out-of-school activities. In the demonstration of this kind of instruction model, it is seen that students work in groups and that the teacher helps his/her students (Whyte & Ellis).

Drawings are used in order to determine which one of the three instruction models preservice teachers choose. Drawings were first used in the 1920s in studies for determining perception (Goodenough, 1926). In the 1980s, studies were conducted to determine elementary students' perceptions of scientists (Chambers, 1983; Schibeci & Sorensen, 1983 cited in Whyte & Ellis, 2003). The 'Draw-A Science Teacher-Test-Checklist' (DASTT-C) was prepared by Thomas et al. (2001) in order to determine the mental models of preservice teachers for science teaching.

Many studies examining the mental models of preservice teachers for science teaching have been conducted. In these studies, it was revealed that preservice teachers mostly adopted explicit and/or conceptual teaching models (El-Deghaidy, 2006; Elmas, Demirdöğen, & Geban, 2011; Markic & Eilks, 2008; Minogue, 2010; Türkmen, 2002; Yılmaz, Türkmen, Pedersen, & Huyugüzel-Çavaş, 2007). For example, Yılmaz et al. determined in their study that out of 213 preservice science teachers, 41% had teacher-centered; 39% had teacher-student centered; and 20% had student-centered perceptions. Furthermore, many studies have examined whether or not the mental models of preservice teachers for teaching differed or not according to gender. Some of the researchers argue that there is a significant difference between the gender of preservice teachers and their mental models (Decker & Rimm-Kaufman, 2008; Elmas et al., 2011) while some of them argue that there is not (Yılmaz et al., 2007). Additionally, there are some research results which revealed that preservice teachers' beliefs concerning teaching showed a transition from teacher-centered models to student-centered models during their undergraduate program (Hancock & Gallard, 2004; Minogue, 2010; Ng, Nicholas, & Williams, 2010). In a study conducted with preservice teachers who study at the first and fourth grade levels, Türkmen (2002) stated that students at the final grade level adopted student-centered teaching models more than did the others.

The Importance of the Research

As opposed to learning passively, when a student tries actively to produce and acquire information, just as a scientist does, and opens it to discussion, the process is called meaningful learning (Milli Eğitim Bakanlığı/Ministry of Education [MEB], 2005). In line with this approach, the roles of science teachers, students and the features of the learning environments have also to be changed. However, according to Tobin, Briscoe and Holman (1990), the prior experiences of preservice teachers have been text-oriented and based on teacher presentation and demonstration. The fact that preservice teachers had undoubtedly had experiences based on traditional science teaching over many years strongly affect their beliefs about the nature of science and science teaching (cited in Thomas et al., 2001). When it is considered that preservice teachers' beliefs concerning teaching may be effective on their future teaching practices, the mental models they have can guide researchers and teacher trainers.

The Purpose and Problem of the Research

It is necessary to examine whether preservice teachers' mental models differ according to gender or not, and how their mental models change during their undergraduate program. The purpose of this study is to determine preservice science teachers' mental models for science teaching and to reveal their relation with gender and grade level. With this in mind, an answer was sought to the question, "What are the mental models of preservice science teachers about science teaching?" Within the framework of this general problem, two sub-problems of the research were expressed as follows: What kind of relation is there between preservice teachers' (*i*) gender, (*ii*) the grade level and their mental models?

Method

Research Design

This research is relational research. The basic examples of relational research are correlation and causal comparative research studies (Frankael & Wallen, 2000). The present research revealed the relation between preservice teachers' mental models in science teaching and the above mentioned variables. For this reason, a correlation research pattern was used in the research. In correlation research, researchers reveal the relation between two or more variables by using correlation statistics without having the variables under their control and manipulating them (Creswell, 2005).

Sample

The study group of the research is composed of 300 preservice science teachers who study in two public universities in Turkey. Since the participants in the study are preservice teachers, studying in the universities where the researchers work, the sampling method used in the research is the convenience sampling method (Patton, 2002). Sixty three percent of the preservice teachers are female; 37% are male. Of the participants, 32% are first grade, 23% are second grade; 24% are third grade; and 21% are fourth grade students.

Instrument

DASTT-C was used in order to determine preservice teachers' mental models for science teaching. The test is based on previous studies which were conducted with drawing tests. Accordingly, firstly the "Draw-A-Scientist-Test" (DAST) was developed by Chambers (1983) in order to determine the perceptions of students towards scientists. Finson, Beaver and Crammond (1995) prepared the "Draw-A-Scientist-Test Checklist" (DAST-C) in order to have alternative images and to be able to make assessments more easily. Then, Thomas et al. (2001) revised the DAST-C and prepared the DASTT-C. DASTT-C is composed of two main sections where preservice teachers will draw and explain students and teacher roles in a written form. The internal consistency coefficient of the test was calculated as .82 by Thomas et al. The internal consistency coefficient which is recalculated within the framework of this study is .74.

Data Analysis and Reliability

The drawings of the preservice teachers were assessed by using the rubric improved by Thomas et al. (2001). In the rubric, there are three main sections, "Teacher", "Student" and "Learning Environment", and their elements. Drawings are assessed according to 13 elements of the three main sections. The drawing is analyzed by giving 1 point if there is the situation mentioned in the related element otherwise a 0 point is given. Moreover, the goodness of fit between the elements in the drawing and the written expressions under the drawing is also controlled. At the end of the assessment, the score that each preservice teacher obtained from the drawing test was calculated. According to the scores that preservice teachers obtained, 0-4 points represent the "exploratory teaching model"; 5-9 points represent the "conceptual teaching model"; and 10-13 points represent the "explicit teaching model" (Thomas et al.).

The researchers analyzed the drawings of 10 participants separately in order to provide reliability in the process of drawing assessment. According to these analyses, the goodness of fit coefficient was calculated as .81. The researchers came together; compared the results and discussed them in order to increase the goodness of fit percentage. The researchers independently analyzed the drawings of 20 participants after reaching an agreement about the elements in the drawings. At the end of this analysis, the goodness of fit percentage between the researchers was calculated as .93. This goodness of fit percentage is accepted as highly reliable (Miles & Huberman, 1994).

The drawings of all the preservice teachers were scored and the categories where the preservice teachers are placed (explicit-conceptual-exploratory) were determined according to the scores they obtained. Concerning the sub-problems of the research, t-test was used for unrelated samplings in order to determine whether the scores that preservice teachers obtained from the drawing test differed or not according to gender; and one-way variance analysis (ANOVA) was used in order to determine whether it differed or not in terms of grade level.

Findings

Mental Models of Preservice Teachers' about Science Teaching

According to the results, the drawings of 17% of the participants reflected the explicit teaching model; the drawings of 61% reflected the conceptual teaching model; and the drawings of 22% reflected the exploratory teaching model. It is a remarkable result that preservice teachers who adopted conceptual teaching frequently used expressions consistent with constructivist learning theory (the student is active, the teacher is a guide); however they wrote explanations which reflect didactic methods (the teacher first gives the lecture, the students conduct the experiments in the course book etc.).

Analysis of Mental Models of Preservice Teachers According to Their Gender and Grade Level

When the preservice teachers' mental models for science teaching were examined, it was seen that the majority of both males (58.2%) and females (65.8%) had the conceptual teaching model. The number of preservice teachers who had the explicit

and exploratory teaching model was close to each other in both genders. When the distribution of the teaching models that the participants had in terms of grade level was examined, it was seen that the mental models of the majority of the preservice science teachers, apart from the fourth grade preservice teachers, were in the conceptual teaching category. When this difference according to grade levels was examined in detail, it was seen that the rate of the exploratory teaching model increased as the grade level increased and, on the other hand, the rates of explicit teaching model decreased as the grade level increased.

There was not a significant relation between the preservice teachers' science teaching drawing test scores and their genders [t (298) =.360; p> .05]. It was found that the difference between the mental models according to grade level was significant at a rate of (p<.01). At the end of the Scheffe test, it was determined that the differences between the fourth grade students and the first, second and third grade students was significant. Accordingly, it was seen that as the grade level increased, preservice teachers' mental models changed from the explicit teaching model to the exploratory teaching model.

Discussion

In the present study, the mental model of the majority of preservice teachers for science teaching (61%) was the conceptual teaching model. The average score that preservice chemistry teachers, who participated in the study of Elmas et al. (2011) obtained from the DASTT-C, showed that their mental model was the conceptual teaching model. On the other hand, 41% of the preservice teachers made drawings which reflected the teacher-centered teaching model in the study of Yılmaz et al. (2007). The remarkable side of the science and technology curriculum is that constructivism is addressed as a learning theory (Ünder, 2010) and it proposes that teachers should use innovative teaching strategies in their lessons (Karadağ, Deniz, Korkmaz, & Deniz, 2008; Sözbilir & Kutu, 2008). The mental models of preservice teachers fell behind the constructivist teacher model which was aimed for by the curriculum. Furthermore, the fact that this model is in the transition area between student-centered and teacher-centered teaching models shows that these beliefs are not in conformity with the traditional/explicit teaching model.

According to Minor et al. (2002), gender is an important element when preservice teachers' perceptions about education and efficient teacher take shape. However, the results of this study show that there is not a significant difference between preservice teachers' mental models according to their gender. Different results were obtained in the studies which examine preservice teachers' beliefs about teaching according to gender. Female preservice chemistry teachers reflected student-centered approaches in the studies of Elmas et al. (2011) while male preservice teachers reflected teacher-centered approaches. Moreover, Decker and Rimm-Kaufman (2008) revealed in their study that male preservice teachers found the teacher-centered learning environment convenient for themselves more than did the female preservice teachers. However, in the study of Yılmaz et al. (2007) where DASTT-C was used, the scores that the preservice teachers obtained did not show any difference according to gender. Moreover, a significant difference was not observed in other studies which examined the beliefs of preservice teachers about science teaching, however, in these studies DASTT-C was not used (Gencer & Cakiroglu, 2007; Sarıkaya, 2004). In the present case, the finding of the research on gender variables is in line with some studies, though it does not share a common perspective with other ones.

According to another finding of the present research, as the grade level increases, the preservice teachers' mental models change from an explicit teaching model to an exploratory teaching model. This finding shows us that it would be erroneous to consider the intellects of preservice teachers as "empty vessels" because they already have beliefs about teaching before entering a teacher training program (Duru, 2006). Chong, Wong, and Queck (2005) argue that preservice teachers believe that teaching is easy and information can be easily transferred when they enter a teacher training program. These, the teacher-centered beliefs of preservice teachers, can be affected (Ng et al., 2010) and changed (Aldemir & Sezer, 2009) with their field experiences. Preservice teachers have rather teacher-centered beliefs about science teaching as they take mostly field courses in the first period of their program (Denizoğlu, 2008). However, as they take classes related to their fields, such as "Teaching Methods", "School Experience" and "Teaching Practice", they get a sense of themselves as teachers and their beliefs about the teaching profession and the learning and teaching process change (Aydın, Selçuk, & Yeşilyurt, 2007; Erarslan, 2009). Liaw (2009) states that the field experiences that preservice teachers have in elementary schools help them to put into practice the educational information and theories they learn. Preservice teachers made rather teacher-centered drawings before having these experiences; however, the drawings changed into ones related to a student-centered

model thanks to those experiences (El-Deghaidy, 2006; Mensah, 2011). The above mentioned studies reveal the effect of their educational experiences on the formation and development of their beliefs about science teaching.

Implications

The present research offers explicit information to the researcher about the mental models of preservice teachers in regard to science teaching. This information can be used as a starting point for academics who work in teacher training in order to determine preservice teachers' beliefs about science teaching. From now on, preservice teachers should be provided with environments where they can discuss their beliefs in changing their teacher-centered beliefs into student-centered beliefs (Aldemir & Sezer, 2009; Markic & Eilks, 2008).

The results of this study are valid for preservice teachers who study in the science teaching departments of two universities. But it may be possible to reach different conclusions by conducting research on preservice teachers studying in different universities.

When recent studies of science education are examined, it can be seen that researchers also use drawing and drawing tests, besides such data collecting instruments as questionnaire and scale (Hestness, McGinnis, Riedinger, & Marbach-Ad, 2011; Katz, McGinnis, Riedinger, Dai, & Pease, 2011). Drawing tests should be considered as instruments to provide profound information concerning the mental models for science teaching (Finson & Pederson, 2011). For this reason, it is proposed that researchers who want data variety should use this test in studies where teachers' or preservice teachers' beliefs about science teaching are examined.

Finally, it is proposed to repeat the present results, which were obtained in relation to gender and grade levels in preservice science teachers' mental models for science teaching, with new research studies. It is also proposed that further studies, where the relation between preservice teachers' individual features, such as previous experience in science teaching and learning styles, and their mental models should be conducted.

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