

Turkish Pre-Service Mathematics Teachers' Beliefs About Mathematics Teaching

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Abstract: The purpose of this study was to ascertain the beliefs of mathematics teacher trainees about their chosen profession before they began their service. Specific topics included instructional approaches, the role of the teacher, interaction among students, and interaction between teacher and students during class. Data were collected by use of an open-ended questionnaire administered to 46 pre-service mathematics teachers. Most of the participants in the study held non-traditional beliefs about mathematics teaching. This finding has several implications for teacher education.

In recent years, much research has been conducted into the affective domain of mathematics education. Studies have found that affective variables, such as attitude, motivation, and anxiety, are strongly linked to learning mathematics. That is, if a student has a negative attitude towards mathematics, this will negatively impact upon his learning (McLeod, 1992; 1994). Nowadays, beliefs are considered to include both cognitive and affective issues. On the other hand, research studies indicate that teachers' beliefs were found to affect their instructional practices (Stipek, Givvin, Salmon & MacGyvers, 2001; Even & Tirosh, 1995; Nespor, 1987; Thompson, 1985). Experiences as a student in school or in teacher education programs, as well as their own teachers, influence how beliefs about teaching are shaped (Brown & Borko, 1992). Beswick (2006) pointed out that "a greater and more explicit focus on teachers' beliefs would be beneficial" (p.17). Moreover, studying beliefs is important because "an analysis of belief structures, attention to the intensity with which beliefs are held, and the nature of the evidence that supports beliefs can provide a forum by which our teacher education programs will be better able to address issues of reform" (Cooney, Shealy & Arvold., 1998, p. 331). It therefore is important to determine teachers' beliefs about teaching during their education program, before they enter service. The purpose of this study was to find out the beliefs of pre-service mathematics teachers about mathematics teaching.

Literature Review The Construct of Beliefs

Before reviewing previous studies about teachers' beliefs about mathematics teaching, it is important to define the term "belief." As Beswick (2005) mentioned, although the concept of beliefs has been a very popular element of research in recent decades, this construct lacks a commonly agreed definition. That is, the literature contains inconsistent definitions of the term "belief." Different researchers used differing definitions. For example, Sigel (1985) described beliefs as "mental constructions of experience" (p.351). According to

Richardson, (1996), beliefs are “psychologically held understandings, premises, or propositions about the world that are felt to be true.” (p. 103).

Various ways have been used to distinguish beliefs from knowledge. For example, Nespor (1987) stated the four characteristics of beliefs to be existential presumption, alternativity, affective and evaluative loading, and episodic structure; these distinguish beliefs from knowledge. One of the features of beliefs is the existential presumptions, which are personal truths and cannot be changed by persuasion. Therefore, the beliefs one holds may not agree with others’, whereas knowledge is a social construct, which must meet the criteria of truthfulness in the over-all community (Green, 1971). And alternativity, the conceptualization of ideal situations separate from present reality, is another characteristic of beliefs. In order to reach this ideal situation, knowledge systems where goals and the paths to their achievement, are required (Nespor, 1987).

In addition, both evaluative and affective components, such as feelings and subjective evaluations, affect one’s beliefs. However, knowledge is not dependent on these components. To clarify, a teacher’s feelings about a subject does not affect his/her knowledge whereas his/her beliefs about teaching that subject are affected by his/her feelings (Nespor, 1987). Finally, beliefs have episodic structure; that is, past experiences or events can be influential in shaping beliefs. As Calderhead and Robson (1991) stated, experiences as a student (*i.e.*, particular events in the classroom) may affect pre-service teachers’ images of teaching.

Belief systems have been described as beliefs organized in a psychological form, however, not necessarily logically (Rokeach, 1968). Within a belief system, intensity of beliefs may be varied: Some beliefs are more central, whereas some are peripheral. The more central the belief, the more resistant it is to change (Green, 1971; Rokeach, 1968). Finally, inconsistencies among beliefs may exist.

Studies on Beliefs about Mathematics Teaching

A teacher’s system of beliefs about teaching involves their beliefs about students, learning, the nature of the science [mathematics], epistemology, and the role of teachers (Wallace & Kang, 2004). Two types of research have dominated the literature about mathematics teachers’ beliefs. Some studies have aimed to investigate descriptively mathematics teachers’ beliefs about mathematics teaching, learning and the nature of mathematics; other studies have explored the relationship between mathematics teachers’ beliefs and their teaching practices.

Descriptive Studies about Teachers’ Beliefs

Studies directed at determining teachers’ beliefs about mathematics teaching have demonstrated that many pre-service teachers believed that mathematics is a closed set of procedures and that mathematics teaching meant transferring the correct information to students (Ball, 1991; Brown, Cooney & Jones, 1990; Thompson, 1992). Gates (2006) pointed out by referring to Romberg and Carpenter (1986) and Cuban (1984) that this characterization of mathematics teaching was widespread and had persisted as a dominant model during the past 100 years.

However, Thompson (1985) found that a mathematics teacher may possess constructivist beliefs. Mapolelo (1998) similarly found that the pre-service teachers in his study believed that learning mathematics meant being able to solve a mathematics problem.

Barkastas-Tasos and Malone (2005) stated that secondary level mathematics teachers held two main beliefs: a contemporary-constructivist orientation and a traditional-

transmission-information processing orientation. Seaman, Szydlik, Szydlik and Beam (2005) stated that the majority of pre-service elementary level mathematics teachers described mathematics as a collection of rules and formulas, but simultaneously believed that mathematics was a creative, flexible endeavor. Cady and Rearden (2007) reported that most pre-service mathematics teachers described the student's role as passive, but believed that mathematics teachers should provide real-life mathematical problems. Beswick (2007) reported nine constructivist beliefs of secondary mathematics teachers; the teachers in her sample advocated the establishment of classroom environments that were consistent with the principles of constructivism.

Andrews and Hatch (2000) compared Hungarian and English teachers' conceptions of mathematics and its teaching and found the most obvious difference between the two groups to be that Hungarian teachers tended to reject the idea of creating a mathematically enriched classroom environment, whereas their English colleagues would accept it.

Gellert (1999) reported that the prospective elementary teachers in his sample regarded mathematics classes mainly in terms of the degree the pupils enjoyed them and thus regarded the teacher's role as an entertainer.

Studies about the Relationship between Teachers' Beliefs and Practice

In terms of the relationship between teachers' beliefs and their practice, some studies indicated consistency (Even & Tirosh, 1995; Stipek *et al.*, 2001; Thompson, 1985; Speer, 2005). Thompson (1985) explained this consistency by noting that a mathematics teacher with constructivist beliefs was observed to encourage her students to construct knowledge by making their ideas explicit and explaining their reasoning in her instruction; this is a constructivist approach. Similarly, Even and Tirosh (1995) brought out that instruction by a teacher who believed mathematics to be a set of unexplainable rules called for memorization of those rules. Moreover, Stipek *et al* (2001) indicated that teachers with traditional beliefs employed traditional practices. For example, they did not give their students much autonomy to become involved in the learning process. Similarly, Speer (2005) pointed to a relationship between teachers' beliefs and their practice, especially regarding the role of the teacher.

On the other hand, some research studies found inconsistency between teacher beliefs and practice (Cooney, 1985; Raymond, 1997; Thompson, 1992; Westerman, 1990; Shield, 1999; Barkastas-Tasos & Malone, 2005). For example, Raymond (1997) found that beginning mathematics teachers although believed to teach according to principles of constructivism; in practice they used mostly traditional methods in the classroom. Similarly, the research of Barkastas-Tasos and Malone (2005) showed that mathematics teachers held less traditional beliefs compared to their instruction, but the reality of the classroom environment prevented them from putting their constructivist beliefs into practice. The classroom situation can influence the transfer of teachers' beliefs into practice (Leinhardt, 1989; Brown & Borko, 1992; Westerman, 1990; Barkastas-Tasos & Malone, 2005; Beswick, 2005).

Underlying Reasons of not Finding Relation between Teachers' Beliefs and Practice

Beswick (2006) explained such inconsistencies by the notion of clustering. From Green (1971) she stated, "[A] person may hold beliefs that contradict one another without being aware of the contradiction" because "beliefs within a system can be held in groups that are isolated from other beliefs." (p.17). On the other hand, Speer (2008) proposed that data

collection and analysis methods might underlie the different findings on relationships between belief and practice. She claimed that if the aim of a study is to find out the relationships between beliefs and instructional practices, then survey and interview research is not productive: "Those methods may be fine for documenting beliefs held by teachers, but those beliefs, at that level of detail, may carry little explanatory power for teachers' instructional decisions" (p.262). Leatham (2006) also argued that such consistencies are due to the underlying framework for conceptualizing teachers' beliefs: "Instead of viewing teachers' beliefs as inconsistent, teachers' abilities to articulate their beliefs as well as researchers' interpretations of those beliefs are seen as problematic." (p. 92).

Factors Influencing Beliefs and Importance of this Study

As cited above, personal experiences, episodes or events in the past, are influential in shaping beliefs (Calderhead & Robson, 1991; Nespor, 1987; Richardson, 1996; Grootenboer, 2008). Thus, beliefs have a contextual nature; they may depend on the contextual factors of the beholder. Furthermore, Hofer and Pintrich (1997) pointed out that teachers' views about mathematics and mathematical knowledge were related closely to what they thought about mathematics teaching and learning.

It is clear that determining teachers' beliefs in different countries is important, because teachers in different countries may have different experiences as a learner. The research question in this study, therefore, was to learn the beliefs about teaching mathematics held by pre-service mathematics teachers in Turkey, in terms of:

- a. the teacher's instructional approach;
- b. the role of the teacher;
- c. interaction among students during class; and
- d. interaction between the teacher and students during class.

Method

Sample

Forty-six mathematics teacher trainees participated in the present study. They were enrolled in a five-year teacher education program at the Secondary Mathematics Education Department of one of the top Universities in Ankara, capital city of Turkey. In the first seven semesters, pre-service teachers in this program complete subject matter courses related to mathematics. In the remaining three semesters, they take pedagogical courses. Participants in the present study were attending the fifth (final) year of the program and expected to graduate at the end of the following semester. They had completed subject matter courses such as General Mathematics, Linear Algebra, Discreet Mathematics, Algebra, and Topology, as well as most of the pedagogical courses such as Introduction to Teaching Profession, Methods of Mathematics Teaching, Classroom Management, Instructional Technology and Material Development. When the pre-service teachers in my sample are graduated from their departments, they will be qualified to teach in middle and high schools. Beside these they can be employed by Mathematics Education Departments of universities as well as by the Ministry of Education and private schools as academics, supervisors, inspectors, curriculum consultants, test and evaluation specialists in mathematics education.

In the general pedagogical courses such as Introduction to Teaching Profession and Classroom Management, participants were taught the basic characteristics of teaching as a profession, the scholastic environment, and educational system, strategies for effective classroom management, and dealing with students with behavioral problems.

Subject-related pedagogical courses, e.g. Methods of Mathematics Teaching, dealt initially with theoretical knowledge about methods such as cooperative learning, discovery-based learning, and problem-based learning. Pre-service teachers then were given the opportunity to teach mathematics topics in the university, using different methods.

They also had completed two School Experience courses, each one semester-long, which placed them in high schools for 40 hours a semester. They had the chance to observe (and hopefully understand) teaching as a profession and the culture of a school and classroom. They observed their mentors' instructional practices, strategies of classroom management, and questioning skills in mathematics classes, and were supposed to report these observations to their university tutors as an activity to be assessed.

In some cases, the teacher trainees were more actively involved in the teaching process; some designed a worksheet and applied it to some students or carried out some group work with the students. However, talks with teacher candidates revealed that they had problems in these courses. For example, they told that they did not see the application of teaching methods taught in the university in the high schools. Moreover, they did not make use of these observations because they just observed similar issues due to the traditional instruction carried out in schools (Boz & Boz, 2006).

Instrument

Participants in this study were asked an open-ended question, containing several subheadings, in order to obtain the pre-service mathematics teachers' beliefs about how mathematics should be taught effectively. The question asked:

In your opinion, how can mathematics be taught effectively? Please consider this issue under these headings:

- a) the teacher's instructional approach;
- b) the role of the teacher;
- c) interaction among students during class; and
- d) interaction between the teacher and students during class.

Please answer in as much detail as possible.

The participants were asked to respond to this question during class; one class hour (50 minutes) were devoted exclusively to this task. They were assured that their involvement in the research would not affect their grades.

Data analysis

In order to make sense of the resulting data, the written responses were first read several times and categorized in four main groups, adapted from the study of Raymond (1997). In that study teachers' beliefs about teaching mathematics were categorized in five groups: "traditional," "primarily traditional," "even mix of traditional and non-traditional," "primarily non-traditional," and "non-traditional." It was impossible to make such clear distinctions of the responses in the present study, but it was feasible to develop four categories of belief: "traditional," "mix of traditional and non-traditional," "non-traditional," and "not codeable." For each aspect of teaching included in the research question (*teachers' instructional approach, role of the teacher, interaction among students during class, and interaction between students and the teacher during class*), four categories were constructed.

- a. *Traditional beliefs*: The beliefs of the pre-service teachers in this group were close to traditional regarding all aspects of mathematics teaching. These pre-service teachers believed that the role of the teacher was to present the facts to students; they therefore expected a quiet class environment, in which students listened to the teacher.
- b. *Mix of traditional and non-traditional beliefs*: The beliefs in this category of pre-service teachers were inconsistent. For example, they believed in the constructivist role of the teacher, but nonetheless preferred the traditional instructional approach. Similarly, a participant might at the same time hold both traditional and non-traditional beliefs about the instructional approach.
- c. *Non-traditional beliefs*: Beliefs in this category of participants were predominately constructivist. For example, they believed the role of the teacher would be to guide and support students' learning. In addition, they also believed student-centered instruction and there should be interaction among students for the construction of knowledge.
- d. *Not codeable responses*: In two cases it was not possible to put the student-teachers' responses into any of the above categories. Therefore, these were categorized as not codeable. As an example, this category included the statement "*I do not think there is an exact answer to this question. Many methods for effective teaching exist. However, in order to use these methods, certain issues need to be considered.*"

After determining the frequency of the participants' responses in the four categories for each aspect of teaching, five cases of students, each representing traditional beliefs, mix of traditional and non-traditional beliefs and non-traditional beliefs were selected as representative of the results. Fatma and Zeynep represented non-traditional beliefs; Sevgi and Ali represented the student-teachers with a mix of traditional and non-traditional beliefs; and Mustafa represented traditional beliefs. Ali and Sevgi mixture of traditional and non-traditional beliefs appeared in the context of a teacher's instructional approach and interaction between students and teacher, whereas they held non-traditional beliefs about the role of the teacher and interaction among students. Therefore, in the present study, two distinct but closely linked sets of data existed. The first data belonged to the larger group and the second belonged to individuals within the different clusters to supplement the group findings and contained illustrative excerpts of these individuals. By means of these sets of data, I hoped to portray pre-service mathematics teachers' beliefs about mathematics teaching.

Profiles of representative examples

Fatma, a female, was a hard-working, successful student, whose grade-point average (GPA) was 3.14 out of 4. She was eager to learn, regularly attended classes, always participated in class discussions, and always handed in her homework on time. She had no prior teaching experience, but said she sometimes taught her brother.

Zeynep, female with a 2.84 GPA, had a good class-attendance record and usually completed her assignments on time. She sometimes participated in class discussions. She said she had no previous teaching experience.

Sevgi, female with a 3.04 GPA, was hard working, had a good attendance profile, and always handed in her assignments on time. However, she was an introverted student who did not participate in classes. She reported not having any prior teaching experience.

Ali, male, was not a hard-working student; his GPA was 2.06. He sometimes did not attend classes and exhibited problems in handing in assignments on time. He was tutoring high school students mathematics privately.

Mustafa was a male with a 2.48 GPA. He did not attend classes regularly and sometimes made excuses for late submission of assignments. He gave private tutoring to some students for mathematics and worked in a private tutoring center.

Results

Table 1 gives the frequency of pre-service mathematics teachers’ responses belonging to each of the four categories for each aspect of teaching.

Category*	A	B	C	D
<i>Teachers’ instructional approach</i>	34	7	3	2
<i>Role of the teacher</i>	41	0	5	0
<i>Interaction between students and teacher during class</i>	27	17	2	0
<i>Interaction among students during class</i>	38	0	8	0

*A: Non-traditional beliefs, B: Mix of traditional and non-traditional beliefs, C: Traditional beliefs, D: responses not codeable

Table 1: Frequency of pre-service mathematics teachers’ responses

Analysis of the data indicated that the great majority of these pre-service teachers held non-traditional beliefs about mathematics teaching overall. Below, results are reported in terms of the four aspects of teaching: the teacher’s instructional approach, the role of the teacher, interaction among students during class, and interaction between students and teacher during class.

Teachers’ instructional approach

Most of these pre-service teachers (34 of 46) thought that mathematics teachers should avoid memorization of formulas and instead promote student-centered instruction. Most criticized instruction in today’s mathematics classes. For example, Fatma gave this explanation (All the written responses to the question were submitted in Turkish. The quotations below were translated into English by the author).

“Mathematics is seen as a boring subject by most students. Teachers only make students memorize the rules. Students are not given the opportunity to find the reasons underlying a rule. Mathematics instruction should be student-centered, and the students should construct the knowledge themselves with the help of the teacher.”

This states that students should be involved in their learning process, a view consistent with the constructivist view of teaching. As Driscoll (2005) stated, according to constructivism students should be encouraged to feel ownership in learning.

Zeynep stated the role of prior knowledge in learning:

“Especially at the beginning of the topic, the teacher should ask open-ended questions to determine the students’ prior knowledge. Then the teacher should provide activities suitable for students to find the correct solution themselves.”

As is understood from this, Zeynep, who exhibited non-traditional beliefs, cited both the importance of pre-existing knowledge as well as the responsibility of learners to reach the correct answer. Both these factors were also included in the constructivist view of teaching (Driscoll, 2005).

Fatma explained knowledge construction by students with a specific example from mathematics:

“In the Material Development course, last semester, we learned to find why there is a need to divide by three in the volume formulae of a pyramid, which is a solid, by using cubes of sugar. We came to the correct solution by this activity; we did not memorize a formula.”

The above explanation reveals that that pre-service teacher’s experience in the Material Development course in the university influenced her belief regarding the instructional approach.

Seven students had conflicting beliefs about the instructional approach of teachers for an effective teaching. For example, Ali gave the following explanation:

“First of all, the teacher should use teaching methods other than traditional to prevent memorization. For example, the teacher may use modeling and some concrete examples in explaining the topic. Students will learn better with visual elements; this will help them remember more easily.”

The first belief this pre-service teacher exhibited was the necessity of applying teaching methods different from traditional instruction, in parallel with non-traditional instruction. However, she mentioned using concrete examples to help students remember easier; she did not mention students’ construction of knowledge at all. Her aim was to find a way to make students remember easily.

Another student with this view, Sevgi, explained her reasoning:

“Student should be active in class. Teachers should not use traditional instruction any more; they should use student-centered instruction. The teacher should not make a student memorize formulas. Instead, the teacher should solve many problems and ask questions of the students while solving the problems. Practice is important for learning.”

Similarly, although the student-teacher believed that using student-centered instruction and creating an active role for the student, both characteristics of non-traditional instruction, were necessary for effective teaching, she mentioned the importance of solving mathematical problems, skill and drill mathematics, which are not closely related to conceptual understanding.

On the other hand, three of the participants believed in traditional instruction for effective teaching of mathematics. For example, Mustafa associated students’ learning with solving multiple problems:

“The teacher should explain the topic. However; the important point is to provide a lot of questions to the class, since students can learn better by solving problems.”

This quotation reflects the traditional instructional approach: transmission of information from the teacher to students.

Role of the teacher

Most of the pre-service mathematics teachers in the study (41 of 46) held non-traditional beliefs about the role of the teacher and described the teacher as a guide and coach for students. The common explanation was given by Zeynep:

“As we learnt from our methods course here, the teacher should not give the correct explanation, instead he should provide the necessary environment to help students think critically and analytically, and he should give some clues and guide students to find the correct solution themselves.”

This explanation provides some evidence of the affect of the methods courses in the university; that is, the theoretical knowledge learned in the methods course was influential in shaping Zeynep’s beliefs about the role of the teacher.

However, five respondents described the role of the teacher as the presenter of the facts. For example, Mustafa stated:

“Mathematics is an abstract subject, and most students do not like mathematics. The role of the teacher is to explain mathematical concepts step-by-step and to review these concepts in order to help students remember.”

This view requires the transfer of correct knowledge, which is consistent with the traditional view.

Interaction between students and teacher during class

A majority of the student-teachers (27 participants) stated they believed there should be an interaction between students and the teacher during class. Some of the pre-service teachers explained that interaction between students and the teacher was necessary for monitoring the students’ progress. For example, Fatma represented this view:

“There should be interaction between students and the teacher. The teacher should also not be too strict. If s/he is too strict, students will be afraid to express their ideas. However, teachers should constantly ask questions, so that students express their ideas continuously. This will help teachers monitor their students’ learning and accordingly adjust their teaching.”

For Fatma, asking questions would help students express their ideas, and the teachers could then adjust their instruction based on these ideas. Since this explanation implies that student ideas are important and that student ideas should be taken as a basis for instruction, this reflects the non-traditional view of teaching.

On the other hand, the explanations of some participants (17) who mentioned the importance of student-teacher interaction did not reflect a constructivist approach. Instead, they mentioned that students would not become bored, instead would enjoy the class due to this interaction. Ali held this view:

“When teachers interact with their students, students enjoy the class and do not get bored. Therefore, they can concentrate on the class more.”

Two participants had completely traditional beliefs about student-teacher interaction during class. Mustafa stated:

“I know from my school years that we used to ask questions of the teacher in order to waste time. Therefore, I do not believe that there should be much interaction between the teacher and students. Instead, students should listen carefully in class and answer the teacher’s questions. If there is something they do not understand, they can ask after class.”

Mustafa’s experience as a learner influenced his belief about student-teacher interaction.

Interaction among students during class

Most (38 of 46) participants thought interaction among students was necessary, as it would help them listen to other students' views. Ali's explanations were:

“Interaction is necessary for learning. I know this from my experience. When I explain to others, I learn better, since I have the chance to share different views. For example, in some cases, you are sure that you know a topic well, but when you explain it to another person, s/he may ask you a question that will make you wonder. Then you begin to search the relevant books, and this helps you learn.”

Thus, Ali cited the importance of social interaction in knowledge construction. As Driscoll (2005) stated, social negotiation is an important aspect of constructivism. In the formation of this belief, Ali's experience as a learner was influential: He learned better by listening to other students' views.

On the other hand, eight teacher trainees with traditional beliefs said they thought a quiet class environment was required for an effective class. They therefore believed there should not be much interaction among students during class.

Discussion

This section will be discussed in two parts; descriptive analysis of teachers' beliefs and factors affecting pre-service teachers' beliefs.

Descriptive analysis of teachers' beliefs

This study investigated pre-service mathematics teachers' beliefs about teaching mathematics in terms of the instructional approach, role of the teacher, interaction among students and between students and the teacher during class. For the instructional approach, most of these mathematics teacher trainees believed that student-centered instruction, including an active role for students in the learning process, was necessary. Similarly, most perceived the role of the teacher to be a guide and believed in the necessity of interaction among students in knowledge construction. Regarding interaction between the teacher and students, some student teachers believed that interaction was necessary, in conformity with the non-traditional view. However, some of these subjects held the belief that interaction was necessary to avoid student boredom.

Considering all aspects of mathematics teaching, the study found that few of the pre-service teachers held traditional beliefs; most followed the constructivist view of teaching. This finding conflicts with several other studies showing that teachers held traditional views (Ball, 1991; Brown, Cooney & Jones, 1990; Thompson, 1992; Mapolelo, 1998). On the other hand, the finding of this later study is similar to that of the research by Thompson (1985) which mentioned constructivist beliefs by a mathematics teacher. Lloyd (2005) also reported that a prospective teacher in his sample had avoided traditional views about the role of the teacher. Specifically, this prospective teacher strongly avoided teacher-centered instruction in which teachers straightforwardly lead students. However, this prospective teacher was reported to have had difficulties developing ideas in line with constructivism about what to do in the classroom.

In addition, this study also revealed inconsistencies in the beliefs of some pre-service teachers had. To illustrate, Sevgi held both constructivist and traditional beliefs about the

instructional approach for effective instruction. Moreover, although Ali's belief about the role of the teacher reflected a non-traditional approach, he held a mix of traditional and non-traditional beliefs regarding teachers' instructional approaches and interaction between students and teacher. Inconsistent beliefs have also been discussed in the literature (Green, 1971; Thompson, 1984; Seaman, Szydlik, Szydlik, & Beam, 2005). However, as these pre-service teachers gain more experience, these inconsistencies may diminish.

Factors affecting pre-service teachers' beliefs

In the present study, university courses seem to have had an effect on shaping the student teachers' beliefs. Clues for this claim were apparent in some responses: Some mentioned courses they took at the university (*e.g.*, Material Development, Methods of Mathematics Teaching). One example was Fatma's experience in the Material Development course learning the reason for dividing three in the volume formulae of a pyramid by using cubes of sugar; this had an effect on shaping her beliefs about the approach to be used for teaching mathematics. She said this demonstrated that students should be involved in the learning process. Another example for the effect of courses in the university was given by Zeynep, another student with non-traditional beliefs: She explained the role of the teacher by referring to what she had learned in methods courses.

Moreover, their experiences as learners were found to have an effect in shaping pre-service teachers' beliefs about mathematics teaching. For example, Mustafa related that he used to ask questions of the teacher in order to waste time. This experience made him believe that students should not ask questions in class and influenced his beliefs about the student-teacher interaction. In this case, Mustafa's experiences as a learner caused him think the opposite. For example, he did not believe in interaction between students and the teacher because he did not have beneficial experience with it. Another pre-service mathematics teacher, Ali believed the necessity of interaction among students because he thought that he learnt better while interacting with his peers. This experience as a learner influenced his belief about the interaction among students.

One of the underlying reasons for the results of this study might be the reform movements in education in Turkey. That is, the fact that most of the prospective teachers held constructivist beliefs might result from their university training. It should be pointed out that a new system for mathematics education faculties in Turkey was started in 1997, when the Higher Education Council – the planning, coordinating and policy making body for higher education in Turkey (Yüksek Öğretim Kurulu, or YÖK) – began implementing changes to set minimum standards common to all Turkish education faculties. The Turkish Ministry of Education (MEB), the World Bank, and YÖK have been working together on projects to develop the quality of Turkish education faculties. According to YÖK, pedagogical courses in the previous system were mainly theoretical courses in educational sciences, which did not perform the function of giving prospective teachers the knowledge, ability, and vision required in teaching. Parallel to staff development for education faculties, courses in these faculties have been reorganized so that their learning outcomes are similar to those in European universities that are partners in the European Higher Education Area.

In curriculum development movements from elementary education to high school, curriculum developers and the minister of National Education cite the dominant effect of the constructivist approach. Issues related to constructivist teaching are widely discussed in Turkish mass media. Hence, constructivist approaches have become very popular in recent years in Turkey, affecting prospective teachers' beliefs about education.

The influence of students' prior experiences and teacher education programs have been covered in the literature (Brown & Borko, 1992; Nespor, 1987; Calderhead & Robson, 1991; Raymond, 1997; Stuart & Thurlow, 2005; Scott, 2005; Seaman, Szydlik, Szydlik, & Beam, 2005; Wilkins & Brand, 2004). Stuart and Thurlow (2005) wrote of the influence of mathematics methods classes in the university on the development of pre-service teachers' beliefs. Scott (2005) mentioned the influence of personal experiences and observations in the university on belief formation. Seaman, Szydlik, Szydlik, and Beam (2005) pointed out the shift of pre-service teachers' beliefs about teaching towards constructivist views within the teacher education program.

Implications

Despite the fact that beliefs are resistant to change, reflecting on classroom experiences has been found to be an effective way to change teachers' beliefs (Cohen & Ball, 1990). Stuart and Thurlow (2005) mentioned the importance of pre-service teachers' reflections on their experiences with mathematics lessons; their previous experiences could be helpful as they reevaluate their beliefs. Since they would observe an actual classroom situation, it may be beneficial for them to reflect on their beliefs. Moreover, Scott (2005) stated the necessity of matching the instruction by lecturers in the university with the advice about instructional methods they give. Therefore, if teachers of education want student teachers to develop constructivist beliefs about mathematics teaching, their class instruction should reflect constructivism. However, as Ambrose (2004) pointed out, building upon prospective teachers' existing beliefs is a gradual process. Furthermore, in order to "build on prospective teachers' beliefs, one must recognize that their beliefs about mathematics teaching and learning are part of a larger system of beliefs that also includes beliefs about teaching generally" (Ambrose, 2004, p. 96).

Future study might investigate the relationship between beliefs and practices, or the effect of teacher education programs on prospective teachers' beliefs. Furthermore, cross-cultural/international research studies on beliefs could be carried out. Finally, further research could consider cross-gender issues.

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