Professional development of Turkish mathematics teachers within a computer-supported learning environment: changes in beliefs

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The purpose of this study is to investigate the degree to which a professional development (PD) course based on the use of dynamic geometry affects the beliefs of school teachers with regard to three aspects: the nature of mathematics, teaching mathematics and learning mathematics. The PD course was designed to provide six teachers with a better theoretical and practical understanding of mathematics teaching and learning through interacting with computer-based mathematical activities that were consistent with the constructivist paradigm. The primary intention was to find out how participants in such a learning environment form their beliefs. The potential shifts in beliefs of the participants were identified using a pre-and post-course mathematical beliefs questionnaire. Overall, the results indicate that such efforts transformed teachers' beliefs to some extent in favour of the constructivist view.

Keywords: professional development, teacher beliefs, dynamic geometry

Introduction

The Turkish Ministry of National Education (MONE) has the responsibility to raise the quality of the educational system and to comply with the standards advised by the European Union. The curriculum designed for mathematics in primary schools addressed to pupils between the ages of 7 and 15, has been revised since 2005 by MONE as part of reforms aiming to move from a subject-based didactic model to a learner-based constructivist one. The new curriculum initiatives have also encouraged the introduction of technology applications into mathematics education. As expected, a great number of teachers tend not to depend upon recent pedagogical trends but rather on their personal conceptions when trying to implement the curriculum in their teaching (Handal and Herrington 2003). Therefore, teachers possess a different range of beliefs about curriculum, their own teaching, students' learning, teaching and learning, in relation to mathematics (Shahvarani and Savizi 2007). Conceptions and beliefs about mathematics and its teaching and learning might be considered as good indicators of teachers' teaching strategies in classroom (Handal and Herrington 2003). In short, teachers' mathematical beliefs might reflect what is being taught and learned in classrooms. It might be argued that participants need support in adopting an approach based on a constructivist perspective and integrating technology in their teaching.

Design of the PD course

The first step of study was to design a course based on the use of dynamic geometry systems (DGS) to help mathematics teachers learn to teach for understanding by adopting an approach based on a constructivist perspective. Six mathematics teachers, all teaching pupils aged 12-14, participated in seven workshops. These aimed at providing experience with how to integrate mathematical software into mathematics education.

Figure 5: PD course stages

Introductory:

The introduction part consisted of technical level activities designed to help the participants to obtain the basic skills needed for independent use of Geogebra. During the introduction, general information about the development and potential of DGS for teaching and learning mathematics was presented and discussed. This session, lasting 3 hours, was to help participants become familiar with Geogebra.

Exploratory:

In the exploratory stage, investigational mathematical activities were adapted from the areas of the Turkish mathematics curriculum and Geogebra website. The second stage included five worksheets in which the activities were described (12 hours). The course participants worked on these activities in pairs. During pair work, I did not give examples or tell them how the tasks are solved. When group work was completed, they were encouraged to discuss their initial thoughts about activities. Such pair work was designed to help teachers keep in touch with each other and share their ideas about mathematics understanding. My involvement was only to initiate discussion or conversation.

Home-based:

Between the group workshops the participants were required to continue working on a home based exercise in their home in order to see the practical results of the pair study because they were able to apply their knowledge about Geogebra. Here, the main aim was to provide participants with a "protected environment" where they would be able to examine their experiences. Then they were asked to present their solution and findings each other at the beginning of each workshop.

Literature Review

Mathematics-related beliefs

Teachers' beliefs "seemed to be manifestations of unconsciously held views of expressions of verbal commitments to abstract ideas that may be thought of as part of a general ideology of teaching" (Thompson 1984, 112). They reflect how teachers come to enact their role in the classroom, their preference for classroom activities, and their approaches to teaching. These beliefs have been developed over years of schooling and frequently are reinforced by the existing culture of the education system. Ernest (1989, 249) strongly argues that "Teaching reforms cannot take place unless teachers' deeply held beliefs about mathematics and its teaching and learning change". The reform in Turkey was introduced by MONE through a top-down approach which disregards teachers' conceptions and classroom practice and the essential changes necessary to the adopted innovation (Perry, Howard and Tracey 1999). Therefore, it is not easy to change (Chapman 2002) or transform a teacher's long-held, and deeply rooted, conception. However, change takes place under such circumstances where the individual encounters novel information and experiences that contradict long-held beliefs (ibid).

In order to understand how teachers learn and change, we have to look at teachers' beliefs and conceptions about mathematics and categorize them. Ernest's study in 1989 has tried to classify teachers' beliefs about the nature of mathematics and its relationship with teaching and learning. These beliefs are a core element in determining the teacher's characteristic patterns of instructional activities and ensuring that these are reflected in their classroom practices. Teachers' mathematical beliefs are often classified into two or three view points in the literature. Perry, Howard and Tracey, (1999) distinguished two different patterns of beliefs among teachers, namely, the transmission view, and the child-centred view. According to the former view, knowledge is generally transferred to the student's mind by the teacher and the student thus takes that knowledge without any active participation. This view encourages the explanation of concepts by the teacher and the students selecting rules and procedures to solve problems rather than constructing knowledge. Those teachers who hold a child- centred view encourage the student to make sense of the subject through self-discovery facilitated by a learner-based environment as they are challenged with learning experiences which build on and draw on existing knowledge.

Potential of Technology and Professional development

Computer applications have appeared throughout all aspects of the education system as a pedagogic tool which might improve higher order thinking and might also provide learners with a new perspective and vision. In particular, dynamic geometry systems (DGS) are designed to provide a learning environment where students can explore and reach an understanding of powerful mathematical ideas independently. That is to say, DGS can be seen as creating an empirical setting in which "students can construct and experiment with geometrical objects and relationships" and for the investigation of "a mathematical domain" (Hoyles and Noss 2003, 332-33). These software packages allow learners to seek patterns, to investigate and to check conjectures by building their own sketches. Erez and Yerushalmy (2006) suggest that learner-centred and active learning can be promoted by incorporation of DGS into mathematics education effectively.

According to the principles of the constructivist approach, the teacher in the classroom should be a facilitator who encourages learners to take responsibility for their learning and play an active role in their process of acquiring knowledge. This process can be catalyzed in a computer environment through the interactive process of conjecture, feedback, critical thinking, exploration and cooperation. Therefore, the PD course was predicated on an interaction with computer-based investigational mathematical tasks. This challenge should involve researcher and teachers in exploration of mathematical situations, communication and application of new ideas. They can do this through individual and small group exploration, discussion and negotiation, all within a collaborative inquiry setting. In order to encourage mathematical thinking beyond the routine, participants engaged with mathematical tasks through inquiry by using Geogebra.

Methodology

Procedure and Instrument

This study is based upon research undertaken as part of my thesis. One source of data for this study, reported here, was the use of pre-post questionnaires containing 36 items dealing with teachers' beliefs about mathematics and its learning and teaching. Questionnaire items had already been used in earlier studies and validated (Goos and Bennison 2002; Barkatsas and Malone 2005). Shifts in teachers' mathematical and pedagogical beliefs were investigated by administering a questionnaire at the beginning and end of the 7 week PD course. Each section includes 12 statements about mathematical beliefs. Half of the items were phrased to reflect a constructivist view and half to reflect a behaviourist view

Analysis

Since the item scores ranged from 1 (Strongly Disagree) to 5 (Strongly Agree), and there were 6 teachers who completed questionnaires both pre-course and post-course, the total score on any item could vary from 6 to 30. Table 1 displays these totals for item pairs (i.e. negative and positive versions of the same construct) in each Section. Goos and Bennison (2002) note that the magnitude of scores is important for indicating the degree of support for each statement and they identify scores of 24 or more, and 12 or less, as indicating general agreement and general disagreement respectively with particular statements. That is to say, they identify the mean score of 4.00 and higher as general agreement and of 2.00 and lower as general disagreement. However, the mean score of 3.40 as the expected level of agreement is suggested because a five-point scale contains 4 intervals and 5 categories with the ratio 4 / 5 being equal to 0.8 (Aydin and Tasci 2005). However, we also adopt the mean score of 2.60 as the expected level of disagreement as illustrated in Figure 1.

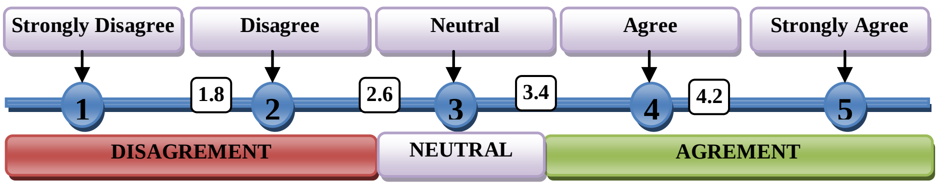

Figure 6: A Scale for Determining Agreement and Disagreement

Findings and Discussion

Table 1 indicates the mean scores of the negative and positive versions of the same construct in the questionnaire before and after the PD course. It shows that the number of positive items which are higher than the expected level of agreement was 16 both before and after the course. That is to say, the course did not influence teachers' beliefs towards positive items in the questionnaire. They inclined to maintain or strengthen their beliefs throughout the course. Surprisingly, for the beliefs about the nature of mathematics, teachers disagreed only with the notion that there are different forms of mathematics in different cultures around the world. In other words, they expressed the view that mathematics is the same worldwide. These higher scores in positive items indicate that course participants appeared to have beliefs consistent with Perry, Howard and Tracey (1999) child-centred view regard to most items. It also shows the number of negative items which are lower than the expected level of disagreement: 2 before the course and 8 after the course. This may suggest that the PD course had some effect in changing teachers' beliefs on the negative items. For example, as the mean score of the negative item Q10 is 2.83 before the PD course, it appears that the participant teachers tend neither to some agree nor disagree according to our measurement scale (see Fig 1.). However, after the PD course, the mean score of the same item reduced to 1.83. As a result, the teachers were less likely to believe that doing mathematics consists mainly of using rules. Another example to indicate the extent to which the PD course changed the teachers' beliefs may be the item Q25. That item mentions that being able to memorise mathematical facts and procedures is important for mathematics learning. The mean score of this item was 3.50 and 2.17 before and after the PD course respectively. This may suggest that participants appeared more in favour of having students to explore mathematical concepts, and were more likely to create a learning environment in which students could work cooperatively and take responsibility for their own work.

Table 4 : Some examples of pre- and post-course responses to Mathematical Beliefs Questionnaire (n=6)

Mean		**Section 1. Nature of mathematics**		**Mean**	
Pre	**Post**	**Item (positive)**	**Item (negative)**	**Pre**	**Post**
2.83	**<u>3.83</u>**	Q8. Mathematics is an evolving, creative human endeavour in which there is much yet to be known.	Q6. Technical mathematical language and special terms are needed to explain mathematics.	3.83	3.00
<u>4.33</u>	**<u>4.83</u>**	Q5. Doing mathematics involves creativity, thinking, and trial-and-error	Q10. Doing mathematics consists mainly of using rules.	2.83	**<u>1.83</u>**
		Section 2. Teaching mathematics			
<u>3.83</u>	**<u>4.67</u>**	Q16. Teachers should regularly devote time to allow students to find their own methods for solving problems	Q13. The most important component of good teaching is that teachers show students the proper procedures to answer mathematics questions.	3.67	**<u>1.83</u>**
<u>4.17</u>	**<u>4.83</u>**	Q18. Good mathematics teaching involves class discussion in which students share ideas and negotiate meanings.	Q19. Children should receive knowledge from the teacher.	3.83	**<u>2.50</u>**
		Section 3. Learning mathematics			
<u>4.00</u>	**<u>5.00</u>**	Q30. Teachers should value periods of uncertainty, conflict, confusion or surprise when students are learning mathematics.	Q36. Mathematics learning is about learning to get the right answers.	2.83	**<u>1.67</u>**
<u>3.50</u>	**<u>4.33</u>**	Q26. Students should be encouraged to build their own mathematical ideas, even if their attempts contain much trial and error.	Q25. Being able to memorise mathematical facts and procedures is important for mathematics learning.	3.50	**<u>2.17</u>**

Conclusion

The purpose of the study was to investigate changes in teachers' beliefs towards the nature of mathematics, teaching mathematics and learning mathematics following a professional development course based on the use of Geogebra. This programme, in line with a constructivist perspective, may allow participants to engage in mathematical tasks in meaningful ways so as to develop a better understanding of the role of the learner in a computer-integrated setting. This type of the course seemed to have supported participants to achieve a new understanding of mathematical learning and teaching. Therefore, the small scale study revealed that the PD course was successful to a certain extent, the number of items supports the child centred view rather than the transmission view increased from 18 to 26 out of 36. This may suggest that the PD course had an impact on a small number of participants' espoused mathematics-related beliefs to some extent in favour of the constructivist view.

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