The Effect of Methods of Teaching Mathematics Course on Mathematics Teaching Efficacy Beliefs of Elementary Pre-service Mathematics Teachers

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Abstract

Teaching efficacy beliefs have been the focus of teacher education studies for some decades as one of the most important factors affecting teachers' behaviours, attitudes and effectiveness. The purpose of this quantitative study was to investigate the effect of methods of teaching mathematics course on the elementary pre-service mathematics teachers' mathematics teaching efficacy beliefs in Turkey. Mathematics Teaching Efficacy Belief Instrument was administered to 172 junior elementary mathematics education students as pre-test and post-test prior to and after the methods of teaching mathematics course. The course was carried out through demonstrations, direct instructions and classroom discussions during 14 weeks. Paired sample t-tests were used to analyze the data and indicated that the methods of teaching mathematics course significantly increased the pre-service teachers' mathematics teaching efficacy beliefs.

Keywords: elementary pre-service mathematics teacher, mathematics teaching efficacy belief, methods of teaching mathematics course

1. Introduction

Self-efficacy, first introduced in the 1970s by Albert Bandura, is one of the important components of social learning theory and is defined as individuals' judgments about how well one can organize and execute courses of action required to accomplish certain goals. Self-efficacy is the belief about one's own capacity of reaching the necessary degrees of learning and behaving (Bandura, 1977).

According to Bandura (1977) expectations of personal efficacy are derived from four principal sources of information: performance accomplishment, vicarious experience, verbal persuasion, and physiological states. Performance accomplishment, especially past success and failure is the most influential source of efficacy beliefs. Vicarious experiences are the other factor effecting self-efficacy; the performances of other similar people may affect the judgments about self-competence, especially as individuals have little personal experience with the task. The third factor influencing self-efficacy is verbal persuasion. Encouragement may be more effective when it is realistic, reinforced by real experience and given by a credible person. Physiological states such as rapid heart beat, fatigue and pain, are the last factor effecting self-efficacy judgments.

Bandura (1977) claimed that efficacy beliefs govern how people think, feel, motivate themselves and behave, and determine whether coping behaviour is initiated, how much effort is expended, how long the behaviour is sustained as faced with obstacles and unfavourable experiences. Further, parts of behaviours are constituted by beliefs (Enochs, Smith, & Huinker, 2000). Self-efficacy beliefs mediate the relationship between knowledge and action; even individuals may possess certain skills they may prevent to perform them. In other words, to perform specific actions effectively, knowledge, skills and efficacy beliefs are required (Huinker & Madison, 1997). People, who have high efficacy beliefs, tend to make more effort when they are faced with obstacles and as they attain necessary skills, they are more faithful for struggle (Schunk, 2007, p. 105-129).

The examination of self-efficacy in relation to teaching has been the focus of several educational studies (Enochs et. al., 2000; Gibson & Dembo, 1984; Guskey & Passaro, 1994; Huinker & Madison, 1997; Tschannen-Moran & Woolfolk Hoy, 2001). Gibson and Dembo (1984, p. 570) relate self-efficacy belief concept with teacher efficacy belief as following:

> …teachers who believe student learning can be influenced by effective teaching (outcomes expectancy beliefs) and who also have confidence in their own teaching abilities (self efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning.

Teacher efficacy belief is defined as 'the extent to which teachers believe they can have a positive effect on student learning, and student achievement' (Ashton, Webb, & Doda, 1982a, p. 3) or 'teachers' belief or conviction that they can influence how well students learn, even those who may be considered difficult or unmotivated' (Guskey & Passaro, 1994, p. 628). Teachers' sense of efficacy is related to students outcomes, such as achievement, motivation and their own sense of efficacy (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998) and approved as one of the most important factors affecting classroom activities implemented by teacher (Isiksal & Cakiroglu, 2005). Teacher efficacy has two dimensions as personal teaching efficacy and teaching outcome expectancy; the first dimension, personal teaching efficacy is defined as the belief in individual's own ability to teach effectively (Dembo & Gibson, 1985; Enochs et. al., 2000; Swars, 2005). The second dimension, teacher outcome expectancy is defined as the belief that effective teaching can affect student learning positively (Enochs et. al., 2000), regardless of external factors such as home environment, family background and parental influences (Swars, 2005), school conditions and IQ (Gibson & Dembo, 1984).

Teacher efficacy influences teacher behaviours such as persistence on a task, risk taking, classroom instructional strategies, effort they invest in teaching, the goals they set, and the use of innovations (Asthon & Webb, 1986; Swars, 2005; Tschannen-Moran & Woolfolk Hoy, 2001). Teachers with high teaching efficacy beliefs, try new teaching strategies which are difficult to implement and involving risks such as sharing control with students (Riggs & Enochs, 1990). Teachers, who have strong sense of efficacy and confidence in teaching, are more likely to have students to improve their basic performances, even though students are coming from difficult home backgrounds or being difficult to motivate (Ashton et. al., 1982a). Further, they are found to be more likely to use inquiry and student centred approaches and to be more effective teachers (Czerniak, 1990; Swars, 2005), and believe that they can control or at least influence student achievement and motivation (Tschannen-Moran et. al., 1998). On the other hand, teachers with low efficacy beliefs have a tendency to use teacher centred approaches like lecturing and reading from the text (Czerniak, 1990; Swars, 2005).

According to Ashton, Webb, and Doda (1982b) teachers who have high or low sense of efficacy have a tendency to behave in some specific ways to affect student motivation and achievement. Efficacy behaviours are listed as elevating expectations, valuing, pushing (encouraging), greeting behaviour, opening and closing ritual, equalizing response opportunities, feedback and teacher help, waiting, praising and respecting. In contrast, there are some inefficacy behaviours stated in the report such as lowering expectations, sorting, devaluing, and excommunication, shot-gunning, questioning and distancing.

In recent years, the concepts of self-efficacy and teacher efficacy are becoming more popular in educational research regarding both students, pre-service teachers and in-service teachers, and there are many studies related with those in many countries. Isiksal and Cakiroglu (2006) conducted a study to investigate pre-service teachers' mathematics and mathematics teacher efficacy, and found that universities attended and grade levels have not affected mathematics teacher efficacy, but affected efficacy beliefs toward mathematics. In order to explore Turkish pre-service science teachers' science teaching efficacy and classroom management beliefs a study was carried out by Savran-Gencer and Cakiroglu (2007). Findings indicated that pre-service science teachers generally expressed positive efficacy beliefs regarding science teaching and they were interventionist on the instructional management dimension, whereas they favoured non-interventionist style on the people management dimension.

Cakiroglu (2008) compared pre-service elementary teachers' sense of mathematics teaching efficacy beliefs in a Turkish university and in a major American university. Results revealed that pre-service teachers in the Turkish sample tended to have a stronger belief that teaching can influence student learning when compared with pre-service teachers in the US. Dede (2008) examined elementary and secondary mathematics teachers' self-efficacy beliefs, and found that the beliefs of the two groups about teaching effectively and efficacy in teaching are higher that the beliefs about helping the students and motivating them towards mathematics. Aksu (2008) and, Yenilmez and Kakmacı (2008) investigated relationship between the level of self-efficacy beliefs of pre-service elementary mathematics teachers, and pre-service teachers' gender, type of high school graduated, grade level and degree of achievement. It was found to be no differences in self-efficacy levels with respect to these variables.

The roles of self-efficacy beliefs, mathematics anxiety and working memory capacity in problem-solving accuracy, response time and efficiency were investigated by Hoffman (2010) and it was found that self-efficacy has a positive effect on problem-solving response time and problem-solving efficiency of pre-service teachers. The effects of community-based service learning (Cone, 2009), scaffolded, student-directed inquiry science course (Liang & Richardson, 2009), integrated science and mathematics content-based course (Moseley &Utley, 2006) and two-part, inquiry-based mathematics and science course (Richardson & Liang, 2008) on pre-service teachers efficacy beliefs were investigated, then results have shown that attending these type of courses increased the pre-service teachers efficacy beliefs.

Woolfok Hoy and Spero (2005) investigated changes in teacher efficacy during the teacher preparation program and in the early years of teaching experience. Findings indicated that pre-service teachers' efficacy belief inclined during teacher preparation and student teaching, but fell with actual experience as a teacher during the first year of teaching and efficacy beliefs of teachers are difficult to change as they are attained.

Since the positive impact on pre-service teachers' efficacy during teacher preparation program increases, then these individuals will engage in more effective teaching behaviours in future (Huinker & Madison, 1997). Woolfolk Hoy explained the importance of investigations carried out to examine teachers' sense of efficacy beliefs as following (Shaughnessy, 2004):

> Student learning is affected most directly by the hours they spend on appropriate tasks in classrooms… We will never have the perfect curriculum or teaching strategy, but teachers who set high goals, who persist, who try another strategy when one approach is found waiting- in other words, teachers who have a high sense of efficacy and act on it- are more likely to have students to learn. So the question of how to support and not to undermine teachers' sense of efficacy is critical.

The purpose of this study was to investigate the impact of Methods of Teaching Mathematics (MTM) course on mathematics teaching efficacy beliefs of elementary mathematics pre-service teachers. The following questions were discussed throughout the study:

(1) What are the pre-service elementary mathematics teachers' beliefs about teaching mathematics?
(2) What are the effects of MTM course in elementary mathematics education on the personal teaching efficacy beliefs of pre-service teachers?
    Is there a difference between pre-service teachers' personal mathematics teaching efficacy beliefs before and after the MTM course?
(3) What are the effects of MTM course in elementary mathematics education on the teaching outcome expectancy beliefs of pre-service teachers?
    Is there a difference between pre-service teachers' mathematics teaching outcome expectancy beliefs before and after the MTM course?

1. 1. Teacher education program in Turkey

In 2003, elementary mathematics program was renewed by Ministry of National Education, and in 2005 and 2006 new mathematics program was implemented in Turkey gradually. As the curriculum has been revised, then significant shifts in teacher beliefs and practices about mathematics teaching and learning were required (Battista, 1994). Since teacher is one of the most important components of implementation of the new curriculum, in-service teachers should be informed about the new curriculum and its' implementation through service training. Further, for successful mathematics teaching and qualified mathematics teachers in the direction of innovations, a new Elementary Mathematics Education Program was established by Higher Education Council in 2007 in Turkey. In general, although some courses included in mathematics teacher education program are flexible, composition of the courses is determined as 50-60% content and content education courses, 25-30% teaching profession courses and 15-20% background studies with a total 152 credits course load. During four-year of education, some of the courses which should be accomplished by the students attending Elementary Mathematics Education Program is summarized in Table 1 (YOK, 2007).

Insert Table 1 here

1. 2. A brief description of MTM course

The MTM course took time for 14 weeks. The general objective of the course was to introduce methods and strategies for teaching mathematics.

The course content was based on the following principles and objectives specifically; and some examples are given to describe the MTM course:

- To introduce general and specific objectives of elementary mathematics curricula developed by Ministry of National Education, teaching and learning processes, the selection and application of appropriate methods, materials and activities for effective mathematics teaching.
- To establish the reason why mathematical knowledge is being taught and worth to learn by using real life applications, concrete materials (geo-board, algebra tiles etc.), pictorial and symbolic representations (drawings of sets, fractions etc.), and brain teasers (magic squares, interesting problems etc.). Moreover, the sources of the mathematical knowledge should be introduced to the students through discussions, proofs, and discoveries. For instance, the units smaller than meter, are used for necessity, and the larger ones for convenience (Author, 2010), this is what the reason for the usage of metric units, and addressed to the pre-service teachers to evoke a discussion related with the measurement of length and its units.
- To enable pre-service teachers to teach mathematics by using appropriate examples to give an opportunity to their students to generalize rather than just giving the rules for memorization.

The heading titles of the mathematics subjects covered during the course were numbers, geometry, statistics and probability, algebra and measurement and strategies for teaching of these subjects. The instructor introduced the topics through demonstrations using manipulative materials and software, direct instructions, problem solving and classroom discussions. During the MTM course, pre-service teachers had the opportunity to attend the instruction actively, in stead of just receiving the subjects as passive recorders.

2. Methods

The design of this quantitative study was a single-group pre-test-post-test pre-experimental design. In this type of design, one group of subject is given a pre-test, then the treatment and then the post test. Pre-test and post-test are the same just given at different times (McMillan & Schumacher, 2010). In most of the universities in Turkey, 'package program' is implemented that is there are must courses students have to attend and MTM course is a must course. For this reason there was no opportunity to assign participants into control or experiment groups by random selection, and single group pre-test-post-test design was carried out by the researchers. The Mathematics Teachers Efficacy Belief Instrument (MTEBI) was administered to a group of pre-service elementary mathematics teachers, attending MTM course, at the first week of the semester as a pre-test and the last week of the semester as a post-test.

2. 1. Participants and ethical issues

In this study the population consisted of the students enrolled in the undergraduate Elementary Mathematics Education program at a public university in the eastern part of Turkey. Participants included in the study were junior pre-service teachers and the group consisted of 78 female and 94 male students that would be attending three-credit MTM course during the semester for 14-week. As mentioned in the introduction part, these students had preceded some content and content education, teaching profession courses and background studies before or together with the MTM course. Participating in the study was voluntary based. For this, the students were informed about the MTM course and the research study, and then their consents were sought orally, none of the students refused to participate in the study. They were also informed that it was not obligatory to reveal their identity while answering the questionnaire. Although the first author was the instructor of the course, the implementation of the instrument, collection and analysis of the data were carried out by the second one in order to prevent the identification of the participants and their responses.

2. 2. Instrument

The instrument used in this study was MTEBI had been developed by Enochs et. al. (2000) by modifying the Science Teaching Efficacy Belief Instrument (STEBI-A) developed by Enochs and Riggs (1990). The instrument consisted of 21 items with a 5-point Likert scale. It was found to be valid and had factorial validity through confirmatory factor analysis carried out by Enochs et. al. (2000). MTEBI had two subscales as Personal Mathematics Teaching Efficacy (PMTE) with 13 items and Mathematics Teaching Outcome Expectancy (MTOE) with 8 items. The reliability analysis was done by Enochs et al. (2000) produced a Cronbach's alpha of internal consistency of 0.88 for the PMTE and 0.77 for the MTOE subscales. The two subscales of the MTEBI were consistent with the teacher efficacy aspects as outcome expectancy beliefs and self efficacy beliefs.

In the PMTE scale pre-service teachers' beliefs in their own capabilities of being effective mathematics teachers and in the MTOE scale pre-service teachers' beliefs that effective teaching enables student learning ignoring external factors were addressed. The instrument administered in the study was translated into Turkish in a previous study by Isiksal and Cakiroglu (2004). For the current study, the reliability coefficient Cronbach's alphas were found to be 0.81 and 0.79 for PMTE subscale, 0.74 and 0.81 for MTOE subscale for the pre and post administration of the tests.

2. 3. Data analysis

The mean scores of pre-service teachers with respect to pre-test and post-tests were analyzed through paired sample t-test using SPSS 12.0.

3. Results

The mean scores and standard deviations of the students with respect to the pre and post-test of subscales PMTE and MTOE are presented in Table 2.

Insert Table 2 here

It was seen that there was a difference between the mean scores of the pre-service teachers prior to and after the MTM course. In order to determine whether this difference between the pre-test and post-test scores of the pre-service teachers attending MTM course with respect to MTEBI were significant, paired sample t-tests were implemented, as the scores were distributed normally. The findings are illustrated in Table 3. It is concluded that there was a significant difference between the pre-test and post-test scores with respect to PMTE ($t(171)= -4.592$, $p= .00$) and MTOE ($t(171)= -3.709$, $p= .00$) subscales from paired sample t-test analysis. This implies that MTM course had a significant positive effect on the elementary pre-service mathematics teachers' mathematics teaching efficacy beliefs.

Insert Table 3 here

In Table 4, responses of pre-service teachers to PMTE and MTOE items with mean and standard deviation values are presented. In the PMTE scale, the items with the highest mean score with respect to post-test were whether teachers would generally teach mathematics effectively and have the necessary skills to teach mathematics. Further the lowest mean score was related with the willingness to be observed by supervisor while teaching mathematics.

Insert Table 4 here.

Responses of pre-service teachers to the MTOE scale items are presented in Table 5. With respect to post-test scores, the item with the highest mean score was 'An improved mathematics grades of students are due to teachers' effective teaching approach' and the lowest mean score was 'The teacher is generally responsible for the achievement of students'.

Insert Table 5 here.

4. Discussion and Conclusion

This quantitative study has applied a single-group pre-experimental design to investigate the effects of MTM course on the teaching efficacy beliefs of elementary pre-service mathematics teachers. The findings of the study implies that elementary pre-service mathematics teachers had high mathematics teaching efficacy beliefs and attending an MTM course changed the mathematics teaching efficacy beliefs of them in a positive manner. As the pre-service teachers participated in MTM course during a semester, their PMTE and MTOE beliefs increased significantly. These findings were consistent with the previous findings related with the effects of methods and special teacher education courses on the efficacy beliefs of pre-service teachers (Cakiroglu, 2000; Cone, 2009; Huinker & Madison, 1997; Liang & Richardson, 2009; Moseley & Utley, 2006; Richardson & Liang, 2008; Swars, 2005; Swars & Dooley, 2010; Woolfok Hoy & Spero, 2005).

It is expected that those pre-service teachers participated in the study have a tendency to use more inquiry, student centred and innovative teaching approaches that might be difficult to implement, and to be more effective teachers (Czerniak, 1990; Swars, 2005; Riggs & Enochs, 1990). Further they tend to believe that they can control or influence student achievement and motivation (Tschannen-Moran et. al., 1998) and help to improve students' basic performances (Ashton et. al., 1982a) even if the students have negative backgrounds.

Additionally, after determining the levels of pre-service teachers' mathematics teaching efficacy beliefs, the reasons why some of the pre-service teachers have high efficacy beliefs whereas the others have low might be investigated. Bandura asserted that efficacy beliefs are shaped by an individual's previous performance and experiences (as cited in Swars, 2005). Therefore, past experiences of pre-service teachers, for instance failure with mathematics in school or negative experiences in mathematics and mathematics lessons might be the underlying reasons for lower efficacy beliefs. For further researches, the reasons behind the lower or higher level of efficacy beliefs might be investigated through a qualitative research, by interviewing with the pre-service teachers with differing levels of efficacy beliefs.

Moreover, the reluctance or enthusiasm for teaching mathematics for the pre-service teachers might be factors influencing teacher efficacy beliefs; in fact the level of teacher efficacy beliefs might be one of the underlying reasons for being reluctant and enthusiastic for being a mathematics teacher. Further researches might be carried out to examine the potential mutual relation between these concepts.

This study indicates that attending in MTM course increases efficacy beliefs, however, it is not analyzed which aspects of the course caused those changes, and also this change is really resulted from the course solely. Although it is difficult to determine which factors make a methods course effective in influencing efficacy beliefs, and to control the other factors apart from the course, that might be affecting these beliefs, an experimental study might be carried out through control and experiment groups. For example, the effects of traditional, problem, inquiry or activity based methods courses might be investigated experimentally and there are these types of studies in related literature. In this way, it might be possible more effective methods courses enabling pre-service teachers achieve higher efficacy beliefs. Furthermore whether courses such as teaching practice, or history of mathematics and other mathematics content courses have an effect on the mathematics teaching efficacy beliefs might be investigated by means of both quantitative and qualitative methods. After all, the effects of in-service training on the teachers', have been already working in schools, teaching efficacy beliefs might be investigated through similar research designs.

The research studies related with teaching efficacy beliefs are important because they can help us understand better how to create learning environments that support teachers in their work (Shaughnessy, 2004). Teacher efficacy belief is an important factor influencing teachers' professional development and bringing about effective, self-confident, innovative teachers for attaining a better, improving, and impact education system to achieve higher order educational goals. Moreover, Hoy states that teaching efficacy beliefs are more open to changes in the early phases of learning to teach (as cited in Cakiroglu, 2008), for this reason attempts to increase the level of pre-service teachers' efficacy beliefs are crucial for teacher education programs. As a consequence, the concept of teacher efficacy beliefs with other dimensions of effective teaching practices will be investigated and findings will lead the ways for enhancing teacher education programs.

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Table 1. Some of the content and content education courses in Elementary Mathematics Education Program in Turkey

Courses	**Credits**
Mathematics	48
Geometry	9
Teaching principles and methods	3
Teaching technologies and material development	3
Methods of teaching mathematics (I-II)	6
School experience and Practice teaching	8

Table 2. Mean PMTE and MTOE scores on MTEBI

Variable	*N*	*Mean*	***SD***
PMTE			
Pre-test	172	3.99	0.46
Post-test	172	4.20	0.38
MTOE			
Pre-test	172	3.92	0.49
Post-test	172	4.11	0.45

Table 3. Test score differences for the subscales of the MTEBI prior to and after MTM course

				95% CI				
	M	SD	SEM	Lower	Upper	t	df	p
PMTE Pre-test Post-test	-0.206	0.588	0.045	-0.295	-0.117	-4.592	171	.00*
MTOE Pre-test Post-test	-0.190	0.670	0.051	-0.291	-0.089	-3.709	171	.00*

Note: * p<.05

Table 4. Responses of pre-service teachers to the PMTE items.

Item	Pre-test		Post-test	
	Mean	SD	Mean	SD
PMTE				
Will find better ways to teach mathematics	4.29	.67	4.41	.52
Will not be able to effectively monitor mathematics activities[a]	4.30	.75	4.33	.63
Will generally teach mathematics ineffectively[a]	4.42	.75	4.46	.68
Will be able to answer students' mathematics questions	4.30	.75	4.33	.62
Will not willing to be observed by supervisor while teaching mathematics[a]	3.91	.99	3.72	1.1
Will not teach mathematics as well as most subjects, even if I try very hard[a]	4.41	.64	4.39	.69
Know how to teach mathematics concepts effectively	2.96	.80	3.91	.68
Understand mathematics concepts well enough for effective teaching	3.22	.97	3.84	.67
Will find difficult to use manipulative to explain why mathematics works[a]	3.70	.87	3.99	.733
Wonder if I will have the necessary skills to teach mathematics[a]	4.35	.73	4.45	.57
Will be at a loss as to how to help the students having difficulty to understand concepts[a]	4.13	.81	4.20	.70
Will welcome students questions	4.41	.75	4.35	.76
Do not know how to turn children on mathematics[a]	3.46	1.0	4.19	.74

Notes: Items are abbreviated for presentation. [a]Items were reversed scored in order to produce consistent values between positively and negatively worded items.

Table 5. Responses of pre-service teachers to the MTOE items.

Item	Pre-test		Post-test	
	Mean	SD	Mean	SD
MTOE				
Improved mathematics grades of students are due to teachers' effective teaching approach	4.19	.89	4.36	.67
When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher	4.03	.89	4.15	.64
The teacher is generally responsible for the achievement of students	3.55	.84	3.75	.76
If parents note an increase in the interest in mathematics, it is due to the teacher's performance	3.67	.85	3.89	.76
When a student does better than usual in mathematics, it is due to teacher's extra effort	3.97	.70	4.12	.71
Underachievement is due to ineffective mathematics teaching	3.60	.92	3.97	.73
The inadequacy of a student's mathematics background can be overcome by good teaching	4.20	.70	4.33	.55
Mathematics achievement of a student is directly related to teacher's effectiveness in teaching	4.15	.77	4.31	.60

Note: Items are abbreviated for presentation