ENHANCING PRESERVICE TEACHERS' EFFICACY BELIEFS IN MATHEMATICS

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The present study sheds light on the factors affecting the development of preservice teachers' efficacy beliefs in mathematics during fieldwork. Data were collected from interviews with 8 subjects in three consecutive intervals. The analysis of the data revealed that almost all subjects' efficacy beliefs were improved during the period of fieldwork, mainly due to change in their mastery experiences in teaching mathematics. However, a number of other factors seemed to interact and form participants' beliefs, providing support to the proposed unified model for studying teachers' efficacy beliefs. Implications for the development of teachers' training programs and for further research are drawn.

INTRODUCTION

Research on mathematics teaching and learning has recently moved away from purely cognitive and metacognitive variables. Considerable effort is nowadays focused on multiple components of learning, including variables of the affective and social domain. The affective domain is a complex structural system consisting of four main dimensions or components: emotions, attitudes, values and beliefs (Goldin, 2001, cited in Schloglmann, 2002). Beliefs can be described as one's subjective knowledge that includes invariably whatever one considers as true knowledge, even though he or she cannot provide convincing evidence to support these beliefs (Pehkonen, 2001). In this study we focus on teachers' beliefs and particularly on beliefs with respect to their efficacy in teaching mathematics.

The construct efficacy beliefs was introduced in social psychology during the 1970s and developed mainly on the lines of Bandura's social cognitive theory. Within this theory, Teachers' Efficacy Beliefs (TEB) are viewed as a subset of the general construct of efficacy beliefs. Specifically, Bandura (1997) defines self-efficacy as one's beliefs about his or her ability to organize and execute tasks to achieve specific goals. In this context, TEB refer to a teacher's beliefs about his or her ability to organize and orchestrate teaching that promotes learning (Tschannen-Moran, Woolfolk Hoy & Hoy, 1998). Research has so far underlined the importance of studying TEB; it was found that TEB are correlated with teacher's professional behavior, teaching approach, as well as with students' conceptions, motivation and performance (Pajares, 1999; McKinney, Sexton & Meyerson, 1999; Lin & Gorrell, 2001). Though many research attempts concentrated on the effects of developing TEB, there is a scarcity of surveys related to the factors influencing the development of TEB. Yet, the review of the relevant literature reveals that a coherent theoretical background has been developed in this domain.

Bandura (1997) assumed four sources of efficacy information: mastery experience, vicarious experience, social persuasion, and physiological and emotional arousal. Mastery or enactive experiences are considered as the most powerful source of efficacy information. Efficacy beliefs are strengthened substantially when success is achieved on difficult tasks with little assistance. However, not all successful experiences reinforce efficacy. For example, efficacy is not enhanced when success is achieved through excessive external assistance, or on an easy and unimportant task. Thus, the critical element, which contributes to the development of these beliefs, is the information that the individual gets about his/hers ability. Vicarious experiences may alter efficacy beliefs through comparison with the attainments of others. For instance, watching admirable and credible teachers with more or less the same abilities with the observer can affect the observers' TEB. Social persuasion serves as a further means of strengthening teachers' beliefs. Usually, TEB are enhanced when significant others express faith in a teacher's capabilities. Finally, the feelings of relaxation and positive emotions signal self-assurance and the anticipation of future success (Tschannen-Moran et al., 1998). Bandura (1997) asserts that the information derived from the aforementioned sources go through a cognitive process which determines how the sources of information are weighted and how they influence the development of efficacy beliefs. Tschannen-Moran et al. (1998) integrated these elements in a *unified model* (see Figure 1) describing the development of TEB.

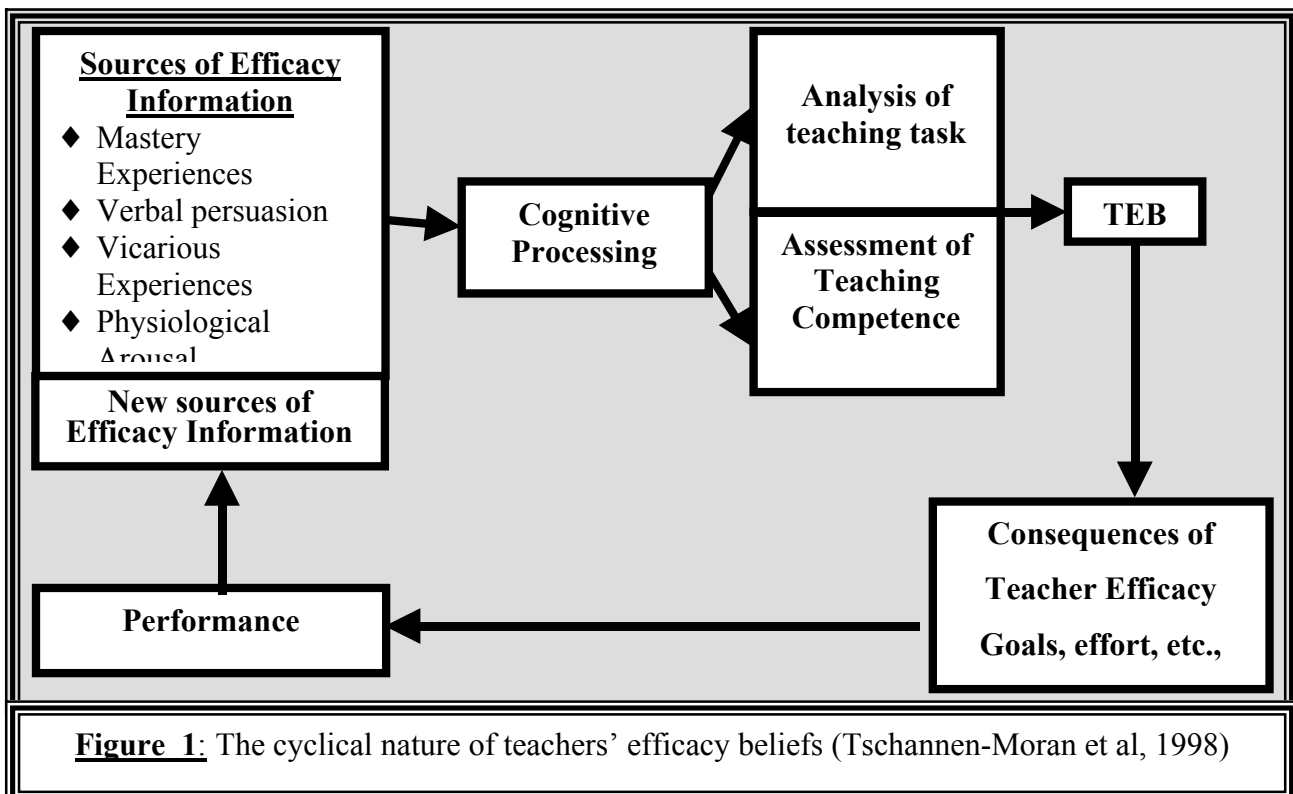**Figure 1**: The cyclical nature of teachers' efficacy beliefs (Tschannen-Moran et al, 1998)

Figure 1 shows that the proposed model adds two new elements to Bandura's assertion about the development of efficacy beliefs. First, it has a cyclical nature, presenting TEB both as a cause and an effect of performance. Secondly, it assumes that beyond the information derived from the cognitive processing, teachers assess

what will be required of them in the anticipated teaching situation (*analysis of teaching task*) and take into consideration their capabilities in a certain domain (*assessment of personal teaching competencies*). Tschannen-Moran et al. (1998) urged researchers to collect empirical data in order to verify the aforesaid model. Specifically, they asserted that future research might focus on the four broad sources of information, as well as on the analysis of teaching task and the assessment of personal competence.

The present study integrates the need to collect empirical data in order to examine the above-described model with the need to explore the development of preservice teachers' TEB. The relevant literature underlined the importance of examining the initial formation of TEB, since these beliefs are generally stable or hard to change (Tschannen-Moran et al., 1998). The crucial phase in the development of these beliefs is the training period, during which future teachers learn to view their role as learning facilitators (Frykholm, 1999; Tillema, 2000). Fieldwork is one of the most important parts of teachers' education, in the sense that it aims at the transformation of student-teachers' theoretical understanding into real classroom activities and evidently provides them with real practice experiences (Ebby, 2000). Apart from bridging theory and practice, stun-teachers live the school climate and interact with other in-service teachers and specifically their mentors (Zanting, Verloop, & Vermunt, 2001). Despite the recently increased interest in the affective domain, to the best of our knowledge, no research studies have been reported that examine the development of prospective teachers' efficacy beliefs during their fieldwork.

Based on the above analysis, the aim of this study was to examine the development of preservice teachers´ efficacy beliefs in teaching mathematics during the course of their teaching practice program (TPP[1]). Specifically, the study aimed to:

1. Examine the development and modification of preservice teachers' TEB during fieldwork, and
2. Collect empirical evidence in order to test the validity of a part of the unified model for TEB (namely, sources of efficacy information, cognitive processing, analysis of teaching task and assessment of personal competence).

METHODS

The study lasted for the whole TPP semester, from January to April 2002. The eight interviewees that participated in the present study belonged to a larger group of 89 four-year students who registered in TPP. The beliefs of the whole group were

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[1] The course lasts for 13 weeks and it is divided into two parts. The students are assigned to lower (1st to 3rd grades) and higher school cycle (4th to 6th grades) in each part, with a week break in the middle for group discussion and reflection on practice. Throughout the program, students have to design and teach nearly 30 mathematics lessons. University tutors provide guidelines for designing the lessons on request; they also attend students' teaching and make suggestions for improvement.

measured using a questionnaire, based on TSES[2] (Tschannen-Moran & Woolfolk Hoy, 2001). After analyzing the data from the first scale distribution, eight subjects were selected to participate in interviews. Interviewees were selected on the basis of gender, performance in mathematics, and the cluster to which they were found to belong in terms of their initial TEB. More specifically, cluster analysis of the questionnaire data revealed four homogenous groups: G1 students entered the program with somewhat higher than the overall mean TEB. These beliefs were improved mainly during the first part of program. G2 consisted of students who started with slightly lower TEB. These students got the more out of the program compared to the other students, particularly during the first half of the program. G3 students entered the program with higher TEB and continued to be above the level of the other group students' TEB. Finally, G4 was a special "group" with only two students with extremely low TEB. The students who participated in the interviews were one from G1 (S_{11}), two from G2 (S_{21}, S_{22}), four from G3 (S_{31}, S_{32}, S_{33}, and S_{34}), and one from G4 (S_{41}). S_{32} and S_{34} were males, while the rest six students were females. Their scores in courses in mathematics were below average (S_{11} and S_{32}), average (S_{21}, S_{31}, S_{33} and S_{41}) or higher than average (S_{22} and S_{34}).

Students were interviewed three times, one at the beginning of the TPP, one in the middle and one at the end of it. The interviews were quasi-structured and were conducted with the aid of a specially prepared interview plan; each interview lasted about 45'. Subjects were asked open-ended questions aiming to clarify (a) their attitude towards mathematics and teaching mathematics, (b) their experiences as mathematics students and mathematics teachers, and (c) their interaction with pupils, other preservice teachers, their mentors and the university tutors in mathematics during fieldwork. The constant comparative method (Denzin & Lincoln, 1998) was used to analyze the qualitative data that emerged from the interviews. Namely, constant comparative method was used in order to conduct "within case analysis" of the development of each participant's TEB. Transcripts were read with the intent of identifying frequently used concepts and integrating themes (Maykut & Morehouse, 1994). The data were then summarised through the identification of key descriptors related to TEB and their development.

FINDINGS

The analysis of the interviews reveals that all students' TEB were improved during fieldwork. S_{11} and one of S_{21} assert that their initial concerns about their abilities to

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[2] The questionnaire included 24 statements on a 9-point Likert scale, reworded to reflect TEB in mathematics. It was administered to students three times: one at the commencement of TPP, one in the middle and one at the end of the program. The internal reliability of the scale was extremely high in each administration (Cronbach's alphas: a= 0.96, a=0.97 and a=0.98, respectively). The exploratory factor analysis that was applied to the data of the questionnaire, revealed a two-factor solution (TEB in teaching mathematics and TEB in managing a mathematics class). Students' scores on the two factors were further submitted to cluster analysis. The statistical analysis and the four emerging clusters are presented in Charalambous & Philippou (2003).

teach mathematics were eliminated during the practicum period. On the other hand, at the beginning of the TPP, S_{22} values her knowledge concerning mathematics as sufficient, but underlines her worries concerning teaching mathematics. In the middle of the program she admits: "*I think I am getting over my fears. I realized that I could flexibly teach mathematics. My teaching trials succeed!*" At the end of the program the student claims that she is convinced that she can teach mathematics effectively. Three of G3 participants (S_{31}, S_{33} and S_{34}) state that, their initial positive feelings about teaching mathematics were strengthened as a result of participating in the TPP. For example, S_{31} points out: "*I came to believe that I could teach mathematics. That feeling was improved during the TPP. I had the chance to teach younger and elder children, obedient and disobedient. Thus I had an inclusive teaching experience, which made me believe that I can even do better in the future*". S_{34} is more informative: "A*t the beginning of the program I was about 70% confident that I could teach mathematics. During the first part of TPP that percentage increased up to 90%, since I realized that students were learning mathematics, as a result of my teaching. When the second part started, my confidence level declined; I was in a new teaching environment, with elder students… and mathematics at that level were more difficult. But finally, my confidence improved, it reached about 80-85%*". On the other hand, the S_{32} admits at the commencement of the TPP that he feels insecure to teach mathematics. In the middle of the program he asserts that he feels more able to teach mathematics, though he has some concerns about teaching mathematics in lower levels. At the end of the program the student states that he is much more confident in teaching mathematics than before, and that his attitude towards mathematics has been improved. Finally, S_{41} initially claims that she is totally inefficient to teach mathematics, since she can hardly understand mathematics, especially the concepts that are taught at upper grades. In the middle of the TPP, the student points out that she is not confident in teaching mathematics, though some successful lessons encouraged her that she "*is not that bad in teaching mathematics*". The final part of the TPP improved her initial negative feelings, though the student failed to overcome some of her initial concerns: "*I think that the second part of TPP eliminated my fears about teaching mathematics… I feel more comfortable in teaching mathematics. But perhaps I was lucky to teach easy concepts. I do not know if I would do as well in the future*".

The above extracts indicate that there were different patterns of improvement of students' TEB. The analysis of the interviews data concerning the factors affecting the development and modification of students' TEB seem to justify the differences witnessed among the students' TEB. More specifically, these beliefs were influenced by students' experiences in mathematics (as mathematics students or as mathematics teachers) and their interaction with the school stuff, and the university tutors.

The initial formation of the students' TEB was based on their overall experience and background in mathematics at school and university. Students' experience as learners and their performance resulted in an analogous personal relationship with the subject, which influenced the level of efficacy beliefs to teach it. Students with low

achievement and failures were feeling that the subject is difficult to teach as well as to learn. For instance, S_{11}, going back to her school years, says: "*In general mathematics was my weak point. Until the age of 13 years old it used to be among my favorite subjects, but then it changed...it started to become more complicated...too hard to understand*". S_{41} faced a similar disappointment. She mentions that she has low confidence in teaching mathematics because of her grades in school: "*At the junior high I always got As in mathematics, but from grade 9 a reciprocal trend started. I could not understand mathematics and got a B. At the high school I opted for the language section and had no major problems with mathematics, but my grades in mathematics were lower than in other subjects. So, I ended in disliking mathematics*". On the other side, positive student experiences were connected with positive attitudes. S_{22}, commending on her positive outlook, says: "*Well, I had begun loving mathematics in the primary school and that developed in the junior and the high school, where I was influenced by my math teacher. I wanted to become a mathematician. His class was very interesting*".

Mathematics courses at the university also affected students' TEB. S_{33}, points out: "*I failed in one of the mathematics courses at the university. I think that incident affected the way I was perceiving teaching and learning mathematics*". In some cases university experiences turned out to be stronger than initial school experiences. For instance, S_{21}, though achieving high scores at high school, had low scores in the mathematics courses at the university. Thus, she ended in wondering whether she could teach mathematics effectively.

The aforementioned experiences gave students indications about their competencies in teaching mathematics. Nevertheless, actual teaching experiences (i.e. mastery experience) played a more decisive role in the way students perceived their selves as mathematics teachers. For instance, S_{31} asserts that having to teach mathematics nearly everyday made her believe that she could be efficient in this domain. S_{32} characterizes the TPP as "*a first class experience*", which helped him get rid of his initial fears regarding teaching mathematics. S_{11} emphasizes the catalytic role of these experiences in the development of her TEB: "*My attitude towards mathematics was negative… And it became even worst at the university, as I failed in one of the mathematics courses... I knew that my knowledge in that domain was deficient. But the TPP made me realize that I could overcome these deficiencies… I had to teach subjects that I was totally unfamiliar with. I prepared lessons a lot, and eventually, there were sufficient learning outcomes*". The second part of the TPP strengthened students' TEB even more, since students had the opportunity to test whether the instructional strategies and teaching ideas they experimented with in the first part of the program were also effective in a different environment and with students of a different level. S_{41} indicates: "*I realized that my teaching was getting better. I was not lost, as I felt in the first part of TPP. I was more effective; I could communicate my ideas to students better… Now, I feel more efficacious to teach mathematics!*" The contribution of actual teaching experiences to the development of students' TEB is also indicated by S_{21}'s assertion at the conclusion of the program: "*TPP was the most*

important part of my studies. Since the beginning of the TPP I had no idea about the way a school works. We have been taught a lot of theories, but I felt insecure to teach mathematics. Now, at the end of the program, I realize that teaching is not so hard, as I thought before".

Interaction with the mentors seemed to influence the development of students' beliefs. Mentors operated either as teaching models or as feedback providers. Yet, the interaction with mentors did not appeared to function in the same way for all students. For instance, during the first half of the TPP, S_{32} and S_{33} attended mentors teaching mathematics in a traditional way (presenting the content and providing ample time for exercise). The interaction with them affected students in totally different ways. S_{32} felt that his mentor was completely different from him: *"He was much older than me, and he used to teach mathematics in a rather traditional way. I tried to teach mathematics in a different way. In a sense, I was competing my mentor; that motivated me to try harder in teaching mathematics... I became even more confident when the mentor failed to recognize pupils' difficulties in decimals, and I was able to do that!"* On the other hand, S_{33}'s TEB initially declined, as a result of the interaction with the mentor: *" She used to teach in a rather mechanical way. She helped students in solving all the textbook exercises. She hardly left students work on their own. I tried to do something different, and I asked students to try harder to solve the exercises on their own. The mentor nodded her head, showing her dissatisfaction. Even if she avoided telling me anything, I felt that she was thinking: 'You failed in teaching mathematics in the proper way, and I have to teach that concept again'. Fortunately, when a new mentor came, I realized that I was efficient in teaching mathematics".* Mentors' feedback also influenced students' TEB. For example, S_{22} states: *"She* [the mentor] *shared her initial teaching experiences with me. She tried to persuade me that we all do mistakes in the beginning. Thus, she helped me a lot".*

Though the majority of students did not seem to interact with the headmasters, one student (S_{31}) pointed out that the discussion she had with the school headmaster helped her overcome her initial disappointment: *"I was preparing lessons very well, but since students were disobedient, I failed to reach expected outcomes. I was very disappointed... But the headmaster persuaded me that it was not my fault and that, in a different school, I could definitely do better".* Finally, university tutors seemed to affect students' TEB, but not the same well for all students. For instance, S_{31} claimed that she weighted most her mentors' opinion about her teaching than the tutors' opinion, since the mentor attended all her lessons. On the other hand, S_{21} had a totally different approach, asserting *"tutors are more expert in the domain of mathematics than mentors".*

Though students seemed to get information about their efficacy to teach mathematics from more or less the same sources, they did not weigh the information in the same way. For instance, S_{11} points out: *"I weighted more the interaction with pupils, and the learning outcomes of teaching. I tried to minimize the influence exerted by fellow students, mentors or the university tutors. Whatever their reaction to my lessons was,*

I avoided analyzing it. I told myself: ´Leave it at the backside of your mind. Do not get encouraged or discouraged´". Cognitive processing of the incoming information is also apparent in the following extract by S_{31}: *"I used to take into consideration the mentors' feedback. But I valued the pupils´ reaction more. On the other hand, if I were convinced that I taught a concept properly, and pupils did not seem to grasp it, I looked at my mentor; from his expression I could realize whether it was my fault or not."* Attributing failures to other factors than the personal performance also helped in keeping students' TEB to the same level. As S_{41} states: *"Pupils did not respond to my lessons as I expected, since they were thinking of me as a student-teacher and not as a teacher."* Finally, the interviews gave evidence about the process of the analysis of task and the assessment of personal competence. The following extract suggests that these processes seem to interact with the cognitive processing of the efficacy information: *"I think I am able to teach mathematics. During the first part of the TPP I was efficient in that domain* [mastery experience]. *I believe that it is all a matter of choosing the correct activities* [analysis of teaching task]. *And I had no problem in that domain* [assessment of personal competence]. *Thus, I foresee that I can also do well during the second part of the TPP, provided that pupils are obedient* [analysis of teaching task] (S_{34}, interview at the middle of TPP).

DISCUSSION

In the present study preservice teachers' TEB were gradually improved while participating in a TPP. This result verifies the hypothesis that carefully designed intervention programs could result in positive changes in dimensions of the affective domain (Goldin, 1998). It also provides support to the theoretical assumption that it is possible to alter student teachers' TEB, since these beliefs are not stable, as is the case with experienced in-service teachers (Tschannen-Moran et al., 1998). Moreover, the findings of the interviews confirm the opinion that the main source of the development of efficacy beliefs is "mastery experience" i.e., actual experiences in a certain domain. However, we cannot ignore a number of other sources -vicarious experience or verbal persuasion, which were eminent through the interaction with mentors, tutors, headmasters etc- that are interwoven with the development and modification of these beliefs. Consequently, training programs should provide preservice teachers with many actual experiences with instructing and managing children in a variety of contexts. However, that is not enough, since such training programs are at risk to be "a sink or swim experience" for preservice teachers. Thus, special attention should be paid to the individuals that are involved in teaching practice programs, who, as the present study illustrated, can influence the development of TEB either by their teaching or by the information they directly or indirectly convey to student teachers about their capability in teaching. The present study also provides evidence about the role of cognitive processing of the efficacy information. The analysis of teaching task and the assessment of personal capabilities seem to interact with the cognitive processing, resulting in different TEB levels, even though students have similar experiences. Thus, training programs should offer

preservice teachers the opportunity to reflect on their experiences and on the way these experiences influence the development of their TEB. Future research should expand the attempt to study TEB in mathematics. Furthermore, the cyclical nature of the development of TEB needs verification through the collection of empirical data.

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