THE DEVELOPMENT OF STUDENT TEACHERS' EFFICACY BELIEFS IN MATHEMATICS DURING PRACTICUM

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In this study we examine the development of prospective primary teachers' efficacy beliefs (TEB) with respect to teaching mathematics during practicum. The analysis of the responses of 89 student teachers in three repeated scale distributions indicated a marked positive change in all groups formed by cluster analysis. Eight students were interviewed at the commencement, in the middle, and at the end of the course to investigate which factors contributed to this change and how. We found that the effect of broad sources informing efficacy beliefs identified by Bandura (1997) supplemented by the influence of individuals involved in the course played a major role in the cyclical process of efficacy change. Implications for further research and for developing practicum courses are drawn.

INTRODUCTION

Nowadays research on mathematics teaching focuses on multiple components of learning, including variables of the affective and social domain. The affective domain can be conceived as a complex structural system consisting of four main components: emotions, attitudes, beliefs, and values. In this study, teachers' self-efficacy beliefs with respect to teaching mathematics are examined. 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, the teacher's efficacy beliefs (TEB) refer to a teacher's sense of ability to organize and orchestrate teaching that promotes learning. The importance of TEB derives from its role in determining both the teachers' professional behavior and pupils' motivation and performance (Ghaith & Shaaban, 1999; Henson, 2001; Brouwers & Tomic, 2001).

Though researchers seem to agree on the significance of TEB, issues such as the measurement and development of these beliefs remain open to discussion. Specifically, researchers are now more sensitive to problems related to the reliability and validity of the measuring instruments; in this respect the appropriateness of widely used scales, such as the Gibson & Dembo scale has been under criticism (Deemer & Minke, 1999). Recently, Tschannen-Moran & Hoy (2001) developed and tested a scale of 24 items (Teacher Sense of Efficacy Scale-TSES), which consisted of three subscales: pupils' involvement in the learning process, adoption of teaching strategies and classroom management. It was further found that the three factors could be grouped into one second-order factor, meaning that all of them measure a wider construct, namely TEB. The authors proposed further studies to examine the validity and reliability of the TSES in different cultures and specific domains. The need to examine the development of TEB in specific areas was also pointed out by other researches (Henson, 2001).

Tschannen-Moran, Hoy & Hoy (1998) proposed a comprehensive cyclical model representing the evolution and development of TEB.

This model includes the four broad sources of efficacy information proposed by Bandura (1997): mastery experience, vicarious experience, social persuasion, and physiological and emotional arousal. Mastery or enactive experience is considered as the most powerful source of efficacy information, vicarious experiences may alter TEB through comparison with peers attainments, social persuasion refers to feedback provided by significant others, and finally, the feelings of relaxation and positive emotions signal self-assurance and anticipation of future success. The model assumes that the information derived from these sources is cognitively processed and weighted vis-à-vis existing beliefs structure and subsequently influence the development of TEB. According to the model, 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*). However, the proposed model has not been yet empirically verified.

The aim of this study was to shed some light on how the aforementioned factors work analyzing the stages of development of TEB, and especially the growth of student teachers' beliefs during practicum. Practicum is one of the most important parts of teachers' education; it functions as the bridge of students' theoretical understanding and real classroom practice, and evidently provides students with real hands on experiences (Ebby, 2000). Furthermore, the teaching training period offers students the opportunity to interact with others and specifically with their mentor (Tillema, 2000).

Based on the above analysis, the aims of this study were to: (1) Examine the development of preservice teachers' efficacy beliefs in teaching mathematics during the course of their final teaching practice program (TPP), using the TSES, and (2) Verify the cyclical model of development of TEB using empirical data.

METHODS

A questionnaire based on the TSES (with 24 statements on a 9 point Likert scale), reworded to reflect TEB in mathematics was administered to the 89 four-year students who attended the TPP from January to April 2002[1]. The students' beliefs were measured at the commencement of the program, after the 1st part, and at the end of it. The internal reliability of the scale was extremely high in each administration (Cronbach's alphas: a1= 0.96, a2=0.97 and a3=0.98, respectively). After analyzing the data from the first measurement, purposive sampling procedure was used to select the eight students who were interviewed. More specifically, the students who participated in the interviews were, in terms of the clusters formed by initial TEB, one from G1 (S11), two from G2 (S21, S22), four from G3 (S31, S32, S33, and S34), and one from G4 (S41). Their scores in courses in mathematics were below average (S11 and S32), average (S22, S31, S33 and S41) or higher than average (S22 and S34). Students were interviewed three times, one at

[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 grade) in each part, with a week break in the middle for group discussion and reflection on practice.

the beginning of the TPP, one at the middle and one at the end of it. The interviews were semi-structured and lasted for 45 minutes; they were based on questions which asked students to provide a detailed description of their beliefs in each of the three thematic factors of the scale (i.e., teaching strategies, student involvement, and classroom management). The constant comparative method (Denzin & Lincoln, 1998) was used to analyze the interview data.

FINDINGS

Exploratory factor analysis applied separately for each of the three scale administrations (see Charalambous & Philippou, 2003) showed a significance level of .001 for the Barlett's test of sphericity and high KMO values (.907, .933 and .948, for each measurement, respectively). The varimax rotation to the data from the first administration resulted in two factors that explained 60.53% of the variance. The first factor consisted of 16 statements (same as those in the first two factors of the TSES) and explained 34.02% of the variance, and the second factor consisted of 8 statements (identical to those in the third factor of TSES) and explained 26.51% of the variance. Applied to the data of the second and third measurement, the two-factor model was found to explain 69.00% and 76.13% of the variance, respectively. Two items of the first factor were discarded because in the analysis of the data from the third measurement they loaded on the second factor rather than on the first. Thus the two-factor solution remained with 22 items; the first factor (F1) consisted of 14 items that referred to TEB in teaching strategy use and activating students during mathematics classes (teaching mathematics, hereafter), and the second (F2) of 8 items related to TEB in managing the mathematics classroom.

The mean TEB in each measurement were found as 5.61, 6.50, and 7.05 for F1, and 5.73, 6.56, and 7.01 for F2, indicating that the students started with rather positive beliefs in both factors; these beliefs were improved in the course of the program. The repeated measures technique and the Bonferroni test (to avoid carry over effects) revealed that improvement was statistically significant; there was no interaction between the two factors ($F_{(2,84)}$= 1.79, p=.173, pillai's =.041), and the observed differences were due to participation in TPP (due to the factor "administration") ($F_{(2,84)}$= 87.65, p<.001, pillai's =.674). Significant differences were found between the first and the second administration ($\bar{x}_{\text{2nd adm.}} - \bar{x}_{\text{1st adm.}} = .85$, p< .001), and between the second and the third administration ($\bar{x}_{\text{3rd adm.}} - \bar{x}_{\text{2nd adm.}} = .55$, p< .001).

To search for patterns of development of TEB, cluster analysis was applied to the data emerged from the first administration. The Ward's method of hierarchical cluster analysis identified four homogenous groups. The four-cluster solution was justified since the Agglomeration schedule showed a fairly large increase in the value of the distance measure from a three-cluster (15.84) to a four -cluster solution (25.41). Table 1 shows the mean and variances of each of these groups for both scale factors. Clearly, G1 students entered the program with somewhat higher beliefs than the sample mean; their beliefs were improved mainly during the first part of program. G2 students started with slightly lower TEB but they got the most out of the program, compared to the other students, particularly during the 1st part of the program. The majority of students (G3) entered the program with higher TEB and these beliefs continued to be above the sample mean level. Finally, the last "group" (G4) consisted of only two students with extremely low TEB;

despite some positive change, their beliefs failed to surpass the scale mean (i.e., remained negative).

Factors	F1 (TEB in teaching strategies)						F2 (TEB in class management)					
	1st Admin.		*2nd Admn.*		*3rd Admin.*		*1st Admin.*		*2nd Admin.*		*3rd Admin.*	
Groups *	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**
G1 (N=25)	5.20	.80	5.67	.78	6.07	.84	5.25	.85	5.68	.82	6.04	.89
G2 (N=13)	4.84	.78	6.74	.61	7.43	.48	4.44	.61	6.43	.54	7.08	.56
G3 (N=45)	6.18	.58	7.02	.63	7.60	.56	6.53	.73	7.26	.72	7.71	.68
G 4 (N=2)	2.46	.45	2.67	1.16	3.96	.15	1.81	.62	1.88	.88	2.43	1.86

* Complete data were selected of only 85 students (nine point scale: 1=not at all good and 9=very good)

Table 1: Means and variances of the four groups formed by cluster analysis

The analysis of the interview data justified the differences in the development of students' TEB concerning both factors (teaching mathematics and managing the mathematics class). The following excerpts are indicative of the patterns witnesses in the above analysis.

During the 1st interview S_{11} expressed concerns indicating somehow low confidence. After the 1st part she felt much better about teaching mathematics: She stated in the 2nd interview: "*I can teach mathematics provided I know the content and I have a detailed lesson plan,…, to know what to do every minute, irrespective of whether I would follow it*". By the end of the program, the student could teach mathematics effectively "*provided that she works hard*". A similar pattern of improvement was witnessed in the case of S_{22}. At the opening, the student valued her mathematical knowledge quite sufficient, but yet she was concerned about her teaching competence. In the 2nd interview she admitted: "*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 claimed that she was convinced that she could teach mathematics effectively. The G3 students indicated that their initial positive feelings about teaching mathematics improved as a result of the program. For example, S_{31} pointed 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*". At the commencement of TPP, S_{41} felt totally incapable of getting through; she could hardly understand mathematics, especially the concepts taught at upper grades. In the 2nd interview she was still far from confident, though some successful lessons encouraged her to say, *"I am not that bad in teaching mathematics"*. The final part of the TPP improved her feelings, though the student failed to get over some of her initial concerns: "*I think that the second part eliminated my fears about teaching mathematics… Now I feel more comfortable in teaching that subject. But perhaps I have been lucky to teach easy concepts. I do not know if I would do the same well in the future*". S_{41} expressed analogous concerns about managing class during a mathematics lesson even at the end of the TPP: "*I learnt some useful things, but discipline continues to be a difficult issue… I cannot do much. The idea that I cannot control the class really terrifies me"*.

The qualitative data were also informative of the developmental process of TEB, explaining at the same time the aforementioned different patterns of improvement. First of all, the analysis revealed that students entered the program with some TEB that were formed on the basis of their overall experiences in mathematics. For example S_{11} admitted: "*Mathematics was my weak point. Until the age of 13 years old, math used to be among my favorite subjects, but then it changed...it started to become more complicated to push me away, too hard to understand*". Similarly, S_{32} indicated, "*I failed and had to retake the first math course. In general my mathematics grades were below average, and that influenced me*". On the contrary, S_{22} stressed, "*Well, I had begun loving mathematics in the primary school through the junior school. In the high school a math teacher influenced me, and I wanted to become a mathematician. He was superb in terms of knowledge and approach*".

Hands on experience influenced students' TEB mainly through regular involvement and a sensed feeling of accomplishment. For instance, S_{11} emphasized the catalytic role of these experiences: "*My attitude towards mathematics was negative… 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 a lot, and eventually, my lessons were very good"*. S_{33} pointed out the almost daily teaching of mathematics, which let her believe that she could be efficient in this task. S_{32} characterized the TPP as "*a first class experience… a baptism in the job*", which helped him to get rid of his worries and insecurity feelings. The second part of the program strengthened more students' TEB, since students had the opportunity to test their ideas and strategies tried during the first part of the program, in another environment and with students of a different level. The contribution of teaching experiences to improving students' TEB is illustrated 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 learnt a lot of theories, but I felt insecure to teach mathematics. Now, at the end of the program I realized that teaching is not so hard, as I thought before"*. Even S_{41} indicated: "*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"*.

Interaction with individuals involved in the TPP (mentors, headmasters, tutors, fellow students) seemed to influence the development of students' beliefs. More specifically, mentors operated either as teaching models or as feedback providers. Yet, the interaction with mentors did not work equally well for all students. 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. I was competing my mentor, and that motivated me to try hard in teaching mathematics…I became 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 her mentor: "*She used to teach in a rather mechanical way. She helped pupils in solving all the textbook exercises. She hardly left pupils work on their own. I tried to do something different, and I asked pupils to try harder in order 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 to teach mathematics in the proper way, and I have to teach that concept again"*. Mentors' feedback also influenced students' TEB. For instance, S_{22}'s mentor during the 2[nd] part was very supportive, "*She 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*".

Despite luck of students and headmasters' interaction, one student (S_{31}) referred to a very positive incident with the school headmaster: "*I was preparing lessons very well, but since pupils were disobedient, I failed to reach the 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"*. University tutors seemed to affect students' TEB, but not equally well for all students. For instance, S_{31} claimed that she weighted most her mentors' opinion 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 experts in the domain of teaching mathematics but mentors are not"*. Finally, some of the students seemed to be influenced by fellow students' comments and achievement as indicated in the following excerpt by S_{34}: "*I had the feeling that some of my ideas were not successful, while other students were going fine. Listening to others supposed successes was deteriorating myself image as teacher."*

The students' individual style and characteristics functioned as a filter differentiating the effect of practically similar information on their efficacy beliefs. For instance, S_{11} pointed out: "*I weighted more the interaction with pupils, and the learning outcomes of my lessons. I avoided being influenced by fellow students, my mentor or the university tutors. Whatever their reaction to my lessons was, I stopped analyzing it. I told myself: "Leave it at the backside of your mind. Do not allow yourself be encouraged or discouraged"*. Cognitive processing of the incoming information was also apparent in the following extract by S_{31}: *"I used to take into consideration the mentors' feedback. But I valued more pupils' reaction. On the other hand, if I was convinced that I taught a concept properly, and pupils did not seem to grasp it, I used to look at my mentor. If he was nodding with satisfaction, I could realize that it wasn't my fault. Pupils were probably tired"*. Attributing failures to other factors than the personal performance also helped in keeping students' TEB to the same level. As S_{41} mentioned, "*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"*. Similarly, S_{22} indicated: "*At first I attributed the responsibility solely to myself, but after trying several methods and means, I came to believe that it was not always my fault. Now I do not assume full responsibility; I realize that some pupils are not willing to participate, simply because they do not care*". Finally, analysis of task and assessment of personal competence seemed to interact with the cognitive processing of the efficacy information, as it is evident from the following extract: "*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 the students are obedient* [analysis of teaching task] (S_{34}, interview in the middle of TPP).

DISCUSSION

The TSES was proved helpful in describing the development of preservice teachers' TEB in the domain of mathematics. Based on the two-factor solution, students' TEB were found to gradually improve while participating in the TPP. However, the four emerging clusters of improvement suggest that the development of TEB was not the same of all students, as a result of the factors involved in the process of forming TEB. More specifically, the findings of the interviews further verify the opinion that the main source of the development of efficacy beliefs is "mastery experience" i.e, actual experiences in a certain domain. Yet, the role of other sources and namely vicarious experience and verbal persuasion was also prevalent. Students' interactions with mentors, tutors, and fellow student-teachers seemed to be an important part of the their experiences, which modified their beliefs. The sources of efficacy information did not operate in the same way for all students, but through a cognitive processing of the incoming information, as Bandura (1997) suggested. Furthermore, the results indicated the presence of task analysis and appraisal of competencies, verifying the model proposed by Tschannen Moran et al. (1998). However, cognitive processing, analysis of task and assessment of competencies seemed to function simultaneously and the whole process of forming these beliefs appears as a reciprocating process, rather than a linear one provided that students were at the same time referring to their experiences, their abilities, and the teaching task. Finally, interviews revealed that the causal attribution was present during the cognitive processing of the incoming information. This result indicates that attribution theory and efficacy theory need not be considered as two distinct or rival theories, as they were viewed before, but rather as two complementary theories (Lyden, Chaney, Danehower & Houston, 2002).

Overall, the present study indicated that the practicum should provide preservice teachers with many "hands on" experiences with instructing and managing opportunities in a variety of contexts. Special attention should also be paid to the individuals that are engaged in teaching practice programs. Future research should expand the attempt to study TEB in certain domains. Furthermore, the claim that the development of TEB should not be conceived as a linear process, as well as the need for intergrading social cognitive theory with attribution theory offer a wide spectrum for further research. Finally, research into the relations between teachers' efficacy beliefs in Mathematics and their effectiveness, measured through the progress made by their pupils, is needed. Implications of such research for authentic professional development of teachers and for the improvement of teaching practice could be drawn.

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