

The Effect of Problem Posing Oriented Analyses-II Course on the Attitudes toward Mathematics and Mathematics Self-Efficacy of Elementary Prospective Mathematics Teachers

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Abstract: Research on mathematics teaching and learning has recently focused on affective variables, which were found to play an essential role that influences behaviour and learning. Despite its importance, problem posing has not yet received the attention it warrants from the mathematics education community. Perceived self-efficacy beliefs have been found to be a strong predictor of mathematical performance, while problem posing is considered to be a fundamental ability in mathematical learning. On the other hand majority of research in this area present a positive relation between attitude toward mathematics and success. Therefore, it is shown that attitude toward mathematics is a determinative of success or failure. In this respect this study examines the effect of problem posing instruction on the attitudes toward mathematics and mathematics self-efficacy of elementary prospective mathematics teachers. The study used a pre-test–intervention–post-test experimental design. Quantitative research techniques were employed to gather, analyze and interpret the data. The sample comprised 82 elementary prospective mathematics teachers. In the result of data analysis, it was determined that the effect of problem posing instruction on the attitudes toward mathematics and mathematics self-efficacy of elementary prospective mathematics teachers was in a positive way and at significant level.

Introduction

Mathematics is a subject that is required by many university degrees, hence future career opportunities largely depends on learning mathematics. This might motivate some students to learn mathematics. Like motivation, attitude toward mathematics, self efficacy might be good predictors of learning mathematics. In a similar vein, problem posing encourages academic independency and increases possessiveness, emphasizes students' responsibility in solving and posing problems. All of these as a result increase inner control (Kliman and Richards, 1992; Silver, 1994).

Research show that when students pose problems they tend to be more motivated and keen on searching answers to their problems (Silverman et. al, 1992). Since there is a strong positive relationship between attitude toward mathematics and mathematics success, attitude

toward mathematics is accepted as a strong determinant (or mediator) of success or failure (Elderveld, 1983; Rives, 1992). In this respect, it is very important to improve students' attitudes toward mathematics and self-efficacy beliefs.

Although problem posing oriented mathematics teaching is regarded as a reasonable teaching strategy, there is little known about the effect of this teaching strategy on cognitive and affective processes of prospective teachers. Moreover, the possible difficulties those students might encounter are not well documented. In educational research since the focus is on problem solving, problem posing become a neglected area (Dillon, 1988). Although it is likely that students may like problem posing oriented teaching and this strategy may positively affect their achievement and attitudes, there is hardly any study that examine the use of problem posing in the classroom (Silver, 1994).

Some teaching associations e.g. NCTM emphasizes the importance of problem posing in mathematics lessons, and recommends its usage in mathematics classrooms (NCTM, 1991, 2000).

On the other hand a teacher who is not proficient in subject matter could not give confidence to the students and establish an authority in the classroom that is based on respect. Since self-efficacy is the self-perception of an individual, it is expected from proficient teachers that they have positive mathematics self-efficacy and attitude toward mathematics (Umay, 2001). Therefore, it is beneficial to carry out research that determines teaching strategies that positively affect prospective teachers' mathematics self-efficacy and attitude toward mathematics. Generally speaking, it is expected that prospective teachers who have high mathematics self-efficacy will become persistent teachers who could solve encountered problems. Therefore it should be interesting to see whether problem posing oriented mathematics teaching has positive effects on prospective teachers' attitudes toward mathematics and increase their mathematics self-efficacy.

Theoretical Framework

Before presenting the analysis and synthesis of the research literature we present definitions of some key terminology used in this paper.

Problem Posing

Problem posing is defined as occurring when students are engaged in reformulating given problems and also when producing new problems or questions (Silver, 1994). Thus, problem posing is not independent from problem solving (Silver, 1994; Cai & Hwang, 2002; English, 2003; Silver & Cai, 1996; Lewis et al., 1998).

Attitudes Toward Mathematics

Aiken (1996) states that an attitude "consists of cognitive (knowledge of intellect), affect (emotion and motivation), and performance (behaviour or action) components" (p. 168). Goldin (2002) distinguished between subdomains of affective representation as 1) *emotions*, 2) *attitudes*, 3) *beliefs* and 4) *values, ethics, morals*. According to Goldin (2002) attitudes imply "moderately stable predispositions towards ways of feeling in classes of situations, involving a balance of affect and cognition" (p. 61). In mathematics education literature, attitudes toward mathematics is operationally defined as enjoying mathematics or not enjoying it, being or not being inclined to mathematical activities, considering oneself as

successful or unsuccessful at mathematics and believing mathematics is useful or not useful (Neale, 1969). This paper deals mainly with students' level of interest and enjoyment with mathematics.

Self-Efficacy

Self-efficacy is an attribute that is effective in forming behaviours; individual's judgement about own capacity of organizing and performing activities that are required for an action. It is a key variable of Bandura's Social Cognition Theory (Bandura, 1997). Perceived self-efficacy is concerned with people's beliefs in their capabilities to exercise control over their own functioning and over events that affect their lives (Bandura, 1994). Recently self efficacy is closely related to task being performed. That is self efficacy is highly contextual whereas self-concept is related to more general goals (Pajares, 2000). In this paper, we examine "mathematics self-efficacy beliefs". In this respect, mathematics self-efficacy belief consists of 1. Mathematics self-perception 2. Awareness of behaviours about mathematical topics 3. converting mathematics to survival abilities (Umay, 2001).

Theoretical Background

Problem posing helps students to gain control from others (e.g. teachers) and at the same time this encourages them to create new ideas by giving them a more expanded view on what can be done with problems (Brown & Walter, 1983). This process can also assist teachers as problem posing opens a window in on students' thinking (Silver, 1994). In this way, teachers can better understand students' cognitive processes; find out about possible misconceptions early in the learning process and gather information about students' achievement levels (Silver et al., 1990) As a consequence their program of study can be tailored according to individual needs of students that is designed to enhance learning (Dickerson, 1999).

Considering attitude toward mathematics as multi dimensional perspectives in affective domain has been developed through the end of 1970s. As a result of recent research, it is claimed that attitude towards mathematics is not just a concept that reflects affective domain but includes more than this. For example, attitude toward mathematics can include any of the perceptions about oneself, his/her mother, father or teacher (Hart, 1989).

There are a lot of studies on attitude toward mathematics. Majority of these studies are carried out in various areas such as intelligent, race, teaching methods, and social-economical background. There are some studies that have consistent results. Particularly there is a meta-analysis of 113 attitude studies that deal with the relationship between attitude and success in mathematics of 82,941 students (Maye & Kishor, 1997). This study shows a positive and significant correlation between mathematics success and attitude toward mathematics. Nevertheless, since this correlation is not so strong, it has no practical and educational value.

In recent years affective variables become very popular research variables among mathematics education research community. It is most commonly agreed that these variables have important roles in learning mathematics. Affective domain is a complex structured system that includes emotion, attitudes, beliefs and values as four fundamental components (Bandura, 1997; De Bellis & Goldin, 1997; Goldin, 2002; Pehkonen, 2001). In this respect this study focuses on mathematics self-efficacy beliefs (or perceived self-efficacy) and attitudes toward mathematics

Self-efficacy belief is recently researched in several domains: teacher efficacy belief, mathematics self-efficacy belief, problem solving and posing efficacy belief, computer usage efficacy belief etc. It is obvious that persons who have high self-efficacy belief would be more successful and get the result more quickly. From this perspective, students', teachers' and teacher candidates' self-efficacy beliefs in affective domain are important concepts that should be researched (Aşkar & Umay, 2001). In this respect, the studies that investigate teachers' behaviours emphasise the expectations and beliefs about teaching qualifications that affect teachers' and students' success and motivation (Eshach, 2003; Wenner, 2001). While some teachers advocate that "all students could learn", other teachers don't accept this. Teachers with low self-efficacy tend to fail low achievers and don't accept responsibility in their academic achievements. These teachers regard themselves as authoritarian teachers and negatively affect their students' attitudes and make them unconfident. On the other hand teachers with high self-efficacy regard low achievers as "accessible" and their learning problems as "solvable". These teachers pride themselves because they help low achievers in their learning. Furthermore, teachers with high self-efficacy could provide good teaching because they don't stress out (Schriver & Czerniak, 1999; Chan, 2003, cited in Altunçekiç et al., 2005).

The relationship between self-efficacy beliefs and success is studied by many researchers, and it is reported that self-efficacy might have positive effects on students' success and attitude; furthermore it is found that it has direct relationship with teacher's in class behaviours, being open-minded, and developing positive attitudes for teaching (Gibson and Dembo, 1984; Tschannen-Moran & Woolfolk, 1998). On the other hand, problem posing ability, attitudes towards mathematics and mathematics self-efficacy belief are considered as three fundamental concepts among the most important features of mathematics learning and teaching and have close relationships with success in mathematics (English, 1998; Silver, Mamona-Downs, Leung & Kenney, 1996; Brown & Walter, 1993; Nicolaou & Philippou, 2004). Klassen (2004) asserted that between mathematics self-efficacy and mathematics success had a strong correlation. The students who have higher success in mathematics lessons are reported to have higher self-efficacy beliefs (Pajares & Kranzler, 1995; Zimmerman, Bandura & Martinez-Pons, 1992). English (1998), Leung & Silver (1997) and Silver & Cai (1996) have reported a positive relation between problem posing and problem solving abilities in common between problem posing abilities and mathematics success (Nicolaou & Philippou, 2004). Mathematics self-efficacy belief is a good predictor of mathematics performance (Bandura, 1986). It was observed that efficacy in problem solving had a casual-effect on students' rating (Pajares & Miller, 1994). Many researchers have reported that problem posing activities not only help to lessen students' anxiety and foster a more positive disposition towards mathematics, but also they may enrich and improve students' understanding and problem solving (Brown & Walter, 1990; NCTM, 2000; Silver, 1994; cited in Cai & Hwang 2003). In this respect, this study focuses on prospective primary mathematics teachers' attitude toward mathematics and their perceived self-efficacy toward mathematics (self-efficacy beliefs of mathematics) together with problem posing oriented instruction.

To sum up, the research so far cited show that problem posing and self-efficacy beliefs of mathematics, mathematics success, problem solving ability and attitude toward mathematics are closely related to each other (Klassen, 2004; Pajares & Miller, 1994; Nicolaou & Philippou, 2004; English, 1998; Silver & Cai, 1996; Leung & Silver, 1997). There is a positive relation among problem posing ability and mathematics achievement (English, 1998; Leung & Silver, 1997). Furthermore this relationship also exists between problem posing and problem solving ability (English, 1998; Silver & Cai, 1996).

Therefore, determining the level of self-efficacy beliefs of mathematics of prospective teachers and factors that affects these beliefs is a problem worth studying. In addition, students' understanding of mathematics, their ability to use this in problem solving, self-confidence, and attitude toward mathematics is shaped with the teaching they get from schools (NCTM, 2000). Otherwise, there is almost no systematic and experimental study that deals with application of problem posing-oriented instruction in different classrooms and teaching of different topics (Dillon, 1988; Silver, 1994). Furthermore, to the best of our knowledge there are not any studies that investigate elementary school teachers' attitudes towards mathematics and the relation between this construct and the ability to pose problems. In this respect, the main purpose of this study was to explore the effect of problem posing instruction on the attitudes toward mathematics and mathematics self-efficacy of elementary prospective mathematics teachers.

The Problems of the Research

The main problem of the study reads as "What is the effect of problem posing on students' attitudes toward mathematics and mathematics self-efficacy when problem posing oriented approach is used to teach the Integral concept in Analyses-II Course to first grade prospective teachers who are enrolled to Education Faculty Primary Mathematics Teaching Program?"

In this study the following 2 sub-problems are stated:

P1.What are pre-test and post-test scores of experimental and control group prospective teachers in Mathematics Attitude Scale (MAS)?

P2.What are pre-test-post-test scores of experimental and control group prospective teachers in Mathematics Self-Efficacy Scale (MSES)?

Method

Sample and Population

Participants in this study included 82 first year students who were enrolled in one of two classes at a Primary Education Mathematics Teaching Program of a Faculty of Education during the 2005-2006 academic year spring term. One classes was assigned randomly to be the control group, the other became the experimental group. The control group and the experimental group consisted of 40 and 42 prospective teachers, respectively.

Research Model

In this research experimental methodology is used. Pre-test post-test control grouped experimental design is used. In this kind of design where an experimental and control group exist is called a "quasi-experimental" design (Linn & Gronlund, 2000). This method is commonly used when the variables of focus are measured quantitatively and where there is the assumption of a cause-effect relationship (Çepni, 2001). Since the groups were assigned randomly, but not the individuals within them, this method is called a non-equivalent control-grouped design (Karasar, 1999). However some variability between the groups was reduced by assigning equal numbers of students from the same department that have similar qualifications to each group.

Data Collection Tools, Reliability and Validity Studies

In this study two different data gathering instruments were used.

Mathematics Attitude Scale (MAS)

This scale was developed by Aşkar (1986). It consisted of 10 positive and 10 negative items about attitude toward mathematics. They were in five-point Likert-type scale: Strongly Agree, Agree, Undecided, Disagree, Strongly Disagree. Positive items were coded starting from Strongly Agree as 5 to Strongly Disagree as 1. Negative items were coded as from 1 to 5. The alpha reliability coefficient was found as 0.96 (Aşkar, 1986). The items of the scale are mostly related to “mathematics is interesting or not” and “like or dislike mathematics”. The followings are examples of some positive and negative items:

1. Negative Items

I don't like mathematics

Being a student would be more amusing without mathematics lessons

2. Positive Items

I study mathematics more fondly than other lessons

I wish lesson hours devoted to mathematics would be more

The reliability of the scale is calculated again by the researchers using alpha reliability coefficient as 0.82. The item-total correlation of 20 different items in the scale was changed between 0, 41 and 0, 81.

Mathematics Self-Efficacy Scale (MSES)

In order to measure prospective teachers' self-efficacy beliefs of mathematics “Mathematics Self-Efficacy Perception Scale (MSES)” developed by Umay (2001) was used. The alpha reliability coefficient of this 5 optioned Likert type scale that consists 14 items is $\alpha = 0, 88$. The average of validity coefficients of items is found as 0, 64 and this can be considered as a sign of validity of the whole scale. There are three factors in the scale, these factors and example items are as follows:

1. Factor: Mathematics self-perception

If I tried hard enough I could solve every kind of mathematics problem.

I realize that my confidence is decreasing while studying mathematics.

2. Factor: Perception about behaviours related to mathematical topics.

I feel like I am going wrong while solving mathematical problems.

I could discover small things by browsing around mathematical structures and theorems.

3. Factor: Turning mathematics into survival skills

While I am planning my time/ day I think mathematically.

I could suggest solution to every kind of real life problems by thinking mathematically.

The validity and reliability analyses are performed again by researchers. The results of these analyses showed validity coefficients for three sub-dimensions as $\alpha = 0, 70$, $\alpha = 0, 71$ and $\alpha = 0, 75$ respectively, and alpha reliability coefficient for the whole scale as $\alpha = 0, 85$. Item-total correlation for 14 items of the scale ranges from 0, 30 to 0, 61.

Analysis of Data

In this research effect of problem posing oriented Analyses-II course on experimental group and effect of traditional teaching on control group are analysed separately. That is the pre-test post-test MAS and MSES scores of experimental and control group students are compared within groups and between groups (Cohen, Manion & Morrison, 2000). For this reason in order to compare the data gathered from control and experimental group before and after the experimental study “t-test for independent groups” and in order to compare the data gathered from the same group at different times “t-test for dependent groups” was used (Mc Millan, 2000). The descriptive statistical information was presented using tables of arithmetic mean (\bar{X}), standard deviation (S.D.), degree of freedom (dF), level of significance(p) and number of subjects(N) . Although it might be thought here that ANCOVA could be used, we should emphasize that there is no significant group differences in terms of pre-test scores. Thus they could be regarded as equivalent groups and t-test seems more suitable.

Experimental Research Design

In this section we will present the strategy that was followed by the researcher in the experimental and control groups. The strategy that was followed in quasi-experimental study is organized according to learning and teaching activities. The experimental study was carried out by the researcher and assistant instructors during spring term of 2005-2006 academic year in Integral Unit of Analyses II course. The study lasted for 10 weeks 6 lesson hours being in each week (6x10=60 hours) simultaneously in both groups. For both groups, two lesson hours (2x50=100 minutes) were devoted on Monday, Tuesday and Wednesday in every week. The lessons for the control group were held between 08:00 and 17:00 and experimental group’s lessons were during the evenings between 17:30 and 22:30. The lessons were given by the same instructor to both groups during study. At the beginning and end of the study MSES and MAS tests were applied to both groups at the same time. The participants were not informed about whether they were in the control group or in the experimental group. In order to prevent bias the tests were checked when the study was completed.

Teaching Strategy that is Employed in the Experimental Group:

At the beginning of the course the terminology “problem posing” was not used rather more informal terminology like “problem producing”, “problem constructing”, “problem writing”, “asking question” or “changing the expressions of a problem” was used. This caution is suggested in order to prevent negative connotations of the term “problem posing” (Owens, 1999).

In the first week of the study, the researcher gave a presentation to the participants in the experimental group and the instructor in order to explain problem solving and posing. In this presentation, the essence of problem solving and posing oriented teaching, its strategies and techniques and the planned problem posing activities were described. The students in the experimental group were firstly introduced with problem solving strategies and problem posing techniques based on Polya’s 4 steps in integral unit of Analyses II course. The instructor followed the 20 minutes of each lesson to present information about the topic. In the remaining 30 minutes, after the problems were solved by the instructor, the students were given a group of problems and asked to solve these problems by explaining what they did at

each step and produce new problems. In this way, a fifth step involving posing a related problem was added to Polya's 4 steps. In order to accomplish this, activity examples of the action plan proposed by Gonzales (1998) that includes development of mathematical communication, questioning techniques and generalizing problems were used as the guidance of the instructor.

The textbook used in the course was Turkish translation of Edwards and Penney's (2001) titled "Calculus and Analytic Geometry". This textbook was suitable to standards of NCTM and American Mathematical Association of Two-Year Colleges (AMATCY) because it aims to relate mathematics to daily life rather than rote learning. Furthermore, a webpage titled "*visual calculus*" (URL-1, 2004) that contains lesson modules related to Integral and visual activities and flash animations was used in the lessons. Teacher candidates frequently wrote questions with the instructor and solved them by discussing with their friends. Secondly, teacher candidates in the experimental group were presented with problem posing activities in which they could use several problem-posing strategies and techniques generally last 30 minutes of lessons.

Systematic structure about problem posing tasks presented in the literature about problem posing reflects experiences and situations that provide opportunities to the students engaged in mathematical activities. Therefore in this research, the classifications of problem posing tasks suggested by Stoyanova (1998), Silver (1995) and Ambrus (1997) were used to carry out activities about Integral concept in the classroom. Three classification of Stoyanova(1998), Silver(1995) and Ambrus(1997) involve five categories of problem posing tasks, used throughout the studies reviewed so far: tasks that merely require students to pose (a) a problem in general(free situation), (b) a problem with a given answer, (c) a problem that contains certain information, (d) questions for a problem situation, and (e) a problem that fits a given calculation (Constantinos et al, 2005).

In this phase, framework of these problem posing activities was developed and the participant instructor by considering the "*what if not*" strategy (Brown & Walter, 1983, 1993), "*semi-structured problem posing situations*", "*structured problem posing situations*" and "*free problem posing situations*" (Stoyanova & Ellerton, 1996; Stoyanova,1998).

Furthermore, "*Mathematical situations*" (Gonzales, 1996), "*open-ended problem-posing situation*" (Silver & Adams, 1987; Silver, 1995; Gonzales, 1998; Lowrie, 1999, 200, 2002; Ellerton, 1986; Hashimoto & Sawada, 1984; Nohda, 1986, 1995; Shimada,1977; Pehkonen, 1995; Dickerson,1999) "*acting-out problem-posing situation*" (Brown, 1983; Burns & Richards, 1981; Walter, 1992; cited in Dickerson,1999) and "*missing data problem posing situation*" (Van Den Heuvel-Panhuizen, 1996) were included in the study and these activities were considered as *semi-structured problem posing situations*.

Some of the problem posing activities related to "Integral" selected from 30 different ones applied to the prospective teachers was presented below:

A. Free Problem Posing Situation	
<p>Activity 1. Write a fractional function of at least third degree and which has three different roots and has nominator degree greater than its denominator degree then find its indefinite integral.</p>	<p><i>Here making use of given mathematical expressions and writing a novel problem before solving is at issue. There is mathematical scenario but mathematical components and expressions are not given. In order to pose a problem according to the given scenario, mathematical components and expressions that are left free can be used.</i></p>

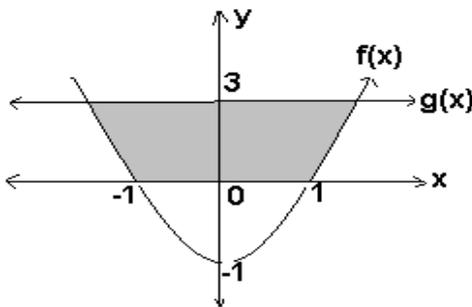
Activity 2. Provided that you are free in choosing a function, can you write an integral problem that you can solve by using consecutive partial integration and then generalise your solution? Discuss your answers with underlying reasons.

Here posing problems before or during the solution of the original problems that would be posed depending on mathematical expressions and components is at issue. That is, problem posing is made before or during the solution of problems. There is no limitation or obligation on mathematical components that would be chosen to pose problems suitable to required mathematical expressions.

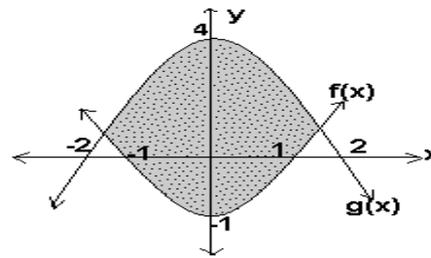
B. Semi-Structured Problem Posing Situations

a. Mathematical situations

Activity 3. As can be seen in the figure below there is a region bounded by the parabolas $f(x)$ and line $g(x)$ and the axes. Pose a problem related to this figure.



Activity 4. As can be seen in the figure below there is a region bounded by the parabolas $f(x)$ and $g(x)$ and the axes. Pose a problem related to this figure.



In activities 3 and 4 the students were provided with semi-structured mathematical expression. In this expression the actual component is not certain. That is, actual problem root is not given here; it is required to pose a problem suitable to "Mathematical Situation".

b. Open-Ended Problem-Posing Situation

Activity 5. In order to compute the volume of a solid figure that is not surface of a revolution, try to pose an Integral problem. Then discuss whether or not you can approximately compute the volume of an item or an object you use in daily life. Explain!

There is a scenario which is semi-structured, and which has mathematical components related to real life. Since there is not any restriction on the components that constitutes the scenario there is "open-ended problem posing" situation. The student could pose problems according to the structure and conditions that he/she prefers.

c. Acting-Out Problem-Posing Situation

Activity 6. You will get engaged when you graduated from the university. If you are going to design your engagement ring, how would you design the ring and determine its cost?

There is semi-structured mathematical situation which is rich content in terms of creativity. A scenario that leads students to concretize and envisage real life situations is given here.

d. Missing Data Problem Posing Situation

Activity 7: Compute anti-derivative of $\int \sin(x) dx = ?$ and after you check your answer could you find anti-derivative of $\int \sin(x^2) dx = ?$ by using change of variable method? If your answer is no can you rearrange it in order to solve the problem?

The student who saw that anti-derivative of $\int \sin(x^2) dx = ?$ could not be found by using change of variable method would complete the missing data and reformulate the problem. In this process s/he would realize that the given data and some structures conflict each other and question the situation.

Activity 8: The volume of an area that is bounded by various lines, x-axis and a non-linear function is rotated about $y=5$ is approximately $9,3 u^3$. Find this non-linear function and various lines. With these compute the

There is a problem with missing data here. In order to get arguments that were not given at the beginning the answer of the problem and the knowledge about volume can be used. Therefore,

volume and ascertain the answer.	<i>the missing data will be completed by using constant questioning.</i>
C. Structured Problem Posing Situations	
Activity 9: $m, n \in Z$ compute $\int \sin^n(x) \cos^m(x) dx = ?$ “Pose different problems depending on the integers m and n . Later try to solve each problem you posed. By looking at your solutions can you get a generalization?”	<i>Here without changing mathematical components, by changing the integers m and n new problems can be posed. That is, in order to criticise the conditions on the general structure of the given expression, new problems can be posed from structured problem posing situation by using What-if & what-if-not strategies.</i>
Activity 10: The function $F(x) = \int_0^x \tan(x^2) dx$ is given. Show that $F' \left(\sqrt{\frac{\pi}{4}} \right) = 1$. Later by making some modifications on this problem write a different integral problem that has solution 2 and check your solution.	<i>Here, there is a problem posing situation in which it is required to change the aims and conditions of the problem that has solution. Furthermore, after problem solving there is problem posing. Here, “What-if & what-if-not” strategies would be useful.</i>

Figure 1. Some problem posing activities used in the experimental group

Teaching strategy that is followed in the control group

In the control group, the lesson was given as the instructor’s plan by using traditional teaching methods (teacher centred; lecturing, question and answer, problem solving etc.). The same textbook was used in the control group (Edwards & Penney, 2001). The same topics were covered in this group however problem posing activities were not applied. Most of the problems in the textbook were solved by the instructor. The students were checked whether or not they understood. The related problems were given as homework at the end of topics. The students were provided with opportunities to ask about the problems they could not solve. However the problems were not opened to discussion in the classroom.

Findings and Interpretation

Findings regarding the first research question (P1)

Group	Test	N	\bar{X}	S.D	df	t	p
Experimental	Pre-test	42	3,70	0,52	41	-2,542	,015
	Post-test	42	3,86	0,56			
Control	Pre-test	40	3,71	0,54	39	1,875	,068
	Post-test	40	3,54	0,64			

Table 1. t-test results for dependent groups related to experimental and control group students’ MSES pre-test post-test scores

As can be seen in Table 1, there is statistically significant difference between MSES pre-test and post-test scores of experimental group prospective teachers [$t(41) = -2,542$; $P < .05$]. Their pre-test arithmetic average score is ($\bar{X} = 3,70$) and post-test arithmetic average score is ($\bar{X} = 3,86$). This shows that the difference is in positive way. Therefore, problem posing oriented course might have an effect on this increase. When we look at MSES pre-test score and post-test scores of control group students, we see that there is not a statistically

significant difference [$t(39)=1,875$; $P > .05$]. As a matter of fact their arithmetic average scores show a decrease from pre-test ($\bar{X}=3, 71$) to post-test ($\bar{X}=3, 54$). This shows that traditional teaching does not positively affect development of mathematics self-efficacy beliefs. In fact, there is a decrease in their average scores. To sum up, it can be said that problem posing oriented teaching and traditional teaching have different affects on developing experimental group students' and control group students' mathematics self-efficacy beliefs.

Test	Group	N	\bar{X}	S.D	dF	t	p
Pre-test	Exp.	42	3,70	0,52	80	-0,111	0,912
	Control	40	3,71	0,54			
Post-test	Exp.	42	3,86	0,56	80	2,337	0,022
	Control	40	3,54	0,64			

Table 2. t-test results for independent groups related to experimental and control group students' MSES pre-test post-test scores

As can be seen from Table 2, there is no statistically significant difference between MSES pre-test scores of experimental group prospective teachers and control group prospective teachers [$t(80)= -,111$; $P > .05$]. This implies that two groups are equivalent in terms of their MSES pre-test score. This result might be of use to compare two teaching methods. In this respect when we look at MSES post-test scores of experimental group students and control group students, we see a statistically significant difference [$t(80)= 2,337$; $P < .05$]. The arithmetic average MSES post-test score of experimental group students ($\bar{X}=3, 86$) is higher than of control group students ($\bar{X}=3, 54$). As a result, when we compare the effects of traditional teaching method and problem posing oriented on improving mathematics self-efficacy beliefs, we can say that problem posing oriented method is more effective.

Findings regarding the second research question(P2)

Group	Test	N	\bar{X}	S.D	dF	t	p
Experimental	Pre-test	42	4,02	0,66	41	-2,086	,043
	Post-test	42	4,15	0,60			
Control	Pre-test	40	4,03	0,65	39	3,306	,002
	Post-test	40	3,78	0,76			

Table 3. t-test results for dependent groups related to experimental and control group students' MAS pre-test post-test scores

As can be seen from Table 3 there is a statistically significant difference between pre-test MAS score and post-test MAS score of experimental group students [$t(41)=-2,086$; $P < .05$]. Their pre-test arithmetic average score is ($\bar{X}=4, 02$) and post-test arithmetic average score is ($\bar{X}=4, 15$). This shows that the difference is in positive way. Therefore, problem posing oriented course might have an effect on this increase. Therefore, it can be said that problem posing oriented teaching strategy is effective in improving students' attitudes toward mathematics. However, when we look at MAS pre-test score and post-test scores of control group students, we see that there is a statistically significant difference in a negative way [$t(39)=-3,306$; $P < .05$]. In fact it is interesting to note that their arithmetic average MAS scores show a decrease from pre-test ($\bar{X}=4, 03$) to post-test ($\bar{X}=3, 78$). That is after using

traditional teaching strategy, their attitude toward mathematics deteriorates. In summary, experimental group students' attitudes toward mathematics are improved whereas control group students' attitudes toward mathematics are deteriorated.

Test	Group	N	\bar{X}	S.D	dF	t	p
Pre-test	Exp.	42	4,02	0,66	80	-0,002	0,999
	Control	40	4,03	0,65			
Post-test	Exp.	42	4,15	0,60	80	2,473	0,016
	Control	40	3,78	0,76			

Table 4. t-test results for independent groups related to experimental and control group students' MAS pre-test post-test scores

As can be seen from Table 4, there is no statistically significant difference between MAS pre-test scores of experimental group prospective teachers and control group prospective teachers [$t(80) = -0,002$; $P > .05$]. This implies that two groups are equivalent in terms of their MAS pre-test score. This result might be of use to compare two teaching methods. In this respect when we look at MAS post-test scores of experimental group students and control group students, we see a statistically significant difference [$t(80) = 2,473$; $P < .05$]. The arithmetic average MAS post-test score of experimental group students ($\bar{X} = 4,15$) is higher than of control group students ($\bar{X} = 3,78$). As a result, when we compare the effects of traditional teaching method and problem posing oriented on improving attitudes toward mathematics, we can say that problem posing oriented method is more effective.

Summary and Recommendations

The purpose of this study was to investigate the effects of problem posing oriented course on elementary prospective mathematics teachers' attitudes and self-efficacy in mathematics. In this respect, two different strategies were employed in teaching Analysis II course for Primary Mathematics Teaching Program students. Experimental group students are taught by using problem posing oriented course and control group students are taught by traditional teaching methods. There are some limitations that need to be addressed. First of all the same teacher (researcher) taught for both groups. This might increase the validity of the study. However, although every caution was taken to prevent bias, it might be thought that if the teacher is the researcher and is motivated/keen to find a group difference then there would be a tendency to not teach and care for the students learning in the control group as much compared to the intervention group. Although the students in the control group are allowed to interact and discuss their problems together, traditional teaching context might limit their interaction. In addition, elementary teacher candidates have to take calculus course which covers topics that might be un-related to elementary mathematics. Furthermore it should be noted again that self-efficacy is task related. Therefore the participants might have difficulties in considering that the problem posing that they were engaged in could be used in elementary teaching. The questions were presented in Turkish to the students. These questions and students' responses were translated into English. Although every care is taken to prevent losing of meaning in this translation process, this might be considered as a limitation of this study.

The pre-test results show that both of the groups have similar scores from MAS and MSES. Such a result inevitably helps to judge the effectiveness of both methods on improving students' attitudes toward mathematics and mathematics self-efficacy beliefs. As a matter of

fact, there are statistically significant differences between MSES and MAS post-test scores of experimental and control group students. Furthermore the improvement of experimental group students' MAS scores ($\bar{X}_{\text{post-test}} - \bar{X}_{\text{pre-test}} = 0, 13$) is in positive direction and this is statistically significant. On the other hand improvement of control group students' MAS scores ($\bar{X}_{\text{post-test}} - \bar{X}_{\text{pre-test}} = -0, 25$) is in negative direction for control group students, this difference is also statistically significant. Similarly, the improvement of experimental group students' MSES scores ($\bar{X}_{\text{post-test}} - \bar{X}_{\text{pre-test}} = 0, 16$) is statistically significant. However, the difference in control group students' MSES scores ($\bar{X}_{\text{post-test}} - \bar{X}_{\text{pre-test}} = -0, 17$) is negative and statistically significant. Consequently, it can be claimed that problem posing oriented Analysis II course has positive effects on improving students' attitudes toward mathematics and mathematics self-efficacy beliefs. On the other hand traditional teaching oriented Analysis II course has negative effects on improving students' attitudes toward mathematics and mathematics self-efficacy beliefs. Thus, analysis of this quantitative data implies that problem posing oriented Analysis II course is more effective than traditional teaching in improving prospective teachers' attitudes toward mathematics and mathematics self-efficacy beliefs.

Our results are parallel to results of some research in the literature. Our results confirm the findings of Brown and Walter (1983,1993), Winograd (1990) English (1997), Moses et al.(1990), Silver at al.(1990), Silver(1994) and Nicolaou & Philippou (2004) who stated that problem posing might reduce common fears and anxieties about mathematics and foster a more positive attitude towards mathematics. Furthermore, our results are consistent with findings of Brown & Walter (1993), English (1997) and Silver, Mamona-Downs, Leung & Kenney (1996) that report problem posing activities improve prospective teachers' attitude toward mathematics, alleviate misunderstandings about the nature of mathematics and since they begin to believe that mathematics would be useful for their job, they begin to feel more responsibility.

Since problem posing activities are used first time in prospective teachers' Analysis II course, their attendances to classes are better than previous terms. As we presented in Akay, H.& Boz, N. (2009) participants enjoyed the course. The qualitative data was used in Akay, H.& Boz, N. (2009) to examine how participants found the course. In this respect, since problem posing provides active involvement of students, it reduces anxiety, by motivating even students that do not have much knowledge about the topic it ensures optimistic atmosphere and hence the students who focus on activities try to think critically move away from negative behaviours.

To sum up, problem posing oriented course has positive effects on mathematics self-efficacy beliefs and attitude toward mathematics. Therefore, we suggest that such a teaching approach could be used in mathematics courses of Primary Mathematics Teaching Programs. In order to strengthen this suggestion this study might be replicated with different sample of prospective teachers across Turkey.

References

- Aiken L. R. (1996). Rating Scales and Checklists: Evaluating Behavior, Personality, and Attitudes. New York: John Wiley & Sons, Inc.
- Akay, H.& Boz, N. (2009). *Prospective Teachers' Views about Problem-Posing Activities* World Conference on Educational Sciences (WCES 2009) Kıbrıs. Procedia Social and Behavioral Sciences 1 (2009) 1192–1198.

- Altunçekiç, A., Yaman, S., Koray, Ö. (2005). Öğretmen Adaylarının Öz-Yeterlik İnanç Düzeyleri ve Problem Çözme Becerileri Üzerine Bir Araştırma (Kastamonu İli Örneği). *Kastamonu Eğitim Dergisi*, 13/1, 93–102.
- Ambrus, A. (1997). Problem posing in mathematics education. Ed: Kansanan, P., *Discussion on some Educational issues VII. Research Repots, Helsinki, Finland*, 5-19.
- Aşkar, P. (1986) Matematik Dersine Yönelik Tutumu Ölçen Likert-Tipi Ölçeğin Geliştirilmesi, *Eğitim ve Bilim*, 11 (62), 31-36.
- Aşkar, P. ve Umay, A. (2001). İlköğretim Matematik Öğretmenliği Öğrencilerinin Bilgisayarla ilgili özyeterlik algısı. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*. 21, 1–8.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (1994). *Self-efficacy*. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71–81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], *Encyclopedia of mental health*. San Diego: Academic Press, 1998).
- Bandura, A. (1997). *Self-Efficacy: The exercise of control*. New York: Freeman.
- Brown, S. (1983). *The logic of problem generation: From morality and solving to de posing and rebellion*, Canadian Mathematics Education Study Group, British Columbia.
- Brown, S. I., & Walter, M. I. (1983). *The art of problem posing*. Hillsdale, NJ: L. Erlbaum Associates.
- Brown, S. I., & Walter, M. I. (1990). *The art of problem posing* (2nd Ed.). Hillsdale, N.J.: Lawrence Erlbaum Associates.
- Brown, S. I., & Walter, M. I. (1993). *Proplem posing: reflection and aplications*. Hillsdale, NJ: Erlbaum
- Burns, M., & Richards, K. (1981). Making sense out of word problems. *Learning*, 9(6), 26–32.
- Cai, J., & Hwang, S. (2002). Generalized and generative thinking in U.S. and Chinese students' mathematical problem solving and problem posing. *Journal of Mathematical Behavior*, 21, 401–421.
- Cai, J. & Hwang, S. (2003). A Perspective for Examining the Link between Problems Posing and Problem Solving. *Proceedings of the Joint Annual Meeting of the PME and PME/NA*. Honolulu, HI: University of Hawaii, July 13–18.
- Chan, D.W. (2003). Multiple Intelligences And Perceived Self-Efficacy Among Chinese Secondary School Teachers in Hong Kong, *Educational Psychology*, 23(5), 521–533
- Cohen, L., Manion, L., & Morrison, K. (2000). *Research Methods in Education* (5th ed.). Routledge/Falmer, Taylor&Francis Group, London.
- Constantinos, C., Nicholas, M., Demetra, P.P., & Bharath, S. (2005). An Empirical Taxonomy of Problem Posing Processes, *Analyses, ZDM*, 37 (3), 149-158.
- Çepni, S. (2001). *Araştırma ve Proje Çalışmalarına Giriş*, Erol Ofset, Trabzon.
- Dickerson, V. M. (1999). *The Impact Of Promlem-Posing Instruction On The Mathematical Problem-Solving Achievement Of Seventh Graders*. Unpublished Ph.D Dissertation, University Of Emory, Atlanta.
- Dillon, J. T. (1988). Levels of problem finding vs. problem solving. *Questioning Exchange*, 2(2), 105–115.
- Edwards, C. H. and Penney, D.E. (2001). *Calculus and Analytic Geometry*; Prentice Hall, Inc., (Çeviri: Prof.Dr.Ö. Akın), Palme Yayıncılık, Ankara,
- Elderveld, P. J. (1983). Factors related to success and failure in developmental mathematics in the community college. *Community Junior Colloge Quarterly of Research and Practice*, 7(2), 161–174.
- Ellerton, N. F. (1986) Children's Made-up Mathematical Problems: a new perspective on talented mathematicians, *Educational Studies in Mathematics*, 17, pp. 261-271.

- English, L. D. (1997). The Development of Fifth grade Children's Problem Posing Abilities. *Educational Studies in Mathematics*, 34, 183–217.
- English, L. D. (1998) Children's problem posing within formal and informal context, *Journal for Research in Mathematics Education*, 29(1), 83–106.
- English, L. D. (2003). Problem posing in the elementary curriculum. In F. Lester, & R. Charles (Eds.), *Teaching mathematics through problem solving*. Reston, Virginia: National Council of Teachers of Mathematics.
- Eshach, H. (2003). Inquiry-Events Es a Tool For Changing Science Teaching Efficacy Belief of Kindergarten and Elementary School Teachers, *Journal of Science Education and Technology*, 12(4), 495–501.
- Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation, *Journal of Educational Psychology*, 76(4), 569-582.
- Goldin, G. (2002). Affect, Meta-Affect, and Mathematical Belief Structures. In G. Leder, E. Pehkonen, & G. Toerner (Eds.), *Belief: A hidden variable in mathematics education?* (pp. 59–72). Dordrecht: Kluwer Academic Publishers.
- Gonzales, N. A. (1996). Problem formulation: Insights from student generated questions. *School Science & mathematics*, 96 (3), 152–157.
- Gonzales, N. A. (1998). A Blueprint for Problem Posing. *School Science & Mathematics*, 94 (2), 78- 85.
- Hart, L. E. (1989). *Describing the affective domain: saying what we mean*. In D.B. McLeod & V.M.Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 37-45). New York: Springer Verlag.
- Hashimoto, Y & Sawada, T. (1984). Research on the mathematicsteaching by developmental treatment of mathematical problems.– In: T.Kawaguchi (Ed.), *Proceedings of the ICMIJSM Eregional conference on mathematical education*. Japan: Japan Society of Mathematical Education, p. 309–313.
- Karasar, N. (1999). *Bilimsel araştırma yöntemi*. Ankara: Nobel Yayın Dağıtım.
- Klassen, R. (2004). A Cross-Cultural Investigation of the Efficacy Beliefs of South Asian Immigrant and Anglo Canadian Nonimmigrant Early Adolescents. *Journal of Educational Psychology*, 96 (4), 731–742.
- Kliman, M., & Richard, J. (1992). Writing, sharing, and discussing mathematics stories. *Arithmetic Teacher*, 40(3), 138–141.
- Leung, S. S., & Silver, E. A. (1997). The role of task format, mathematics knowledge, and creative thinking on the arithmetic problem posing of prospective elementary school teachers. *Mathematics Education Research Journal*, 9 (1), 5–24.
- Lewis, T., Petriner, S. & Hill, M. A. (1998) Problem Posing-Adding a Creative Increment to Technological Problem Solving, *journal of Industrial Teacher Education(JITE)*, 36 (1), 5-35.
- Linn, R. L., & Gronlund, N. E. (2000). *Measurement and assessment in teaching* (8th Edition). New Jersey, USA: Prentice Hall.
- Lowrie, T. (1999) Free Problem Posing: Year 3/4 students constructing problems for friends to solve, in J. Truran & K. Truran (Eds) *Making a Difference*, pp. 328–335. Panorama, South Australia: Mathematics Education Research Group of Australasia.
- Lowrie, T. (2000) Grade 1 Children in Problem-posing Contexts: problem solving prior to completing the task, in J. Bana & A. Chapman (Ed.) *Mathematics Education Beyond 2000*, pp. 385–393. *Refereed Proceedings of the Annual Mathematics Education Research Group of Australasia Conference*, Fremantle.
- Lowrie, T. (2002). Designing a Framework for Problem Posing: young children generating open-ended tasks, *Contemporary Issues in Early Childhood*, Volume 3, Number 3, pp. 354–364.

- Maye, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics education*, 28(1), 26-47.
- McMillan, J. H. (2000). *Educational Research, Fundamentals for the Consumer*, Longman, USA.
- Moses, B.M., Bjork, E., & Goldenberg, E.P. (1990). *Beyond problem solving: Problem posing*. In T. J. Cooney (Ed.), *Teaching and learning mathematics in the 1990's* (pp. 82-91). Reston, VA: National Council of Teachers of Mathematics.
- National council of Teachers of Mathematics (NCTM). (1991). *Principals and Standards for School Mathematics*, Reston, Va: National council of Teachers of Mathematics Pub.
- National Council of Teachers of Mathematics (NCTM). (2000). *Principals and Standards for School Mathematics*, Reston, Va: National Council of Teachers of Mathematics Pub.
- Neale, D. C. (1969). The role of attitude in learning mathematics. *Arithmetic Teacher*, 16, 631-640.
- Nicolaou, A. A., & Philippou, G. N. (2004). Efficacy Beliefs, Ability in Problem Posing, and Mathematics Achievement, *Proceedings of the 3rd International Biennial SELF Research Conference Berlin, Self-Concept, Motivation and Identity: Where to from here?* 4 – 7 July, 2004.
- Nohda, N. (1986). A study of “open-approach” method in school mathematics. – In: Tsukuba J. of Educ. *Study in Math.* 5, p. 119-131.
- Nohda, N. (1995). Teaching and evaluating using “open-ended problems” in the classroom. – In: *ZDM, Zentralblatt für Didaktik der Mathematik* 27 (2), p. 57-61.
- Owens, M. E. (1999). *The Relationships of Cognitive Learning Styles, Mathematics Attitude, and Achievement in a problem-posing Classroom*, Unpublished Ph. D Dissertation, The University of Tennessee, United States.
- Pajares, F. (2000). Current Directions in Self-Efficacy Research. In M. Maehr & P. R. Pintrich (Eds.) *Advances in motivation and achievement*, 10, 1-49.
- Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, 86 (2), 193-203.
- Pajares, F., & Kranzler, J. (1995). Self-efficacy beliefs and general mental ability in mathematical problem solving. *Contemporary Educational Psychology*, 20, 426-443.
- Pehkonen, E. (1995): Use of open-ended problems. In: *ZDM, Zentralblatt für Didaktik der Mathematik*, 27 (2), p. 55-57.
- Pehkonen, E. (2001). A Hidden Regulating Factor in Mathematics Classrooms: Mathematics-Related Beliefs. In M. Ahtee, O. Bjorkqvist, E. Pehkonen, & V. Vatanen (Eds.), *Research on Mathematics and Science Education* (pp. 11-35). Institute for Educational Research, University of Jyväskylä.
- Rives, B. S. (1992). A structural model of factors relating to success in calculus, college algebra and developmental mathematics. *Dissertation Abstract International*, 5309A, 3134.
- Schrivver, M., & Czerniak, C. M. (1999). A Comparison of Middle And Junior High Science Teachers Levels of Efficacy And Knowledge of Developmentally Appropriate Curriculum And Instruction, *Journal of Science Teacher Education*, 10(1), 21-42.
- Shimada, S. (Ed.) (1977). *On lessons using open-ended problems in mathematics teaching*. – Tokyo: Mizuumishobo.
- Silver, E. A., & Adams, V. M. (1987). Using open-ended problems. *Arithmetic Teacher*, 34(May), 34-35.
- Silver, E. A., Kilpatrick, J., & Schlesinger, B. (1990). *Thinking through mathematics: Fostering inquiry and communication in mathematics classrooms*. New York: The College Board

- Silver, E. A. (1994). On mathematical problem posing. *For the Learning of Mathematics*, 14 (1), 19–28.
- Silver, E.A. (1995): The nature and use of open problems in mathematics education: Mathematical and pedagogical perspectives. In: *ZDM, Zentralblatt für Didaktik der Mathematik*, 27 (2), p. 67–72.
- Silver, E. A., & Cai, J.(1996). An analysis of arithmetic problem posing by middle school students. *Journal for Research in Mathematical Research*,27(5), 521–539.
- Silver, E.A., Mamona-Downs, J., Leung, S.S. & Kenney, A.P. (1996). Posing Mathematical Problems: An exploratory study. *Journal for Research in Mathematics Education*, 27 (3), 293–309.
- Silverman, F. L., Winograd, K., & Strohauser, D. (1992). Student-generated story problems. *ArithmeticTeacher*, 39(8), 5–12.
- Stoyanova, E., & Ellerton, N. F. (1996). A framework for research into students' problem posing. In P. Clarkson (Ed.), *Technology in Mathematics Education* (pp. 518–525). Melbourne: Mathematics Education Research Group of Australasia.
- Stoyanova, E. (1998). *Extending and Exploring Students' Problem Solving via Problem Posing: A Study of Years 8 and 9 Students involved in Mathematics Challenge and Enrichment Stages of Euler Enrichment Program for Young Australians*. Unpublished doctoral thesis, Edith Cowan University.
- Tschanen-Moran, M., & Woolfolk, A. H. (1998). Teacher efficacy: Its meaning and measure, *Review of Educational Research*, 68, 202-248.
- Umay, A. (2001). İlköğretim Matematik Öğretmenliği Programının Matematiğe Karşı Öz-yeterlik Algısına Etkisi, *Journal of Qafqaz*, 08(4), 37-44.
- URL-1 (2004). "Visual Calculus-Integration". Retrieved March 5, 2006 from <http://archives.math.utk.edu/visual.calculus/>.
- Van Den Heuvel-Panhuizen, M (1996). *Assesment and realistic mathematics education*. Utrecht: CD-B Pres/ Freudental Institute, Utrecht University
- Walter, R. (1992). Mathematics from almost anything, part I. *Mathematics Teaching*, 120, September 1987, 3–7; part II. *Mathematics Teaching*, 121, December 1987, 2–6.
- Wenner, G. (2001). Science and mathematics efficacy beliefs held by practicing and prospective teachers: a 5-year perspective, *Journal of Science Education and Technology*, 10(2), 181–187.
- Winograd, K. (1990). *Writing, solving, and sharing original math. Story problems: Case studies of fifth grade children's cognitive behavior*, Unpublished Ph. D Dissertation, Universty of Northern Colorado, Greeley, Colorado.
- Zimmerman, B.J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, 29, 663-676.

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