

The Investigation of Prospective Elementary Mathematics Teachers' Problem Posing Self-Efficacy Beliefs

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Abstract

Problem-solving and posing are skills at the center of mathematics education and mathematical thinking. However, little is still known about the affective aspects of problem-posing. This study aimed to determine the level of prospective elementary mathematics teachers' problem-posing self-efficacy beliefs and to compare their beliefs according to the variables of gender, grade, and academic achievement levels. This study was carried out by survey method. Descriptive and causal-comparative survey research design was used in this study. The study group consisted of 130 prospective teachers studying at the Elementary Mathematics Education department in a state university, located in the Eastern Anatolia Region of Turkey. Problem-Posing Self-Efficacy Beliefs Scale was used as a data collection tool. In data analysis, descriptive statistics, the independent samples t-test, and one-way analysis of variance were used. Findings of the study indicated that levels of the prospective teachers' PP self-efficacy beliefs were high. It was found in the present study that the problem-posing self-efficacy beliefs of the prospective teachers did not differ significantly with regard to gender. Furthermore, a statistically significant difference was found between the prospective teachers' problem-posing self-efficacy beliefs in terms of their grade and academic achievement. In the light of the research results, suggestions were presented.

Keywords: Self-efficacy, Problem-posing self-efficacy, Problem-posing, Prospective mathematics teacher

Introduction

Problem-posing (PP) is one of the most interesting topics in the world of mathematics education because of its important role in students' mathematical thinking and understanding (English, 2020). There are a number of different perspectives on what constitutes a PP activity. However, there is general consensus that PP implies creating new problems or reformulating existing problems to form new problems (Dunker, 1945; as cited in Leavy & Hourigan, 2021). PP is critical for high quality mathematics teaching (Cai & Hwang, 2020). However, little is still known about the affective aspects of PP that will improve PP applications in classroom settings (Cai & Leikin, 2020).

Mathematical Problem-Posing

PP, which is accepted as the fifth of Polya's problem-solving steps, is defined as creating a new problem based on the current situation (Stoyanova & Ellerton, 1996; Gonzales, 1998). PP is important for both teachers and students (Cai & Hwang, 2020) because helping students develop their PP capacity can be an effective way to develop their innovative thinking (Bonotto, 2013).

PP can help teachers to provide insight into students' thinking and understanding (Cai & Leikin, 2020; Cai et al., 2020). In this context, PP can be used as a tool in mathematics instruction (Cai & Leikin, 2020). In addition, research reveals that PP can be used to improve teachers' competencies and professional development (English, 2020; Xu et al., 2020). For this reason, PP is important both for teachers' own PP situations and for helping their students to pose problems better (Li et al., 2020).

In studies on PP with prospective teachers, prospective teachers' PP skills (Crespo, 2003; Crespo & Sinclair, 2008; Ellerton, 2013; Kılıç, 2015; Kar, 2016), predictions of problems posed students (Xu et al., 2020), analysis of problems posed for fractions (Xie & Masingila, 2017), mathematical modeling (Ellerton, 2015), ratio-proportion (Bayazit & Kırap-Dönmez, 2017) or geometry (Erdogan, 2020) were examined. According to the results of the research, the problems posed by the prospective teachers are not of high quality and prospective teachers have difficulties in PP. This situation points to a critical need to investigate how prospective teachers have learned and can improve PP to teach mathematics (Cai & Hwnag, 2020).

Problem-Posing Self-Efficacy Beliefs

PP is a unique mathematical activity that provides opportunities for the advancement of both cognitive and affective competencies (Cai & Leikin, 2020; Cai & Hwang, 2021). Emotions, attitudes, and beliefs are often seen as key stages that determine success in problem-solving and posing (Voica et al., 2020). In this context, one of the affective structures associated with PP is self-efficacy (Pajares, 1996; Nicolau & Philippou, 2007; Cai & Leikin, 2020; Li et al., 2020; Voica et al., 2020).

Self-efficacy is the belief of an individual to successfully organize and execute the procedures necessary to achieve a specific goal (Bandura, 1986). Based on the concepts of PP and self-efficacy, the definition of PP self-efficacy belief can be obtained. PP self-efficacy belief can be defined as the self-judgment of an individual to concretely explain past mathematical experiences with the help of various strategies, taking into account existing mathematical problems, different mathematical representations

or open-ended situations encountered in real life (Özgen & Bayram, 2019).

Various studies have shown that students' PP self-efficacy beliefs have an effect on their PP skills (Nicolau & Philippou, 2007; Liu et al., 2020; Aydın-Güç & Keskin, 2021). Aydın-Güç & Keskin (2021) determined that students' PP self-efficacy beliefs are related to the quality of the posed problems. In addition, considering that teachers' PP self-efficacy beliefs are related to their PP performance and creating problem-based learning environments (Philippou et al., 2001; Voica et al., 2020), the beliefs of prospective teachers, who are the teachers of the future, emerges as an issue that needs to be researched. However, it is seen that studies examining the PP self-efficacy beliefs of prospective mathematics teachers and/or mathematics teachers are limited (Philippou et al., 2001; Ünlü & Sarpkaya-Aktaş, 2016; Özgen et al., 2019; Li et al., 2020; Voica et al., 2020).

The Present Study

Recently, it has been suggested that in the field of mathematics education, more emphasis should be placed on emotional and motivational variables (e.g., Goldin, 2017). However, little is known about the affective aspects of PP (Cai & Leikin, 2020; Cai et al., 2020; Guo et al., 2020). Considering the importance of PP and self-efficacy for both mathematics education and teachers, prospective teachers' PP self-efficacy beliefs emerge as an issue that needs to be researched.

Investigating prospective teachers' PP self-efficacy beliefs in a specific area such as PP can provide important clues for that area (Cai & Leikin, 2020). However, studies on the prospective elementary mathematics teachers' PP self-efficacy beliefs, who are the teachers of the future, are quite limited (e.g., Ünlü & Sarpkaya-Aktaş, 2016; Li et al., 2020; Voica et al., 2020). Therefore, it is seen that more studies are needed to expand the literature. This study is important in terms of expanding the literature on mathematics education.

The study is important in terms of revealing the current situation in terms of prospective elementary mathematics teachers' PP self-efficacy beliefs and providing feedback about the effectiveness of

teacher education programs. The findings obtained from this study are expected to provide preliminary information to the studies to be carried out to improve the prospective elementary mathematics teachers' PP self-efficacy beliefs. In addition, the study findings can inform teacher training programs and professional development efforts that will help prospective teachers develop productive beliefs about PP.

The aim of this study was to determine the level of prospective elementary mathematics teachers' PP self-efficacy beliefs and to compare their beliefs according to the variables of gender, grade, and academic achievement levels. Within the scope of the purpose of the study, answers to the following questions were sought:

1. What is the level of prospective elementary mathematics teachers' PP self-efficacy beliefs?
2. Do their beliefs differ significantly according to the variables of gender, grade, and academic achievement levels?

Methodology

Research Design

This study was carried out by survey method, one of the quantitative research approaches. Descriptive and causal-comparative survey research design was used in this study. In descriptive studies statistics such as percentage, frequency, average, and histogram are used (Gliner et al., 2015), whereas the aim of causal-comparative studies is to determine the existence or the degree of significant differences between groups (Pallant, 2015). In this sense, descriptive approach was used to determine prospective elementary mathematics teachers' levels of PP self-efficacy beliefs in the study. A causal-comparative approach was also employed as the prospective elementary mathematics teachers' PP self-efficacy beliefs were compared with regard to gender, grade and academic achievement.

Study Group

The study group consisted of 130 prospective teachers studying at Elementary Mathematics Education department in a state university, located in the Eastern Anatolia Region of Turkey, in the 2020-2021 academic year [87 females (66.9%), and 43

males (33.1%); 46 (35.4%) sophomores, 47 (36.2) junior, and 37 (28.5%) senior classes]. Purposive sampling was used in the selection of the study group. In this sampling design, certain inclusion criteria need to be defined before the research for the participants (Gliner et al., 2015). In this regard, the participants were enrolled the courses that Basics of Mathematics I-II, Mathematical Learning and Teaching Approaches, Middle School Mathematics Education Program, Special Teaching Methods I-II is determined as the basic criterion. It is thought that domain-specific education courses enable prospective teachers to have knowledge of PP. Thereinafter, the researchers prefer to use 'prospective teacher' to refer prospective elementary mathematics teacher for a shorter and clearer expression.

Data Collection Tools

Personal Information Form: The Personal Information Form was used to determine participants' demographic information such as gender, grade and academic achievement level (the grade point average [GPA] for the last term). GPAs were evaluated as low if it was "2.99 and below", moderate if between "3.0-3.4", and high if "3.5 and above".

Problem Posing Self-Efficacy Beliefs Scale (PPSEBS): PPSEBS was used to investigate the prospective elementary mathematics teachers' PP self-efficacy beliefs. Scale, developed by Kılıç & İncikabı (2013), is a 5-point Likert type scale (from Completely Agree to Completely Disagree). The scale is made up of 26 items, 9 of which are negative and 17 of which are positive. The negative items were reversely scored in the data analysis. PPSEBS has three sub-scales: teaching efficacy, effective teacher efficacy, and field knowledge. Cronbach's Alpha internal consistency coefficient of PPSEBS was calculated as .91 by Kılıç & İncikabı (2013), and as .93 in the present study.

Data Analysis

First, the lower and upper limits of scales were calculated in order to determine prospective teachers' PP self-efficacy belief levels. Therefore, "4.20-5.00 very high, 3.40-4.19 high, 2.60-3.39 moderate, 1.80-2.59 little, 1.00-1.79 very little" ranges were taken into consideration in the evaluation of the average

scores of PPSEBS. The normality of the scores was investigated using the Shapiro-Wilk (S-W) test when the sample size was less than 50, and using the

Kolmogorov-Smirnov (K-S) test when it was more than 50 (Stevens, 2009). The normality results of the scores are presented in Table 1.

Table 1 The Normality Results of the PPSEBS' Scores

| Variables | | N | K-S _(z) | p | S-W _(w) | p |
|----------------------------|----------|-----|--------------------|------|--------------------|------|
| Gender | Female | 87 | .095 | .051 | .975 | .088 |
| | Male | 43 | .080 | .200 | .975 | .475 |
| Grade | 2 | 46 | .097 | .200 | .963 | .148 |
| | 3 | 47 | .070 | .200 | .973 | .356 |
| | 4 | 37 | .069 | .200 | .981 | .753 |
| Academic achievement level | Low | 45 | .107 | .200 | .981 | .674 |
| | Moderate | 61 | .110 | .066 | .956 | .027 |
| | High | 24 | .154 | .147 | .947 | .232 |
| Total | | 130 | .073 | .087 | .982 | .078 |

As shown in Table 1, statistically significant results could not be found as a result of the K-S and S-W tests performed for all subgroups of gender, grade and academic achievement level variables and total-scale mean scores ($p > .05$). The statistically insignificant value obtained as a result of the tests indicates that the data are normally distributed (Pallant, 2015). The findings of the present study revealed that the average scores obtained from PPSEBS were normally distributed. In addition, variance homogeneity was analyzed by Levene test. If the Levene test result is not statistically significant ($p > .05$), the variance homogeneity assumption is ensured (Pallant, 2015). It was seen that mean scores of PPSEBS satisfied the variance homogeneity assumption with regard to the variables of gender ($F = 2.30, p = .13 > .05$), grade level ($F = .12, p = .88 > .05$) and academic achievement level ($F = 1.09, p = .34 > .05$). Therefore, parametric tests were used in the statistical analyses.

In data analysis, the independent samples t-test was used to compare the mean values of two groups, and one-way analysis of variance (ANOVA) test was used to compare the average values of more than two groups. For multiple comparisons, Tukey HSD was performed to investigate which groups differed. Furthermore, effect sizes were calculated to compare groups. The obtained partial eta squared (η^2) effect size values were interpreted as .01= small effect, .06= medium effect, .14= large effect.

The .05 significance level was accepted for all tests performed.

Findings

For the first sub-problem, the descriptive findings with regard to the PPSEBS sub-dimensions and participants' average scores are presented in Table 2.

Table 2 Descriptive Findings with regard to PPSEBS Average Scores

| Dimensions | N | \bar{x} | Sd | Level |
|----------------------------|-----|-----------|-----|-------|
| Teaching efficacy | 130 | 3.69 | .72 | High |
| Effective teacher efficacy | 130 | 3.59 | .59 | High |
| Field knowledge efficacy | 130 | 3.51 | .59 | High |
| Total | 130 | 3.60 | .57 | High |

Table 2 shows that the participants "agreed" with the statements on the PPSEBS and its sub-scales. This finding indicated that levels of the prospective teachers' PP self-efficacy beliefs were high. The high level of prospective teachers' PP self-efficacy beliefs can be interpreted as promising regarding PP activities they will carry out in classroom environments. The results of the independent samples t-test performed to examine whether the prospective teachers' PP self-efficacy beliefs differ with regard to gender are shown in Table 3.

Table 3 Independent Samples t-Test Results Regarding the Comparison of mean PPSEBS Scores by Gender

| Gender | N | \bar{x} | Sd | Df | t | p | η^2 |
|--------|----|-----------|-----|-----|-----|-----|----------|
| Female | 87 | 3.60 | .54 | 128 | .16 | .87 | .00 |
| Male | 43 | 3.59 | .62 | | | | |

As seen in Table 3, there was no significant difference between the mean PPSEBS scores of female (\bar{x} =3.60, Sd=.54) and male (\bar{x} =3.59, Sd=.62) participants [$t(128)$ = .16; p = .87> .05]. In addition, eta squared value showed that the magnitude of the difference between the averages was insignificant (η^2 = .00). These findings suggest that the prospective teachers' PP self-efficacy beliefs were not related to the gender variable. Table 4 shows the descriptive findings of prospective teachers' average PP self-efficacy beliefs scores with regard to grade level.

As shown in Table 4, the average scores of the participants were the lowest at the second grade level (\bar{x} =3.49) and the highest at the fourth grade level (\bar{x} =3.81). Although participants' mean PPSEBS

scores were close to each other, it can be said that their scores increased with the grade level. ANOVA results of the participants' mean PPSEBS scores with regard to the grade level are presented in Table 5.

Table 4 Descriptive Analysis Results of Average Scores for PPSEBS according to Grade Level

| Grade level | N | \bar{x} | Sd |
|-------------|----|-----------|-----|
| 2 | 46 | 3.49 | .54 |
| 3 | 47 | 3.54 | .58 |
| 4 | 37 | 3.81 | .54 |

Table 5 ANOVA Results Regarding the Comparison of mean PPSEBS Scores by Grade Level

| Variance source | Sum of squares | df | Mean square | F | p | η^2 |
|-----------------|----------------|-----|-------------|------|-----|----------|
| Between groups | 2.26 | 2 | 1.13 | 3.66 | .03 | .05 |
| Within groups | 39.25 | 127 | .31 | | | |
| Total | 41.51 | 129 | | | | |

As seen in Table 5, a statistically significant difference at $p < .05$ level was found in prospective teachers' mean PPSEBS scores for three grade levels [$F_{(2,127)}$ =3.66; p = .03< .05]. In addition to statistical significance, it was found that the real difference in mean scores between groups was slightly below the average (η^2 = .05). Tukey HSD test results, presented in Table 6, were examined in order to interpret the difference between grades.

Table 6 Tukey HSD Results Regarding the Comparison of Mean PPSEBS Scores by Grade Level

| Grade (I) | Grade (J) | Mean Difference (I-J) | p | Difference |
|-----------|-----------|-----------------------|------|------------|
| 2 | 3 | -.05 | .90 | |
| | 4 | -.31 | .03* | 4>2 |

| | | | | |
|---|---|------|------|-----|
| 3 | 2 | .05 | .90 | |
| | 4 | -.26 | .08 | |
| 4 | 2 | .31 | .03* | 4>2 |
| | 3 | .26 | .08 | |

The Tukey HSD test results in Table 6 showed that the average score of the participants in the fourth-grade (\bar{x} =3.81, Sd= .54) was significantly different from those of the second-grade participants (\bar{x} =3.49, Sd= .54) (p = .03< .05). The significant difference was in favor of the participants in the fourth-grade. In addition, the average scores of the participants in the third-grade (\bar{x} =3.54, Sd= .58) did not differ significantly from the mean scores of both the second and fourth grade prospective teachers. Table 7 shows the descriptive findings of prospective teachers' average PP self-efficacy beliefs scores with regard to academic achievement level.

Table 7 Descriptive Analysis Results of Average Scores for PPSEBS according to Academic Achievement Level

| Academic achievement level | N | \bar{x} | Sd |
|----------------------------|----|-----------|-----|
| Low | 45 | 3.38 | .55 |
| Moderate | 61 | 3.63 | .57 |
| High | 24 | 3.92 | .41 |

Table 7 showed that the participants with higher

Table 8 ANOVA Results Regarding the Comparison of mean PPSEBS Scores by Academic Achievement Level

| Variance source | Sum of squares | df | Mean square | F | p | η^2 |
|-----------------|----------------|-----|-------------|------|-----|----------|
| Between groups | 4.80 | 2 | 2.40 | 8.31 | .00 | .12 |
| Within groups | 36.71 | 127 | .29 | | | |
| Total | 41.51 | 129 | | | | |

Table 8 indicated a significant difference between prospective teachers' mean PPSEBS scores with regard to academic achievement level [$F_{(2-127)}=8.31$; $p=.00<.05$]. In addition, it was found that the effect size for the differences between the

level of academic achievement had the highest PPSEBS scores ($\bar{x}=3.92$). The mean PPSEBS scores of prospective teachers having low and moderate academic achievement levels were found to be ($\bar{x}=3.38$) and ($\bar{x}=3.38$), respectively. It was revealed that the mean PPSEBS scores increased as the academic achievement level increased. ANOVA results of the participants' mean PPSEBS scores with regard to the academic achievement level are presented in Table 8.

means of the groups was almost large ($\eta^2=.12$). Tukey HSD test results, presented in Table 9, were examined in order to interpret the difference between grades.

Table 9 Tukey HSD Results Regarding the Comparison of mean PPSEBS Scores by Academic Achievement Level

| Academic achievement (I) | Academic achievement (J) | Mean difference (I-J) | p | Difference |
|--------------------------|--------------------------|-----------------------|-------|--------------|
| Low | Moderate | -.26 | .045* | Moderate>Low |
| | High | -.55 | .00* | High>Low |
| Moderate | Low | .26 | .045* | Moderate>Low |
| | High | | .07 | |
| High | Low | .55 | .00* | High>Low |
| | Moderate | .29 | .07 | |

Tukey HSD test results in Table 9 showed that the average scores of prospective teachers having moderate academic achievement ($\bar{x}=3.63$, $Sd=.57$) was significantly different from those of prospective teachers having low academic achievement ($\bar{x}=3.38$, $Sd=.55$) ($p=.045<.05$). In this regard, the prospective teachers with moderate academic achievement had significantly higher levels of PP self-efficacy beliefs than those with low academic achievement. Similarly, a significant difference was found between the mean PPSEBS scores of the participants with high ($\bar{x}=3.92$, $Sd=.41$) and low

academic achievement ($\bar{x}=3.38$, $Sd=.55$) ($p=.00<.05$). This difference was in favor of prospective teachers having high level of academic achievement.

Results and Discussion

The findings of the present study showed that the PP self-efficacy belief levels of the prospective teachers were high (agree). This finding is line with other studies in the literature. These studies have indicated that in-service/prospective elementary school mathematics teachers (Ünlü & Sarpkaya-Aktaş, 2016; Özgen et al., 2019) and in-service/

prospective primary teachers (Altıntaş & Tanrıseven, 2017; Deringöl, 2018) had high levels of PP self-efficacy beliefs. Investigating prospective teachers' PP self-efficacy beliefs in a specific area such as PP can provide valuable insights (Cai & Leikin, 2020). It is anticipated, as a result of the present study, that prospective teachers can use PP activities efficiently in their future teaching career as they had higher PP self-efficacy belief level. In addition, such a high level of PP self-efficacy belief is expected and desired. Thus, teachers having higher levels of PP self-efficacy belief can also assist students to develop self-confidence in PP (Li et al., 2020). As stated by Aydın-Güç & Keskin (2021) students having higher levels of beliefs can pose problems with higher quality.

It was also found in the present study that the PP self-efficacy beliefs of the participants did not differ significantly with regard to gender. It can be put forward, on the basis of this finding, that prospective teachers' PP self-efficacy beliefs are comparable in terms of gender. This finding is also in line with studies in the literature, which have revealed that beliefs do not differ by gender (Altıntaş & Tanrıseven, 2017; Özgen et al., 2019).

Furthermore, a statistically significant difference was found between the prospective teachers' PP self-efficacy beliefs in terms of their grade levels. In addition to significant difference, it was found that the real difference in mean scores between the groups was almost medium. Prospective teachers' mean PPSEBS scores with regard to grade level showed an increasing trend from the second grade to the fourth grade. The PP self-efficacy belief levels of fourth-grade prospective teachers were significantly higher than those of prospective teachers in the second-grade. The reason for this differentiation may be the fact that prospective teachers take courses such as Special Teaching Methods I-II at lower grade levels. These courses require prospective teachers to be active participants, to make observations, and to gain experience by presenting lessons. Leavy & Hourigan's (2019) study supports such a conclusion. Researchers stated that prospective teachers' experience with different types of problem-solving and posing and their teaching practices improved their PP beliefs.

Another result of the present study was that the prospective teachers' PP self-efficacy beliefs differed significantly in terms of academic achievement level. It was found that the average PPSEBS scores of the participants increased with the increase in their academic achievement level. This increase was statistically significant and the effect size for the difference between groups was almost large. The results regarding the difference between groups showed that prospective teachers with high and medium academic achievement levels had significantly higher levels of PP self-efficacy beliefs than those having low academic success. This result of the study is supported by Bandura's statement on the relationship between self-efficacy belief and achievement-performance. Bandura argued that students with high self-efficacy beliefs set higher goals for themselves and as a result achieve higher intellectual performances (Bandura, 1986). This result is also consistent with Nicolaou & Philippou's (2007) study in which PP self-efficacy belief was found to positively predict mathematics achievement.

Limitations and Recommendations

This study showed that the PP self-efficacy beliefs of the prospective teachers were likely to increase as the grade level increased. Therefore, it can be concluded that the courses prospective teachers take during their undergraduate education have an influence on their PP self-efficacy beliefs. In this context, theoretical and applied undergraduate courses, which include models and strategies that will support the development of prospective teachers' PP self-efficacy beliefs, should be included in the teaching program of education faculties. This recommendation is in line with the recommendation of Usta et al.'s (2019). Researchers also suggest that studies should be carried out to improve mathematical process skills to increase the belief levels of prospective mathematics teachers.

This study was carried out by survey method, one of the quantitative research approaches. Therefore, qualitative studies should also be carried out to obtain more in-depth information about the PP self-efficacy beliefs of prospective teachers. In addition, this study was a cross-sectional study. Thus, longitudinal

studies may be used to investigate the effects of undergraduate programs on prospective teachers. It is anticipated that longitudinal studies will provide valuable insights to program developers in terms of the development of teacher education programs.

In recent years, experimental studies with prospective teachers or teachers have been observed (e.g., Liu et al., 2020; Voica et al., 2020). These studies have focused on the cause-effect relationship between PP activities and the concept of self-efficacy. However, such studies are quite limited. Therefore, the number of experimental studies should be increased. For example, PP workshops with prospective teachers may be organized and then the effects of this activity on PP self-efficacy belief may be investigated.

This study was limited to 130 prospective elementary school mathematics teachers studying at a state university in Eastern Anatolia Region of Turkey. Larger-scale studies can be conducted with prospective teachers studying in different regions and universities. In this study, prospective teachers' PP self-efficacy beliefs were compared with regard to the variables of gender, grade and academic achievement. Therefore, causal-comparative studies including more variables, such as the high school graduated from, can be conducted. Finally, analyzes dealing with the relationships between PP self-efficacy belief and such variables as motivation, critical thinking, and metacognitive skills can be carried out in future studies.

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