Educational Sciences: Theory & Practice - 13(2) • Spring • 1207-1211

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Determining the Performances of Pre-Service Primary School Teachers in Problem Posing Situations

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Abstract

This study examined the problem posing strategies of pre-service primary school teachers in different problem posing situations (PPSs) and analysed the issues they encounter while posing problems. A problem posing task consisting of six PPSs (two free, two structured, and two semi-structured situations) was delivered to 40 participants. Participants were allowed 30 minutes to complete this task. Of the 40 pre-service primary school teachers that participated in the study, 10 were selected for interview. Interviews took 25–30 minutes and were video-taped and transcribed. The data obtained from the study were then analysed using content analysis. The presented results showed that pre-service primary school teachers used different strategies in free, semi-structured, and structured PPSs and encounter a range of issues when tackling them.

Key Words

Mathematics Education, Problem Posing, Problem Posing Situations, Problem Posing Stratgies, Pre-Service Primary School Teachers.

Problem solving is the most important topic in mathematics education; however, it is a complex process that has many components. Problem posing is one of the most important components of problem solving. Although many definitions exist, problem posing typically involves the generation of new problems and questions to encourage students to explore a given situation and the reformulation of a problem during the course of solving it (Silver, 1994). Problem posing thus refers to both creation and reformulation problems.

Problem posing not only provides opportunities for teachers to investigate students' understanding of the nuances of mathematics (Stoyanova, 2003), it is also a tool for developing and strengthening critical thinking (Nixon-Ponder, 1995) and reasoning (Akay & Argün, 2006) skills. Further, problem-posing tasks allow teachers to gain insights into the ways in which students construct mathematical models and thus they serve as a useful assessment tool (Lin, 2004). Moreover, they are connected with improved creativity (Leung, 1997; Silver, 1994, 1997; Yuan & Sriraman, 2010) and allow students to generate more diverse and flexible thinking patterns, enhancing problem solving and enriching basic mathematics concepts (English, 1997).

Posing mathematical problems requires an understanding of the mathematical concepts involved (Pirie, 2002). A strong emphasis is thus placed on developing problem posing abilities and processes. Problem posing assists the development of the pedagogical content knowledge of pre-service primary school teachers (Tichá & Hošpesová, 2009) and influences teachers' beliefs about mathematics and mathematics instruction (Barlow & Cates, 2006). It also positively affects the knowledge of pre-service teachers and their views about what this means to mathematics education (Toluk-Uçar, 2009). In Turkey, problem posing activities have been incorporated into the Turkish mathematics curriculum (grades 1–5) since 2005, with a strong emphasis on such activities for grades one to five (Milli Eğitim Bakanlığı [MEB], 2009).

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According to the literature on this topic, a number of different tasks can be applied to analyse problem posing performance and understand problem posing processes (Christou, Mousoulides, Pittalis, Pitta-Pantazi, & Sriraman, 2005; Silver & Cai, 1996; Stoyanova & Ellerton, 1996). For example, Stoyanova and Ellerton identified three problem posing situations (PPSs): free, semi-structured and structured situations. In free PPSs, students are asked to generate a problem from a given situation, which may involve general directions such as 'create a difficult problem'. In structured PPSs, students are provided with an open situation and are invited to explore the structure or to complete it using the knowledge, skills, concepts and relationships gathered from their previous mathematical experiences. In semi-structured PPSs, students might be asked to pose problems from pictures, equations, inequalities and so on (Stoyanova, 2003) and problem similar to given problems, problems with similar solutions and word problems (Abu-Elwan, 1999).

Similarly, Christou et al. (2005) classified PPSs based on the findings of Stoyanova and Ellerton (1996). Their model incorporates semi-structured and structured PPSs and four processes, namely editing, selecting, comprehending and translating. In editing processes, quantitative information is mostly associated with tasks that require students to pose a problem without restrictions. In selecting processes, quantitative information is associated with tasks that require students to pose problems or questions that are appropriate to specific answers. In comprehending processes, quantitative information refers to tasks in which students pose problems from given mathematical equations or calculations. In translating processes, quantitative information requires students to pose appropriate problems or questions from graphs, diagrams or tables (Christou et al.).

The development of students' problem posing skills relies on establishing teachers' problem posing skills (Korkmaz & Gür, 2006). Previous studies of pre-service teachers have examined their problem posing abilities in the areas of fractions (Toluk-Uçar, 2009), geometry (Lavy & Bershadsky, 2003) and mathematics (Tichá & Hošpesová, 2009). Prospective primary teachers' ways of making sense of mathematical problems was investigated by Chapman (2012), while (Işık, 2011) analysed problems requiring multiplication and division with fractions. Moreover, other studies have researched posing problems in different representations (Işık, Işık, & Kar, 2011) and examined the problem posing processes of prospective mathematics and primary teachers (Korkmaz & Gür, 2006). The present study examines pre-service primary school teachers' problem posing strategies in free, semi-structured and structured PPSs and analyses the issues they encounter during problem posing activities. In that sense the questions as below were addressed;

1. What kind of strategies was used by participants in all three problem posing situations?
2. What kind of issues participants encountered in all three problem posing situations?

Method

In this study, task-based interviews were adopted as the qualitative research method for data collection and analysis (Clement, 2000; Goldin, 2000) in order to understand participants' problem posing strategies and the issues they encounter while posing problems.

Research Sample

Participants were selected using a criterion sample strategy (Patton, 1990). Attendance to Mathematics Instruction I and II courses and gender were considered to be the inclusion criteria. Ten pre-service primary school teachers volunteered to participate in the study (five boys and five girls). The real names of participants were kept confidential. The codes P_{G1}, P_{G2}, P_{G3}, $P_{G4,}$ and P_{G5} were used for female participants and P_{B1}, P_{B2}, P_{B3}, $P_{B4,}$ and P_{B5} for male participants. The researcher was coded R (Patton, 2002).

Data Collection Procedure

In that study the models of Stoyanova and Ellerton (1996) and Christou et al. (2005) were combined for data collection. The reason for combining these models is as stated by Christou et al. the different forms of representation (symbolic, tables, pictures, etc.) served to determine the participants' thinking processes in different problem posing situations. In this respect that new classification developed based on these studies differs from other problem posing classification and problem posing on the performance of teachers thought might reveal in detail. Moreover, in this study it was considered that preservice teachers' performance on problem posing might reveal in detail.

Each participant completed a problem posing task consisting of six PPSs: two free (posing a difficult problem and a fraction problem), two semi-structured (editing and translating) and two structured

(comprehending and selecting). In the free PPSs, participants were asked to pose a difficult problem and a problem related to fractions. In the semi-structured PPSs, participants were given a picture and a table, while in the structured PPSs, participants were asked to pose problems based on an equation and a story. A total of 30 minutes were allowed for completing the task. Thereafter, 10 participants were selected for the task-based interviews, which lasted for 25–30 minutes.

During their interviews, participants were asked to explain why they posed problems in order to understand their specific problem posing strategies and issues. As indicated by Hunting (1997), interview questions were open-ended in order to allow students the freedom to choose their preferred ways of responding. Further, both students and the interviewer reflected on their respective thought processes. Questions such as *"Could you tell me what you were thinking?", "Why did you pose that problem?" and "Is it a problem that you posed?"* were asked to uncover participants' reasons for problem posing. The interviews were videotaped by one of the assistants and two experts checked the items for content validity. A pilot study was then conducted with one participant to check the task-based interview questions and the comprehensibility of the problem posing task.

Data Analysis

For the data analysis, a content analysis approach was used. Participants' problem posing responses and issues were analysed under the free, structured and semi-structured PPSs**.** Data analysis consisted of four stages. After data collection, the videotaped records were first transcribed verbatim. In the second stage, the researcher read the interview transcripts, while in the third stage data were selected and coded according to the three PPSs and their sub-categories. In the fourth stage, data were tabulated. The interpretations of the researcher and participants' quotations from the interviews were provided by the researcher as an excerpt. In order to improve the validity and reliability of the study, the techniques of long-term interaction with participants, expert scrutiny, participant confirmation, detailed description, purposeful sampling and confirmation scrutiny were used. Inter-rater reliability was calculated using Miles and Huberman's (1994) formula and it was found to be 90%.

Results

In the free PPSs, pre-service primary school teachers considered the steps taken in students' problem solving processes and typically posed problems based on problem posing structures and stereotyped problems. In addition to these strategies, they used the techniques of envisaging, adapting to daily life and adapting to the problem solving process as well as emotional approaches, framing solutions and exploiting problems. In the semi-structured and structured PPSs, participants mostly posed problems regarding the PPSs and the steps that students would follow. However, in the semi-structured PPSs, the editing story strategy was also used by participants.

In summary, it was found out that all participants used some of the same strategies in all three PPSs. These strategies relied on PPSs and on understanding the steps that students would follow in problem solving processes. Moreover, pre-service primary school teachers encountered a number of issues while posing problems, such as not being in a problem situation, issues related to PPSs, using missing data while posing problems and considering missing data in PPSs.

Discussion

The analysis of the problems posed by pre-service primary school teachers showed that they used different problem posing strategies in the free, semi-structured and structured PPSs but shared many of the issues related to PPSs while posing problems. Some of the strategies used by participants were also common such as *taking into account the steps students would use in problem solving processes* and *posing problems based on problem posing structures*. However, in some cases, different strategies were used. For instance, in the free PPSs, *taking into account the steps students would use in problem solving processes* was used, whereas in the semi-structured and structured PPSs, *posing problems based on problem posing structures* was used. The strategies used in structured PPSs were line with those presented in study by Stoyanova (2003). Therefore, it can be concluded that the reasons for preferring different problem posing strategies in the free, semi-structured and structured PPSs stem from the representation of PPSs as tables, equations, stories, pictures and so on. Participants' previous experiences and learning can also be seen as another reason. These findings are in line with those of previous studies (Chapman, 2012; Işık et al., 2011; Leung & Silver, 1997).

In terms of issues, in the free PPSs participants had difficulties in the fractions PPS. A similar finding was found by Toluk-Uçar (2009). In the semi-structured PPSs, most participants had issues with the translating dimension but not the editing dimension. In the structured PPSs, participants had issues both with the selecting and with the comprehending dimensions. Overall, participants had more issues in the structured PPSs than they did in the free PPSs because of the structure of the former. Rizvi (2004) asserted that insufficient experience about subjects hampers posing problem activities. The perceptions of pre-service primary school teachers about problems can be another hindrance to problem posing activities.

Conclusion

According to the findings of the present study, it can be concluded that pre-service primary school teachers use both similar and different problem posing strategies in different PPSs and share common issues while posing problems. The representation types of PPSs as well as the previous and mathematical knowledge of participants are also reasons for these challenges. It is clear that the more teachers become more proficient in problem posing activities, the more their students engage in such activities and become better mathematical problem posers.

The findings of this study suggest that problem posing activities should be integrated into mathematical method courses on teacher training programs (Barlow & Cates, 2006; Lavy & Bershadsky, 2003; Rizvi, 2004; Tichá & Hošpesová, 2009; Toluk-Uçar, 2009). In order to educate pre-service primary school teachers to become qualified problem posers, teacher educators should provide them with opportunities to recognise the relationship between mathematical concepts and real-life situations. In-depth analysis can then be carried out in order to understand pre-service teachers' reasons for having issues to investigate the factors that affect problem posing reasons and the general views of pre-service teachers on problem posing.

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