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ScienceDirect

Procedia - Social and Behavioral Sciences 174 (2015) 1364 – 1370

Procedia
Social and Behavioral Sciences

INTE 2014

The analysis of the problems posed by prospective mathematics teachers about 'ratio and proportion' subject

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Abstract

Problem posing means either posing new problem situations in terms of given conditions or re-formulating an already written problem. In this study, the aim is to evaluate problems written by prospective mathematics teachers about ratio and proportion subjects in terms of criteria specified according to problem posing methods. According to this purpose, 'Problem Posing Form about Ratio and Proportion Subject' including questions for determining the tasks of free problem posing, semi-structured problem posing, structured problem posing and for determining which one is the most challenging problem posing task, was developed by the researchers. The data form was applied to 45 sophomore students who are studying in Kocaeli University, Teaching Primary School Mathematics department. The data collected throughout this study was evaluated by considering*; i) Problem text (language and expression), ii) The compatibility of the problem with the mathematical principles, iii) The type/structure of the problem* and *iv) The solvability of the problem*. In conclusion, it was concluded that prospective mathematics teachers posed clear and understandable problems which are compatible with the mathematical principles in the form of activity and which can be solved by students. The challenging sides of problem posing appeared as the hesitation on posing problems which are suitable to students' levels, the difficulty in remembering the subject clearly and not having sufficient information about problem posing.

Peer-review under responsibility of the Sakarya University
Keywords: Ratio, proportion, problem posing, analysing posed problems

1. Introduction

Problem posing which is a special case of problem solving (Christou, Mousoulides, Pittalis, Pitta-Pantazi & Sriraman, 2005) is re-formulating a given problem or creating new problems in accordance with the given situation. Problem posing is cognitively a more difficult task than problem solving (Mestre, 2002) and it is accepted as problem finding or formulation (Dickerson, 1999). Problem posing can be practised before solving a given problem as well as while solving a problem or after problem solving (Lavy & Bershadsky, 2003). In this sense, when the previous research about this subject was analyzed, it was seen that there are various problem posing methods (Abu-Elwan, 2007; Dickerson, 1999; Grundmeier, 2003). They are methods such as; *i) free problem posing*, *ii) semi-structured problem posing, iii) structured problem posing* (Stoyanova, 2003) and *iv) What if ... What if not?* (Abu-Elwan, 2007).

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This research were supported by Marmara University, Scientific Research Commission (BAPKO)

Peer-review under responsibility of the Sakarya University
doi:10.1016/j.sbspro.2015.01.760

In free problem posing, students are given a situation or a subject from daily life. Students generate problems by using them. (Akay, 2006). It is the case of asking students to pose problems about any subject without providing them any data, figure or problems (Ergün, 2010).

In semi-structured problem posing, an open–ended situation is given to students and students are asked to generate problems about this situation by using their own skills, knowledge and mathematical experiences (Akay, 2006). The semi-structured problem posing strategies are mathematical situations, posing open-ended problems and interpretation (Dickerson, 1999).

In structured problem posing, the matter is posing a new problem by changing the known (Akay, 2006). Students pose problems by considering the limitations determined by their teacher. For instance, the teacher can ask students to pose a problem including a mathematical concept such as multiplying decimals (Dickerson, 1999) or to only change the numbers in a given problem. *"What if? ...What if not?"* method is in the scope of structured problem posing method (Brown & Walter, 1993). In this study, prospective teachers were asked to pose problems about 'Ratio and Proportion' subject in compatible with all the methods other than the method of "What if? …What if not?".

In order to improve students' problem posing skills, it is necessary to evaluate all the products obtained about the topic of problem posing (Ergün, 2010). In this sense, the evaluation in problem posing can be practiced in two ways. The first one is to evaluate students' problem posing skills, concept knowledge and proficiencies with the help of posed problems. And the second one is to evaluate problems and process (Silver & Cai, 2005).

Silver and Cai (1996) considered the following determined criteria in the evaluation of posed problems as; *i) the solvability of the problem, ii) problem text, iii) mathematical complexity* and *iv) the relationship between posed problems*. Albayrak, İpek and Işık (2006) evaluated the problems in their studies by considering the following criteria, *i) writing nothing, ii) using all the given material, iii) adding new materials* or *iv) the process of creating samples from the data*. Cai, Moyer, Wang, Hwang, Nie and Garber (2012) used rubrics for evaluating posed problems. Ergün (2010) paid attention to following criteria in the evaluation of problems; *i) the clarity of the problems, ii) the compliance of the problem with physics principles, iii) the structure of the problem, iv) the number of questions, v) the type of problem* and *vi) the solvability of the problem.* Grundmeier (2003) in the evaluation of problems considered the following criteria; *i) reasonableness and plausibility ii) whether the problem consists sufficient information or not* and *iii) the number of operations required for the solution.* Işık and Kar (2012) evaluated the problems in their studies according to criteria as stated by Silver and Cai (2005) *"quantity"* and *"originality"*.

The purpose of this research is to analyze problems posed by prospective teachers about the subject of "Ratio and Proportion". In this sense, the aim is to evaluate problems posed by prospective teachers about the subject of "Ratio and Proportion" within the framework of criteria specified in accordance with problem posing methods. The answers of the following sub-problems were searched for this purpose.

1. How is the situation of prospective teachers about posing free problems about the subject of Ratio and Proportion?
2. How is the situation of prospective teachers about posing semi-structured problems about the subject of Ratio and Proportion?
3. How is the situation of prospective teachers about posing structured problems about the subject of Ratio and Proportion?
4. How is the general problem posing profile of prospective teachers?
5. Which is the most challenging problem posing method for prospective teachers? Why?

2. Method

2. 1. Research Design

Qualitative research is a search for demonstrating perceptions and events in a holistic and realistic manner in natural environments and a qualitative process is followed (Yıldırım & Şimşek, 2008). In this sense, this study is a qualitative research which is aimed to demonstrate results of a particular situation and includes the analysis of the written worksheets. The document analysis involves the analysis of written documents about the case or cases which are intended to study (Yıldırım & Şimşek, 2008). In this study, data forms which were filled by prospective teachers were used as document.

2. 2. Working Group

The work group of this study consisted of 45 prospective sophomore students who are studying in Kocaeli University, Teaching Primary School Mathematics. 40 of the prospective teachers are female (88,89%) and 5 (11,11%) of them are male.

2.3. Data Collection Tools and Collecting Data

The data of this study was collected by using "The Problem Posing about Ratio and Proportion Form" which was prepared by the researchers. This data form consisted of four sections. These sections are as in the following; *i) free problem posing and the task of solving posed problem, ii) semi-structured problem posing and the task of solving posed problem, iii) structured problem posing and the task of solving posed problem* and *iv) In which problem posing task did you have difficulties? Why?*. This form

which was prepared by the researchers distributed to prospective teachers and prospective teachers were asked to fill in this form. Prospective teachers had one hour (60 minutes) to fill in this form.

2.4. Data Analysis

First of all, the researchers specified four criteria to evaluate the data obtained in this study. These are; i) Problem text (language and expression), ii) The compatibility of the problem with the mathematical principles, iii) The type/structure of the problem and iv) The solvability of the problem. When the data obtained was analyzed within the framework of this given criteria, it was appeared that the specified criteria needed to involve sub-dimensions. In this sense, sub-dimensions were added to the specified criteria by each two researchers separately. Later on these sub-dimensions were compared and an agreement on dimensions was reached.

This evaluation tool that the dimensions and sub-dimensions were determined by the researchers was given to two expert researchers other than the researchers of this study in the field of teaching mathematics for taking their opinions. The experts were asked to evaluate the compatibility of the dimensions for evaluation and the compatibility of the sub-dimensions to the dimensions as "applicable" and "not applicable". After the evaluation results, the level of agreement between experts and researchers was calculated by using the formula "*Agreement Percentage = [Agreement / (Agreement + Disagreement)] x 100"* as stated by Miles and Huberman (1994). It was decided that the agreement percentage regarding the compatibility of each dimension for evaluation changed between 0,89 and 0,92 and the agreement percentage regarding the compatibility of the sub-dimensions to dimensions changed between 0,86 and 0,90.

Although the evaluation form took the form of a rubric, the evaluation criteria was not decided by considering the purpose of the study. In this sense, an evaluation form involving 4 dimensions and 3 sub-dimensions for each dimension was developed for evaluating the problems posed by prospective teachers. The data obtained was evaluated by using this evaluation form. The researchers and two experts from the field of teaching mathematics evaluated each problem separately and evaluation results were compared. The differences appeared were discussed and then an agreement was reached. In conclusion, the evaluation results as being related with each sub-dimension was presented on the basis of frequency (f) and percentage (%).

2.5. The Reliability and Validity of Study

The validity in qualitative research means observing the searched issues objectively as much as possible and as it is (Kirk & Miller, 1986). In order to present a holistic picture of the searched topic, the researcher should confirm the data and outcomes of the study through variation, participant confirmation and colleague confirmation (Yıldırım & Şimşek, 2008). In this regard, data of this study was analyzed by two experts in the field of teaching mathematics other than the researchers and the validity of the study was provided through colleague confirmation.

The qualitative research begins with the thought that realities constantly change according to individuals and to environments and repeating the same study with similar groups may not create the same results. In this regard, in order to provide reliability to qualitative research, the researcher should define the individuals who are the source of information clearly (Yıldırım & Şimşek, 2008). In this study, to get reliability, the study group defined in details.

In addition to that, the data obtained were frequently given in the study. Besides, the results of the evaluation were presented on the basis of frequency (f) and percentage (%). The purpose here is to increase the reliability of the data, to reduce bias and to provide a chance to make a comparison between the data. Besides, the data presented in numbers in order to have an opportunity to repeat this small scale study later on to reach a wider sample with tools such as surveys (Yıldırım & Şimşek, 2008).

3. Findings and Comments

Findings and comments regarding the first research problem which was specified as *"How is the situation of prospective teachers about posing free problems about the subject of Ratio and Proportion?"* are as in the following;

Table 1. The evaluation of the task of posing free problems

Evaluation Criteria		f	%
Problem Text (Language and Expression)	The text of the problem is not clear and understandable.	1	2,22
	The text of the problem is relatively clear and understandable.	10	22,22
	The text of the problem is clear and understandable.	34	75,56
The Compatibility of the Problem with the Mathematical Principles	The problem is not suitable to Mathematical Principles.	1	2,22
	The problem is relatively suitable to Mathematical Principles.	2	4,44
	The problem is suitable to Mathematical Principles.	42	93,33
The Type/Structure of the Problem	Exercise.	21	46,67
	Simple normal problem.	11	24,44
	Normal problem.	13	28,89
The Solvability of the Problem	The problem cannot be solved.	0	0
	Problem can be solved but it is erroneous.	1	2,22
	It can be solved.	44	97,78

When Table 1 is analyzed, it is seen that 34 of the posed problems (75,56%) have clear and understandable texts. It is determined that 42 (93,33%) problems are suitable to mathematical principles. 21 (46,47%) prospective teachers posed problems in exercise type, 11 (24,44%) prospective teacher in simple normal problem type and 13 (28,89%) prospective teachers in normal problem type. It is understood that all the posed problems are solvable. An example regarding the task of posing free problems stated below.

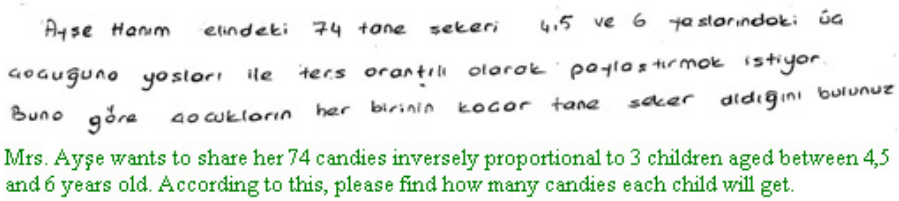

Fig. 1. Task of posing free problem of prospective teacher with number 29

Findings and comments regarding the second sub problem which was specified as *"How is the situation of prospective teachers about posing semi-structured problems about the subject of Ratio and Proportion?"* are as in the following;

Table 2. Evaluation of the task of posing semi-structured problems

Evaluation Criteria		f	%
Problem Text (Language and Expression)	The text of the problem is not clear and understandable.	0	0
	The text of the problem is relatively clear and understandable.	6	13,33
	The text of the problem is clear and understandable.	39	86,67
The Compatibility of the Problem with the Mathematical Principles	The problem is not suitable to Mathematical Principles.	0	0
	The problem is relatively suitable to Mathematical Principles.	5	11,11
	The problem is suitable to Mathematical Principles.	40	88,89
The Type/Structure of the Problem	Exercise.	41	91,11
	Simple normal problem.	4	8,89
	Normal problem.	0	0
The Solvability of the Problem	The problem cannot be solved.	0	0
	Problem can be solved but it is erroneous.	0	0
	It can be solved.	45	100

When Table 2 is analyzed, it is seen that 39 (86,67%) of problems posed by prospective teachers have clear and understandable texts. In addition to that, it is seen that 40 (88,89%) problems are suitable to mathematical principles. It is determined that 41 (91,11%) problems out of 45 posed problems are in exercise type and 4 of them (8,89%) is in normal problem type. It is understood that all the posed problems are solvable. An example regarding the task of posing semi-structured problems stated below.

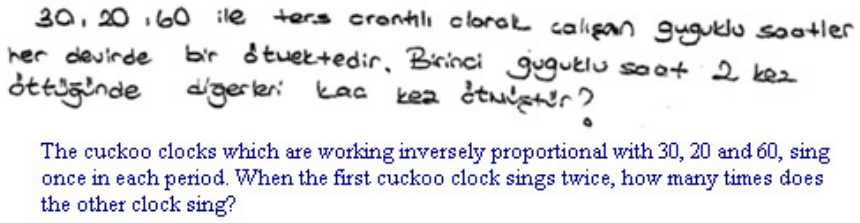

Fig. 2. Task of posing semi-structured problem of prospective teacher with number 7

Findings and comments regarding the third sub-problem which was specified as *"How is the situation of prospective teachers about posing structured problems about the subject of Ratio and Proportion?"* are as in the following;

Table 3. Evaluation of the task of posing structured problems

Evaluation Criteria		f	%
Problem Text (Language and Expression)	The text of the problem is not clear and understandable.	0	0
	The text of the problem is relatively clear and understandable.	6	13,33
	The text of the problem is clear and understandable.	39	86,67
The Compatibility of the Problem with the Mathematical Principles	The problem is not suitable to Mathematical Principles.	0	0
	The problem is relatively suitable to Mathematical Principles.	7	15,56
	The problem is suitable to Mathematical Principles.	38	84,44
The Type/Structure of the Problem	Exercise.	38	84,44
	Simple normal problem.	7	15,56
	Normal problem.	0	0
The Solvability of the Problem	The problem cannot be solved.	0	0
	Problem can be solved but it is erroneous.	0	0
	It can be solved	45	100

When Table 3 is analyzed, it is seen that the text of 39 (86,67%) posed problems are clear and understandable. It is determined that 38 (84,44%) problems are suitable to mathematical principles. It is appeared that 38 (84,44%) problems are in exercise type. It is understood that all the problems posed by prospective teachers regarding the task of posing structured problems are solvable. An example regarding the task of posing structured problems stated below.

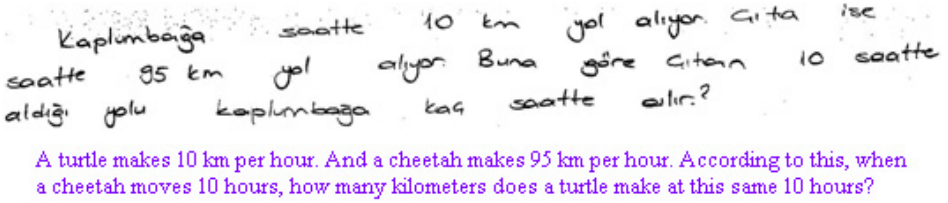

Fig. 3. Task of posing structured problem of prospective teacher with number 36

Findings and comments regarding the fourth sub-problem specified as *"How is the general problem posing profile of prospective teachers?"* are as in the following;

Table 4. Evaluation of the problem posing task

Evaluation Criteria		f	%
Problem Text (Language and Expression)	The text of the problem is not clear and understandable.	1	0,74
	The text of the problem is relatively clear and understandable.	22	16,29
	The text of the problem is clear and understandable.	112	82,96
The Compatibility of the Problem with the Mathematical Principles	The problem is not suitable to Mathematical Principles.	1	0,74
	The problem is relatively suitable to Mathematical Principles.	14	10,37
	The problem is suitable to Mathematical Principles.	120	88,89
The Type/Structure of the Problem	Exercise.	100	74,07
	Simple normal problem.	22	16,29
	Normal problem.	13	9,63
The Solvability of the Problem	The problem cannot be solved.	0	0
	Problem can be solved but it is erroneous.	1	0,74
	It can be solved	134	99,26

When table 4 is analyzed, it is determined that 112 (82,96%) of the problems out of 135 posed problems have clear and understandable texts and 120 (%88,89) of them are suitable to mathematical principles. It is seen that 100 (%74,07) of the posed problems are in exercise type and 134 (99,26%) of them can be solved.

When the data is evaluated about the last sub-problem specified as *"Which is the most challenging problem posing method for prospective teachers? Why?",* it is seen that 12 (26,67%) of the prospective teachers stated that they did not have any difficulties in any of the methods. 16 (%35,56) prospective teachers stated that they had difficulties in posing free problems and 13 (28,89%) of them had in semi-structured problem posing and only 4 (%8,89) of them had difficulties in structured problem posing. As for the reason of the difficulties of the prospective teachers, they expressed that they had concerns about posing problems suitable to middle school level. In addition to that, they stated that since they did not remember the ratio and proportion subject clearly, they thought that they could not pose suitable problems. Besides, it is seen that they expressed that they were away from problem posing and such studies have not been conducted.

4. Conclusion, Discussion and Implications

As a result of the analysis regarding the task of posing free problems, it is concluded that the texts of the problems posed by prospective teachers were clear and understandable. It is appeared that the posed problems were suitable to mathematical problems and all the problems were solvable. As a result of the data about the task of posing semi-structured and structured

problems, it is appeared that the texts of the problems posed by prospective teachers were clear and understandable, suitable to mathematical principles, in the type of exercise and solvable problems

In general evaluation of the research findings, it is concluded that prospective teachers posed problems which have clear and understandable texts, suitable to mathematical principles and all the problems were solvable. In addition to that all the posed problems are in exercise type. As a result of posing problems in the type of exercise, it was determined that this result echoed with the research findings as problems posed by prospective teachers are predictable, simple and well-structured problems (Albayrak, İpek & Işık, 2006; Crespo, 2003; Crespo & Sinclair, 2008; Işık, Işık & Kar, 2011).

The researchers such as Fetterly (2010), Silver & Cai (2005) and Yuan & Sriraman (2010) express that posing different problems is related with creativity. Işık and Kar (2012) concluded in their studies that prospective classroom teachers posed limited number of different problems. They also indicated that this could be a sign for prospective teachers' lack of creativity and their ability to associate. In this sense, it can be said in this study that prospective teachers pose problems in exercise type because they do not have enough creativity skills and they do not have conceptually well-structured basic mathematical concepts.

It is concluded that prospective teachers mostly have difficulties in free problem posing. In the study, it was asked to pose a problem according to the sample in structured problem posing task and posing a problem according to a figure in semi-structured problem posing task. However, in free problem posing it is expected from prospective teachers to pose problems by using their current mathematical knowledge and experiences. In this sense, the reasons of prospective teachers have difficulties in free problem posing task can be thought as there is no help or information. Besides, it is determined that as for the reason of having difficulties, prospective teachers expressed that they could not remember the subject clearly. Moreover, prospective teachers stated for the reasons of difficulty that they had concerns about posing problems suitable to middle school level. It is thought that this difficulty can be overcome by making more problem posing studies. It is seen that prospective teachers indicated another reason for having difficulties as they did not have enough information about problem posing. In conclusion, it is seen that the reasons of having difficulties are the fear of not posing problems suitable to level, not remembering the subject clearly and not having enough information about posing problem.

The findings of the study point out the fact that prospective teachers need to gain more experience on posing problems. In this sense, it is suggested that problem posing subject should be included in programs more in educational faculties. Together with this study, problem posing situations of prospective teachers in a single subject in mathematics was evaluated. Different subjects in mathematics should be analyzed with bigger samples. Moreover, it can be analyzed experimentally in terms of different variables (academic achievement, gender etc.) by determining on which subjects prospective teachers are successful.

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