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Formation of mathematical culture of students based on the solution of parametric problems

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Abstract

The purpose of this research is to obtain the opinions of teachers in order to create a mathematical culture of students based on the solution of parametric problems. The qualitative research method was used in this study. The study group of the research consists of 40 mathematics teachers who teach at various high schools in Almaty, Kazakhstan. Research data were collected with a semi-structured interview form developed by the researchers. The research data were evaluated by using the content analysis method. As a result of the research, the majority of the mathematics teachers participating in the research stated that the students were insufficient in solving parametric problems. The vast majority of mathematics student teachers stated that they were very inadequate in posing parametric problems. The suggestions of the majority of the mathematics teachers participating in the research on the creation of a mathematics culture based on the solution of parametric problems are to create a technology-supported lesson environment, to conduct a needs analysis in the formation of the mathematics culture of the students and to provide in-service training to the teachers.

Keywords: Parametric problems, mathematics education, mathematics culture, teacher opinions;

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1. Introduction

Education now aims to raise people who not only know, but also constantly learn, criticise, think, question, innovate and keep up with innovations, for example, both producing and using technology (Er, 2017). In recent years, there have been significant changes in both education and perspectives on mathematics and mathematics education. Mathematics education also aims to raise people who not only know mathematics but also apply what they know, do mathematics, solve problems, communicate and enjoy doing these. Developments in learning and teaching approaches also significantly affect mathematics education (Hasibuan, Saragih, & Amry, 2019).

1.1. Theoretical and conceptual framework

In today's world, where information spreads rapidly and new information is added every day, efficient, useful and more permanent learning of information emerges as an element that needs to be investigated in the education process (Roksa & Robinson, 2017). It is also among the aims of education that students develop themselves in personal, social and educational areas and have the necessary competencies. Due to the increase and development of the information to be learned, traditional teaching methods are insufficient and new methods, techniques and strategies are needed in the learning–teaching process (Torani, Majd, Maroufi, Dowlati, & Sheikhi, 2019).

The skills gained through effective mathematics teaching enable the evaluation of opportunities for practice in daily life or in different disciplines (Bichi, Suleiman, & Ali, 2019; Cheema & Kitsantas, 2014; Zakaria, Chin, & Daud, 2010). Individuals who have mathematical skills and can demonstrate these skills in the problems they encounter are needed in every field (Fariza, Assel, Gulzhan, & Marzhangul, 2021; Kalelioglu & Gülbahar, 2014).

Considering the contribution of mathematics to the individual's thinking development and daily and real-life situations, individual and social mathematical competence and therefore problem solving gains importance (Depaepe, Verschaffel, & Kelchtermans, 2013; Tezer & Özreçberoğlu, 2017). Mathematics is a formal language that enables us to express our abstract thoughts as systematic knowledge. In other words, it is a very cheap, fast and precise software technology, a programming language (Uzunboylu & Cumhur, 2015).

In the changing world, those who understand and are interested in mathematics have more options to shape the future (Wikholm & Aerila, 2016). Mathematical habits of mind is a network that mathematicians use, consisting of special ways of thinking about mathematical concepts and approaching mathematical problems, and this intellectual network is related to thinking and mental habits, not specific definitions, theorems or algorithms found in textbooks (Matsuura, Sword, Piecham, Stevens, & Cuoco, 2013). It includes intellectual activities such as guessing, questioning solutions (even the right ones), discovering patterns, customising, careful classification, using alternative representations (Levasseur & Cuoco, 2003), analysing answers, problems and methods, defending explanations and supporting with evidence (Mark, Cuoco, Goldenberg, & Sword, 2010).

When the definitions of the concepts of problem-solving and problem-solving skills are examined in the literature, it can be seen that the difficulties, troubles and problems encountered in daily life are also expressed with this word (Ginting, Prahmana, Isa, & Murni, 2018). Problem-solving skills have an important place among math skills. Problem-solving can be seen as an integral part of mathematics lessons and mathematics activities (Yuanita, Zulnaidi, & Zakaria, 2018). Problem-solving is an integral part of the mathematics course. Mathematics is definitely included in almost every learning area (Schoenfeld, 2016). It would be wrong to think of problem-solving as the sequence of strategic operations brought to a problem situation only (Cragg & Gilmore, 2014).

Problem-solving is not only a basic skill used in mathematics, but also any situation that needs to be solved in daily life (Tambunan, 2019). Problem-solving approaches in traditional mathematics education are not only insufficient to meet the changing and developing needs of our age, but also often create problems (Curaoglu, 2012; Psycharis & Kallia, 2017). Forcing students to solve problems according to certain patterns, showing only one solution and searching for different solutions, students encountering problems with solutions and being unaware of problems that have no solution and not evaluating the process by considering only the result are some examples of the negativities (Nurlaily, Soegiyanto, & Usodo, 2019).

1.2. Related research

Cai (2003) investigated the mathematical thinking of Singaporean fourth-, fifth- and sixth-grade students in problem-solving and posing. The results of this study showed that the majority of these students were able to choose appropriate solution strategies to solve the questions and choose appropriate solution representations to clearly communicate their solution process. Durmaz and Altun (2014) investigated the level of using non-routine problem-solving strategies of sixth-, seventh- and eighth-grade secondary school students. This research group consists of students who have not received any training on problem-solving strategies before. As a result of the research, the highest percentage of use was found in finding correlations and unusual division problems, while the lowest percentage of use was found in elimination, table-making and diagram-drawing strategies.

Avcu and Avcu (2010) examined the problem-solving success of pre-service secondary school mathematics teachers and the strategies they used. A problem-solving test was applied to 93 pre-service teachers forming the research group. Different strategies used in solving the problems in the test formed the data of the research. The findings revealed that pre-service teachers had the ability to solve problems by using problem-solving strategies, but their level of using different strategies was quite limited. In Lamb's (2010) study on the comparison of reading level and mathematics, it was revealed that increasing difficulties in reading mathematics questions negatively affect students' performance. It was concluded that the most important step of a complex process, such as problem solving, is reading comprehension.

Leikin (2009) stated that solving a mathematical problem in more than one way can be described as an instructive and creative diagnostic tool. They stated that geometry is a suitable field for obtaining more than one solution, and they evaluated both the geometry knowledge and creativity of the students with a geometry problem.

1.3. Purpose of the research

The purpose of this research is to obtain the opinions of teachers in order to create a mathematical culture of students based on the solution of parametric problems. In accordance with this purpose, the following sub-objectives have been developed:

1. How do mathematics teachers evaluate students' competence in solving parametric problems?

2. How do mathematics teachers evaluate students' parametric problem posing competencies?

3. What are the suggestions of mathematics teachers regarding the creation of a mathematical culture based on the solution of parametric problems?

2. Methods and materials

In this section, the method of the research is given in detail. In addition, information about the participant group of the research, the data collection tool of the research, the data collection process and the evaluation of the data are given.

2.1. Research method

The qualitative research method was used in this study. Historically, qualitative research has been given different names, such as 'natural research', in an effort to identify natural phenomena, 'interpretive research', because it contains the subjective views of the researcher about the problem, and 'field research', because it examines a subject in depth in a certain social environment (Baltacı, 2017).

Qualitative research is a method that inquires about the problem it examines, interprets and tries to understand the form of the problem in its natural environment. Qualitative research, which uses qualitative data collection methods such as observation, interview and document analysis for the solution of a problem, refers to a subjective–interpretive process of perceiving previously known or unrecognised problems and dealing with the natural phenomena related to the problem in a realistic way (Seale, 1999). In this direction, in this study, the opinions of the teachers obtained in order to create the mathematical culture of the students based on the solution of parametric problems were evaluated in accordance with the qualitative research method.

2.2. Participants

The study group of the research consists of mathematics teachers who teach at various high schools in Almaty, Kazakhstan. The mathematics teachers who participated in the research agreed to participate in the research voluntarily. 40 mathematics teachers participated in the research. 14 teachers are female and 26 are male. 10 teachers have 1–5 years, 8 of them have 6–10 years, 7 of them have 11–15 years and 15 of them have 15 years or more of experience.

2.3. Data collection tools

Research data were collected with a semi-structured interview form developed by the researchers. A literature review was conducted during the preparation of the semi-structured interview form. Semi-structured interview questions were prepared considering the researches in the field were presented to two field experts for their opinions. The questions were rearranged in line with expert opinions. Then, it was presented to two mathematics teachers in order to test whether the questions were understandable. Mathematics teachers found the questions understandable. Two mathematics teachers who participated in this part of the research were excluded from the study group of the research. In the semi-structured interview form prepared to collect the research data, there are two demographic questions created to determine the gender and professional experiences of the mathematics teachers participating in the research. In order to get the opinions of the mathematics teachers on the creation of the mathematical culture of the students based on the solution of parametric problems, three interview questions were formed. The interview questions in the semi-structured interview form are as follows:

1. How do you evaluate students' competencies in solving parametric problems?

2. How do you evaluate students' parametric problem posing competencies?

3. What are the students' suggestions for the creation of a mathematical culture based on the solution of parametric problems?

2.4. Data collection process

In order to collect the research data, face-to-face interviews were conducted with mathematics teachers. The interviews were carried out in high schools where mathematics teachers work. Interviews with teachers were conducted face-to-face and individually. Semi-structured interview forms were given to mathematics teachers and they were asked to answer the questions. While the teachers were answering the questions, the researcher was in the interview room and asked the teacher to ask the questions when they did not understand. It took approximately 25–30 minutes for

the teachers to answer the questions in the semi-structured interview forms. It took approximately 3 weeks to complete the interviews with all mathematics teachers participating in the research.

2.5. Data collection analysis

The research data were evaluated by using the content analysis method. Content analysis requires a more detailed examination of the collected data and reaching the concepts, categories and themes that explain this data. Content analysis focuses on collected data; codes are extracted from the events and facts that are frequently repeated in the data set or that the participant emphasises heavily from the codes to the categories and from the categories to the themes. In short, data (codes) that are found to be similar and related to each other are interpreted by bringing them together within the framework of certain concepts (categories) and themes. In content analysis, the content of the participants' views is systematically decomposed (Bengtsson, 2016). The answers given by the mathematics teachers to the questions in the semi-structured interview form were separated by the content analysis method and converted into frequency and percentage tables and given in the findings section in tabular form. Direct quotations from the answers given by the mathematics teachers participating in the research to the questions were made and used directly in the research, provided that their personal information is kept confidential. The opinions of the mathematics teachers were given by coding as M-1, M-2, M-3….

3. Results

The answers given by the mathematics teachers to the questions in the semi-structured interview form were evaluated in this section.

In Table 1, the evaluations of the mathematics teachers participating in the research about the students' competencies in solving parametric problems are given.

Table 1. Mathematics teachers' evaluations of students' competencies in solving parametric problems

Category	***F***	**%**
Very enough	2	5
Sufficient	4	10
A little is enough	10	25
Insufficient	21	52.5
Very inadequate	3	7.5
Total	40	100

In Table 1, the opinions of the mathematics teachers participating in the research about the students' competencies in solving parametric problems are categorised. 5% of the mathematics teachers gave the answer very adequate, 10% sufficient, 25% somewhat sufficient, 52.5% insufficient and 7.5% very insufficient. The opinions of the mathematics teachers who participated in the research about the competencies of the students in solving parametric problems are given below.

'M-7: I find my students very competent. Willing to learn, hardworking and open to self-improvement. I think this is the most important factor. They are open to improving their weak points. M-3: Actually, I find it sufficient. I see students' effort on parametric problems. M-38: They are partially sufficient. They have a negative attitude about mathematics, which is formed due to their prejudices and fears. Turning this attitude into a positive one will not only change their perspective, but also positively affect their attitudes towards learning. M-13: I think they are insufficient. Since

they do not have sufficient infrastructure, they cannot easily perform new learning. They do not like the lesson. M-26: I think that the students are very inadequate. In the mathematics education they received from primary school, the failures they encountered in mathematics caused them to stay away from the lesson'.

In Table 2, the opinions of the mathematics teachers participating in the research about the parametric problem posing competencies of the students are given.

Table 2. Opinions of mathematics teachers on students' parametric problem-posing competence

Category	***F***	**%**
Very enough	1	2.5
Sufficient	3	7.5
A little is enough	6	15
Insufficient	11	27.5
Very inadequate	19	47.5
Total	40	100

In Table 2, the opinions of the mathematics teachers participating in the research about the parametric problem posing competencies of the students are categorised. 2.5% of the teachers gave the answer very adequate, 7.5% sufficient, 15% somewhat sufficient, 27.5% insufficient and 47.5% very insufficient. The views of the mathematics teachers who participated in the research on the parametric problem posing competencies of the students are given below.

'M-19: I also stated that I find students' proficiency in solving parametric problems to be high. Similarly, I can state that he found parametric problem posing competencies very sufficient. M-36: I think that parametric problem posing skills are sufficient in students. M-16: I find my students sufficient in terms of mathematical problem solving and problem posing. M-29: I think that my students are somewhat sufficient in posing new problems based on the given problem. M-40: Students do not have the ability to make analogies between problems. That's why I think they're not enough. M-2: They do not even succeed in trying different ways to solve a problem. They cannot look at a given problem from different angles. For this reason, I find students very inadequate in posing parametric problems'.

In Table 3, the suggestions of the mathematics teachers participating in the research regarding the creation of a mathematical culture based on the solution of parametric problems of the students are given.

Table 3. Suggestions of mathematics teachers on creating a mathematics culture based on solving students' parametric problems

Category	***F***	**%**
A technology-supported lesson environment should be created	32	80
Needs analysis should be done to create students' mathematical culture.	27	67.5
Teachers should be given in-service training	23	57.5
Additional training should be given to students to make them love mathematics.	19	47.5

Different ways should be taught in parametric problem solving	15	37.5
Emphasis should be placed on the creation of a mathematical culture starting from primary school education.	12	30
The student should be switched from passive to active in mathematics education.	8	20
Teacher training policies should aim to train teachers who can create a mathematical culture in students.	5	12.5

In Table 3, the suggestions of the mathematics teachers participating in the research regarding the creation of a mathematical culture based on the solution of parametric problems are evaluated. 80% of the teachers answered that a technology-supported lesson environment should be created, 67.5% of them answered that needs analysis should be done to create the mathematical culture of the students, 57.5% of the teachers should be given in-service training and 47.5% of them should be given additional trainings that will make students love mathematics. 37.5% of the mathematics teachers answered that different ways should be taught in parametric problem-solving, 30% of them gave the answer that importance should be given to the creation of a mathematical culture starting from primary school education and 20% of them answered that students should be switched from passive position to active position in mathematics education. In addition, 12.5% of the mathematics teachers suggested that teacher training policies should aim to train teachers who can create a mathematical culture in students. The suggestions of the mathematics teachers participating in the research on the creation of a mathematical culture based on the solution of parametric problems are given below.

'M-2: I believe that technology support should be taken in order to create a mathematical culture in students. Teachers' deficiencies should also be filled with in-service training. Mathematics culture can be created by providing students with problem solving skills in different ways. M-17: In order to create a mathematical culture in students, a programming in this direction should be made starting from primary school. We cannot think of mathematics education in the form of education in accordance with the needs of the age independently of technology. With technology-supported education, the transition of the student from passive learner to active learner will be easier. M-33: First of all, it is necessary to make students love mathematics. It is possible to achieve this with educational technological games. In addition, the education policies of the education faculties that train teachers need to be arranged so that they can train future teachers in a way that creates a mathematical culture in their students.'

4. Discussion

The majority of the mathematics teachers participating in the research stated that the students were insufficient in solving parametric problems. The vast majority of mathematics student teachers stated that they were very inadequate in posing parametric problems. The suggestions of the majority of the mathematics teachers participating in the research on the creation of a mathematics culture based on the solution of parametric problems are to create a technology-supported lesson environment, to conduct a needs analysis in the formation of the mathematics culture of the students and to provide in-service training to the teachers. Some of the teachers stated that additional training should be given to the students to make students love mathematics, different ways of solving parametric problems should be taught, the creation of a mathematical culture should be given importance starting from primary school education and students should be moved from a passive position to an active position in mathematics education. In addition, some teachers stated that teacher training policies should aim to train teachers who can create a mathematical culture in students.

When the studies in the field are examined, it has been revealed that the problem-based learning approach is more effective than the traditional teaching approaches in transforming students' attitudes towards the mathematics lesson (Espey, Ogburn, Kalishman, Zsemlye, & Cosgrove, 2007; Gude et al., 2005; Herron & Major, 2004). Desai and Richards (1998) determined that there is a relationship between math anxiety and performance. Accordingly, anxiety must be taken into account in the process of increasing the performance of learners.

Ma and Xu (2004), in their study on high school students, aimed to determine the causes of mathematics anxiety and mathematics achievement. In this study, the effects of mathematics anxiety and mathematics achievement on each other were examined. In addition, mathematics anxiety and mathematics achievement were examined in terms of gender. It has been stated that the effects of mathematics anxiety in female students are stronger than the effects of mathematics anxiety in male students. Hmelo-Silver (2004) revealed that well-structured and open-ended problems used in problem-based learning support students' intrinsic motivation and interests because they are related to daily life and students' experiences. Because the students' ownership and responsibility for the problems, which are the basic elements of the problem-based learning approach, are seen as a result of students' interests, curiosity and desires.

5. Conclusion

In today's understanding of education, problem-solving skills is a tool that aims to raise people to overcome difficulties on their own, to adapt to life and to contribute to the development of the country. However, while too much priority is given to reading, writing and math skills in schools, learning, reasoning and problem-solving skills, which include reading and the more complex aspects of basic mathematics, are neglected. The creation of a mathematical culture based on the solution of parametric problems of students is very important in terms of educational services. In this direction, this research aimed to get the opinions of teachers in order to create a mathematical culture of students based on the solution of parametric problems. As a result of the research, the majority of the mathematics teachers participating in the research stated that the students were insufficient in solving parametric problems. The vast majority of mathematics student teachers stated that they were very inadequate in posing parametric problems. The suggestions of the majority of the mathematics teachers participating in the research on the creation of a mathematics culture based on the solution of parametric problems are to create a technology-supported lesson environment, to conduct a needs analysis in the formation of the mathematics culture of the students and to provide in-service training to the teachers.

6. Recommendations

In light of the results obtained from the research, the following recommendations were made for mathematics teachers and future mathematics teachers:

1. The majority of the mathematics teachers participating in the research stated that the students were insufficient in solving parametric problems and they were very inadequate in posing parametric problems. For this reason, it is necessary to revise the course curricula in order to meet the needs of the students.

2. In-service trainings should be organised for mathematics teachers, additional trainings should be given in order to make up for the teachers' deficiencies and creative practices should be designed to support the creation of a mathematics culture in students by ensuring cooperation between the school and the teacher.

3. Teacher training policies in universities should be regulated in order to train teachers who will create the competence of creating a mathematical culture in students based on the solution of parametric problems in students.

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