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Original scientific paper
UDC: 371.398
DOI: 10.5937/IstrPed2201001Y

EXAMINING THE PROBLEM POSING SKILLS OF GIFTED STUDENTS IN MATHEMATICS TEACHING

Abstract: Gifted students are individuals who show extraordinary development in at least one area compared to their peers. The common feature of gifted students is their creativity. The gifted students need training to improve their skills. If they do not receive such training, their abilities will fade out over time. Problem posing is one of the activities that promote the creative skills of gifted students. Problem posing activities, which are more effective in the development of creativity than problem solving, have little place in the curriculum. Thus, it is thought that awareness will be created about problem-posing activities in the education of gifted students. In this context, the study aims to examine the problem posing skills of gifted students. The results of the present research reveal that one-third of gifted students' answers are left blank. The problems they pose are not difficult. Solving problems often requires at least three steps. The established problems are grammatically correct in view of Turkish language. The gifted students have used the mathematical language correctly in the problems. These results are compared with the studies in the literature and discussed. As a result of the research, various suggestions have been made to the teachers of gifted students and other teachers who will work in the field in question.

Key words: Gifted students, Math education, Mathematical giftedness, Problem solving, Problem posing.

Introduction

The current pace of science and technology in the world and adaptation to this rapid development require the training of gifted individuals who can produce creative ideas in the fields of science, technology, engineering, and mathematics. Giftedness has been defined according to different theoretical models, but a common definition could not have been made. The common point of these models is creativity (Gagné, 2003; Renzulli, 2012). In general, the term giftedness can be defined as an extraordinary competence systematically developed in at least one area (Nolte, 2018).

In recent years, efforts to meet the educational needs of gifted students have been increased and intensified (Smedsrud, 2018). If gifted students are not given the training they need to improve their abilities, their abilities may fade out (Hu, 2019). The education of gifted students aims to enable these students to contribute to society according to their abilities (Davis & Rimm, 2004).

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The curriculum and pedagogical approach used in the classroom may not be suitable for gifted students' education. Schools cannot provide enough opportunities for gifted students to reach their full potential. Existing resources and practices that will improve gifted students' abilities are insufficient (Mackay, 2006).

Just like giftedness, mathematical giftedness has come to the fore in recent years. This concept refers to a range of mathematical abilities that manifest in the form of successful performance or creativity in a mathematical subject or task (Krutetskii, 1976). Mathematically gifted students are aware of the aesthetic value of mathematics (Goldberg, 2008).

In this context, various skills come to the fore in mathematical gifted individuals (Freiman, 2018; Gutierrez, Benedicto, Jaime & Arbona, 2018; Johnson, 2000; Poulos & Mamona-Downs, 2018; Sheffield, 2018; Young & Worrell, 2018). These skills are:

- Mathematical creativity,
- To be able to make inferences by thinking logically,
- Willingness to deal with mathematical subjects,
- To be able to take advantage of different strategies in solving mathematical problems,
- Ability to transfer the acquired mathematical knowledge and skills to new situations,
- To be able to recognize the relationship between mathematical concepts and structures,
- To understand the structure of a mathematical problem and to offer practical solutions,
- To be able to set up mathematical problems,
- Categorizing, processing, and interpreting data,
- Testing the validity of the mathematical proposition/structure encountered.

While problem solving, one of these major skills, has been included in mathematics curricula for many years, problem posing has been included in recent years (Cai & Hwan, 2019). Improving problem posing skill is as important as problem solving (Bonotto & Santo, 2015). Several studies indicate that problem posing activities are important to encourage creativity in gifted students (Rosli, Capraro & Capraro, 2014; Singer, Pelczer & Voica, 2011).

Meeting the educational needs of gifted students is a complex task and cannot be performed using simple educational tasks (Singer, Sheffield, Freiman & Brandl, 2016). For example, gifted students' interest in mathematics dies out at the end of secondary school since the tasks they engage in classroom settings can be solved with repetitive, simple, and familiar strategies, which do not actually attract their attention (Diezmann & Waters, 2004). Hence, more challenging tasks are needed to increase curiosity and develop the creativity and scientific thinking skills of gifted students (Johnson, 2000; Singer et al., 2016; Taylor, 2008). One method of meeting the needs of gifted students is problem posing, which is regarded as a challenge that goes beyond problem solving (Leikin, 2009; Sheffield, 2008). Moreover, Leikin, Koichu, and Berman (2009) and Assmus and Fritzler (2018) included problem solving and setting up in their models of giftedness.

Turkish Language Association describes the term problem as "any question or difficulty that is to be solved through theorems and rules". Lester (1980) defines a problem as a situation that cannot be solved with standard solution methods and requires certain thinking skills. Problem posing is an important cognitive activity both in mathematics education and the process of creating a problem again related to a given mathematical concept, structure, expression, or drawings (Cai & Hwan, 2019). It is a teaching strategy that can enable students to learn mathematical concepts, structures, and expressions. It can also be used as an assessment tool to test this learning (English, 2019).

There are several studies in the literature showing that mathematical problem posing has substantial contributions to students' cognitive and affective skills.

- It encourages students to participate actively in mathematical activities (Silver & Cai, 2005).
- It improves mathematical thinking (Xie & Masingila, 2017).
- It supports the scientific research process (Cai, Hwang, Jiang & Silber, 2015).
- It enhances creativity (Sheffield, 2018).
- The purpose of the problem, its basic elements and the relationship between these elements can be illuminated (English, 1997).

Review of the Literature

When the literature is examined, it is possible to encounter various studies on the problem posing skills of gifted students. Many studies have emphasized the importance of problem-posing for the development of mathematical creativity and relevant abilities and skills (Singer, Ellerton & Cai, 2013). Although there are many national and international studies on problem posing, there are limited studies in mathematics education programs (Xie & Masingila, 2017).

Espinosa, Lupianez, and Segovia (2013) state that gifted students were able to construct problems in various semantic structures and involving different computational processes. Similarly, Erdogan and Erben (2018) expound that gifted students can pose problems related to four operations. Voica and Singer (2013) state that problem-posing is more effective than problem-solving in developing creativity.

Kesan, Kaya, and Guvercin (2010) report in their research among the eighth grade students that problem posing activities can be used to diagnose gifted students. They also underline that problem posing activities can be used to improve the mathematical skills of gifted students. Levenberg and Shaham (2014) have asked gifted students to explain geometric concepts and pose problems related to them. However, they have found that the students could not adequately define geometric concepts and fail to pose problems. Singer and Voica (2015) posit that problem posing skill can be used as a tool to determine giftedness.

Espinosa, Lupianez, and Segovia (2016) have compared the problem-posing skills of normally developing students with those of mathematical gifted students. The results of the comparison reveal that the problems created by gifted students are more complex and difficult, with a high variety of procedures. . They also suggest that problem posing can also be used in determining mathematical gifted students.

All these studies accentuate that problem posing skills are important for the education of gifted students. However, the problem posing skills of gifted students in Turkey have not been adequately studied. It is crucial that problem posing activities are important in determining and improving the mathematical skills of gifted students. In this context, problem posing skills of gifted students will be examined in terms of various variables, and deficiencies, if any, will be identified. It is thought that the results obtained in the study will make significant contributions to both mathematics education and the education of gifted students. The main purpose of the present study is to identify the skills of gifted students to pose mathematical problems and make relevant recommendations

Method

Research Model and Study Group

This qualitative case study was conducted to evaluate gifted students' ability to pose mathematical problems. The case study allows a case or an event to be examined in detail by asking how and why questions (Yildirim & Simsek, 2013). In the case study, the individual, process, behavior, or event that is the main subject of the study is examined (Yin, 2017). In this study, the problem posing skills of gifted students constitute the situation I to be examined.

30 fifth grade students studying at a special education center for the gifted are the participants of the study in Turkey's Central Anatolia Region. In order to determine the participants; an appropriate sampling method was preferred. Appropriate sampling provides easy access to the participants, so it can support researchers in terms of time and cost (Mcmillan & Schumacher, 2010; Muijs, 2004). 12 of the participants were female (40%) and 18 male (60%). Participants were selected according to two specified criteria. The first of these is to volunteer to participate in the research. The second is to have received previous training on the subjects in the problem-posing form.

Measures

In the study, a five-item problem-posing form was used as a data collection tool. The problem-posing form was arranged by making use of 6 problems for the gifted Gokkurt, Ornek, Hayat and Soylu (2015) used in their research. Considering the grade level of the participants, five of these questions were used in the procedure. In the problem-posing form, there are four open-ended problems on operations with natural numbers and one open-ended problem on operations with fractions. The questions in the problem posing form are included in Table 1.

Table 1. *Problem posing form questions*

No	Question	Subject
1	The price of a book is 10 TL more than Ali's money, 8 TL more than Zeynep's money and 12 TL more than Sena's money. If Ali has 20 TL, what is the total amount of money for all three?	Operations with natural numbers
2	Eren's age 4 years ago is equal to Serdar's age 5 years later. Since the current ages of Eren and Serdar are 61, what is Eren's current age?	Operations with natural numbers
3	One-person, two-person and three-person invitations for a wedding are printed. At least one of each invitation has been sent. Since the number of invitees is 33, how many invitations are maximum for two?	Operations with natural numbers
4	After spending 1/4 of a civil servant's pension on house rent, he spends 2/3 of his remaining money on kitchen expenses. The officer, who spends half of his remaining money on other expenses, has 450TL. Accordingly, how much is the monthly kitchen expenses of this officer?	Operations with fractions
5	2 kilograms of apples and 3 kilograms of tangerines purchased from the greengrocer cost 6 TL. 4 kilograms of apples and 1 kilogram of tangerines are 7 TL. How many TL is the price of apples more than tangerines?	Operations with natural numbers

Within the scope of the research, the students were asked to pose problems similar to the problems in Table 1. There is no other restriction for students to produce creative ideas.

Data Collection Procedure and the Role of the Researcher

The data collection was carried out in the fall semester of the 2020-2021 academic years. The students were given 60 minutes to fill out the problem posing form. The researcher gave information about the problem posing form and answered the questions of the students. The researcher provided the necessary environment for students to pose problems individually. While the students were posing the problem, the researcher observed them. The researcher also took part in the research as the first rater.

Data Analysis

The responses of gifted students to the problem posing form were analyzed using descriptive analysis. The descriptive analysis allows the obtained data to be organized and presented according to certain themes in line with the research question (Yildirim & Simsek, 2013).

The data obtained from the problem posing form were analyzed with the problem posing evaluation rubric developed by Ada and Ozturk (2019). In the first section of the rubric, the answers are categorized as mathematical problem, non-mathematical, and blank answer. If an answer contains only operational statements or no question statements, it is classified as non-problem. In addition, expressions that are in the form of exercises without making any connection with daily life are also classified as non- problem. The mathematical problems prepared by the students were analyzed in terms of the language used in the rubric, the complexity and solubility of the problem.

In addition to the researcher, the descriptive analysis was performed by a maths teacher with a master's degree in mathematics education. The consensus between the raters was calculated using the consistency formula proposed by Miles and Huberman (1994). As a result of analyzing mathematical problems with rubrics, the consistency between the raters was calculated as 92%. This value shows that the consistency between the raters is adequately high (Miles & Huberman, 1994).

The frequency and percentage tables regarding whether the answers are mathematical problems or not are included in the findings of the study. The answers to the mathematical problems are presented in the form of the language used, the complexity of the problem and the solubility categories with the frequency and percentage tables of these themes. In addition, direct quotations regarding the answers of gifted students are also included.

Findings

The results of examination of the answers formed by gifted students reveal that the student answers are either blank or mathematical problems. Table 2 shows the frequency and percentage distributions of how many students created mathematical problems and how many students gave blank answers for each question.

Table 2. *The distribution of the answers of gifted students*

	N	%
Math problem		
Question 1	28	93
Question 2	20	67
Question 3	19	63
Question 4	18	60
Question 5	12	40

Total blank answer		
Question 1	2	7
Question 2	10	33
Question 3	11	37
Question 4	12	40
Question 5	18	60

When Table 2 is examined, it is seen that gifted students create 97 mathematical problems. Almost all of the gifted students created a problem for question one (N=28, %93). In addition, the majority of the gifted students created problems for questions two (N=20, %67), three (N=19, %63), and four (N=18, %60). However, the minority of the gifted students created a problem for question five (N=12, %40). There are also 53 blank answers. Very few of the gifted students could not pose a problem for question one (N=2, %7). The minority of the gifted students could not pose a problem for questions two (N=10, %33), three (N=11, %37), and four (N=12, %40). The majority of gifted students could not pose a problem for question five (N=18, 60). It is seen that the number of blank answers increases as the question order progresses. The reason why students give blank answers is that they get bored as time progresses in the lesson, they get distracted and they want to complete the task as soon as possible.

Frequency and percentage calculations for other findings of the study have been calculated over 97 mathematical problems. Moreover, the mathematical problems prepared by the students were examined in view of the contextual language, complexity of the problem and the solubility of the problem themes, and the sub-categories of these themes.

The results of the examination for the category of "written language" for the "language used" theme are given in Table 3.

Table 3. *Examination results of the problems in terms of written language*

Code	f	%	An example problem posed by students
Unclear problem text	9	9	S16: Ali spends 5/3 of his money on himself. He spends the rest on his expenses. Ali has 3000 liras in a case of 5/3. How much is a quarter of the money of 5/1?
Partially clear problem text where statements or figures are sloppy	36	37	S19: Eren, Kerem, and Ayşe will buy a drone. Eren's got 63 liras and Kerem's money is 45 liras less than that of Eren's. If the drone is 150 lira, how much is Ayşe's money?
Understandable problem text	52	54	S14: There is a birthday party to be thrown. Twelve women attended this birthday party. There were 12 women, 4 more men than twice all the women, and 13 less children than all the men who attended this birthday party. How many people came to this party altogether?. How many people attended this party in total?

When Table 3 is examined, it is seen that 52 of the problems created by gifted students are clearly and reasonably written. It is also obvious that the written language used in only 9 of these problems is unclear. In the problem written by S16, both fractions are written incorrectly and the second sentence is meaningless.

The problems created by the students were analyzed by considering the "mathematical language". The results of the investigation are given in Table 4.

***Table 4**. Examination results of the problems in terms of mathematical language*

Code	f	%	An example problem posed by students
The mathematical language has been used correctly.	11	11	S1: A driver spends 5/2 of his monthly salary on his vehicle, 3/2 for his family, and the rest for his rent. If the rent is 800 lira, how many lira will the driver earn monthly?
The mathematical language is used incompletely or incorrectly in some parts.	27	28	S7: The total ages of Aytuğ and Kağan are 31. The ages of Aytuğ after 3 years and Kağan after 4 years are equal. How old will Kağan be after 10 years?
The mathematical language has been used correctly.	59	61	S6: The flower that mother, father, and grandfather want to buy; 20 lira more than mother's money, 10 lira more than father's money, and 15 lira more than grandfather's money. If your grandfather has 30 liras, how much is the sum of the three of them?

When Table 4 is examined, it is seen that mathematical language is used correctly in 59 problems created by gifted students. In 11 of these problems, it is seen that the mathematical language is incorrectly used. It is not possible to spend 5/2 of the salary in the problem written by S1 and leave money.

The results of the analysis regarding the category of "structure of the problem" belonging to the theme of complexity of the problem are given in Table 5.

***Table 5.** Examination of the problems in terms of structure*

Code	f	%	An example problem posed by students
Problem with unclear number of operations	30	31	S2: Ahmet Bey caught 4 fish. He will trade it for fruit in the greengrocer. If one watermelon is equal to 4 oranges and 4 oranges equal to 1 banana, how many bananas can Mr. Ahmet get?
Problem requiring an operation	2	2	S29: A mother spends 2/4 of her salary on the expenses of her children, on food, and the house rent. Since the money he spent on the house rent is 500 lira, what is his total salary?
The problem that requires two operations	12	15	S25: On one holiday, the Yol family bought 5 trays of baklava, 50 on each tray. If they offero 3 baklava to each person, how many people will the baklava end?
The problem that requires three operations	25	26	S15: Rahman's age 6 years ago is equal to Ali's age 3 years later. If the current age of Rahman and Ali is 81, what is the current age of Ali?
Problem requiring four or more operations	28	26	S17: The ages of Zehra, Serap and Jale are from their fathers; Zehra's age is 22, Jale's age is 11, and Serap's age is 28 less. If their father's age is 47, what is the total age of the girls?

When Table 5 is examined, it is seen that 28 of the problems created by gifted students can be solved by performing at least 4 operations. In the solution of 30 problems, the number of operations is not clear. The questions with an unclear number of operations are often those containing incomplete information. Only two problems are of the type where the result is reached by performing a single operation. In the problem written by S29, the result can be reached by performing a 500x4 operation.

The analysis results regarding the "difficulty" and the complexity theme of the problems are given in Table 6.

Table 6. *Examination of the problems in terms of difficulty*

Code	f	%	An example problem posed by students
Simple problem	44	45	S23: Faruk, Osman and Berat have a toy car they want to buy. The price of this toy car is 30 lira more than Faruk's money, 10 lira more than Osman's money and 20 lira more than Berat's money. If Faruk has 40 liras, what is the sum of these three friends' money?
Normal problem	39	40	S28: In a store, five shirts and four ties cost 50 lira, ten shirts and a tie 18 lira. How much is the price of a shirt more than a tie?
Hard problem	14	15	S12: The teacher divides a class of 45 people into groups of two, four and seven. What is the number of groups since the teacher Demet, who wants the minimum number of groups, will make at least two groups of two, four and seven at the same time?

When Table 6 is examined, it is seen that most of the questions formed by gifted students are simple problems. The problem written by S23 can only be done with four additions. Gifted students were only able to pose fourteen difficult problems. In the solution of the problem written by S12, a solution can be achieved by employing different thinking processes.

The solubility of mathematics problems has been examined in detail by taking into account the "sufficiency and solubility" category of the data, and the results are given in Table 7.

Table 7. *Examination of the problems in terms of solubility*

Code	f	%	An example problem posed by students
The problem where the information and data in the problem are not sufficient to solve the problem (includes logical error	27	28	S4: Ahmet, Ayşe and Yusuf are three brothers. Ahmet's age is twice that of Ayşe. Yusuf is 5 years less than Ayşe's age. Accordingly, what is the total age of the three siblings?
Solvable problem but not meaningful result	2	2	S2: The age of Emel's brother 3 years ago is equal to the age of Fatma's sister after 4 years. If the total age of the two is 24, how old is Fatma's sister?
Solvable but missing data problem	9	10	S8: There are invitations for 1 person, 2 people, 3 people and 4 people for graduation. Since the number of invitees is 37, how many invitations are maximum of 4 persons?
Solvable problem, for which data is complete and appropriate for solution	58	60	S11: 5 kilograms of kiwi and 3 kilograms of orange bought from the market is 15 lira. Since 5 kilograms of kiwi and 1 kilogram of orange are 10 lira, how much is 1 kilogram of kiwi?

When Table 7 is examined, it is seen that the data in fifty-eight of the problems created by gifted students are complete and can be solved. Twenty-seven problems appear to be unsolved due to missing data or logic errors. Only two problems can be solved with the given, but the result is not meaningful. In the problem of the student with code S2, the age of Fatma's brother is 7.5 and this is meaningless. Nine problems can be solved even though they contain incomplete information.

While the students were posing the problem, the researcher observed them. The findings obtained from the observation results are also included. Gifted students preferred to solve all the problems first and then create their problems. They gave more importance to solving problems. Because students are accustomed to activities related to problem solving rather than problem posing. However, since the purpose of the research is to examine the problem posing skills of gifted students, it was stated that students should give more importance to problem posing. While posing problems, the students first changed the numbers of the questions in the form given to them. The researcher stated that this would be wrong and that they should create original questions on their own. Gifted students created new original problems similar to the sample problems for the first and second questions. However, as the question order progressed, they got bored and their attention decreased. They wanted to complete the activity as soon as possible. For this reason, very few gifted students were able to pose original problems regarding the sample questions in the last row.

Conclusion and discussion

The aim of this study is to examine the problem posing skills of gifted students in terms of various variables. For this purpose, firstly, all the answers in the problem posing form were examined. One-third of gifted students' answers were blank. In other words, there have been cases among gifted students that they could not establish their own problems. The reason for this result may be that the questions in the classroom are usually created by the teachers. This result of the research contradicts the literature about the problem posing skills of gifted students. Ashley et al. (2016) and Freiman (2018) stated that gifted students have a substantial problem posing skills. In addition, Erdogan and Gul (2020) stated in their study that gifted students do not leave any answers blank.

It was observed that the problem posing skills of the gifted students were similar to those students with normal development. In the studies of Kar and Işık (2014) with seventh-grade students and Işık and Kar's (2015) with sixth-grade students, it was found that approximately one-fifth of the students left the questions blank. Ada, Demir, and Öztürk (2020) stated that about half of the sixth-grade students could not establish a mathematical problem. However, many studies explain that gifted students' problem posing skills are higher than their peers (Johnson, 2000; Mathilde et al. 2016; Singer et al., 2016; Yuan & Sriraman, 2011).

The language used in most of the mathematical problems created by gifted students can be understood. Similarly, the language of mathematics in the problems was used correctly to a large extent. Only one-tenth of the problems have mistakes in terms of both the written and mathematical language. This indicates that gifted students have brilliant linguistic skills since brilliant linguistic skills are required to associate mathematical expressions with daily life (Ocal, Ipek, Ozdemir, & Kar, 2018). Ada et al. (2020) stated that students can successfully use Turkish and mathematical language while posing problems. In addition, Arikan and Unal (2013) stated that students with low problem posing skills are similarly unable to use their mother tongue sufficiently.

In about one-third of the problems created, the number of operations is not clear. These types of problems generally contain incomplete information. Most of the created problems are solved using at least three operations. About half of the problems created by the students are at a simple level. Gutierrez et al. (2018) stated that gifted students pay attention to the difficulty of mathematical structures when posing problems. Furthermore, Dai, Moon, and Feldhusen (1998) stated that gifted students are more successful in challenging problem posing than their peers. However, as a result of the research, it was observed that gifted students created very few difficult problems. Similarly, Levenberg and Shaham (2014) stated in their research that the problems created by gifted students are at a low level. This may be due to the inadequate problem posing experience of gifted students as problem posing activities are used less than problem solving activities in the teaching process (English, 2001; Levenberg & Shaham, 2014; Sheffield, 2018).

About a quarter of the problems cannot be solved due to missing information or logic errors. Çelik and Özdemir (2011) stated that some of the problems created by middle school students could not be solved due to incomplete information. Levenberg and Shaham (2014) stated that specially gifted students create problems that do not fit the geometrical terms. Only two problems are solvable but the result is not meaningful. More than half of the problems can be solved with the information provided. Ada et al. (2020) stated that students mostly set up solvable problems.

To sum up, the gifted students left one-third of the answers blank. The vast majority of the problems they created remained simple. At least three procedures are required to solve problems. Ashley et al. (2013) analyzed the arithmetic problems established by mathematically gifted students. They stated that number types and quantities vary in the problems that students set up, the question expressions differ semantically, at least four steps are required to solve the problems, and the problems involve two or more calculation processes.

Implications

Considering the results of the research, various suggestions have been made for teachers and researchers.

Teachers involved in the education of gifted students can give their students more tasks related to posing problems since problem posing tasks can offer gifted students the educational opportunities they need thus enhancing the creativity of gifted students. They can organize activities that support language development to increase the comprehension of the problems created by students. While setting up the problem to increase the solubility of the problems, thought-provoking strategies can be used.

Problem posing can be used both as an educational activity and as an evaluation tool. Teachers should learn how to use problem posing activities in their lessons (Cai & Hwang, 2019). In order to achieve this, first of all, in-service training can be given to these teachers about how to use problem posing activities in mathematics lessons. Because, teachers who gain knowledge and skills about mathematical problem-posing can more easily transfer them to their students (Cai & Hwang, 2019). Additionally, rich content can be provided for teachers and students by including more activities on problem posing in mathematics textbooks.

The researchers can also compare the problem posing skills of gifted students with normal development students in similar studies. The problem posing skills of gifted students in different grades or levels can be examined. Several studies can also be conducted to identify the problem posing skills of teachers of gifted students since the problem posing skills of gifted students depend on the problem posing skills of the teachers (Stoyanova, 2003).

Problem-posing attitudes may also be effective on students' problem posing performances (Kılıç, 2019). For this reason, the relationship between success in problem posing and affective skills such as attitude and self-efficacy can also be examined in future studies.

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