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Research Article

An analysis of the gifted and non-gifted students' creativity within the context of problem-posing activity

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The purpose of this study was to examine the mathematical creativity of gifted and non-gifted students through the indicators of creativity (fluency, flexibility, and originality). The study involved 12 secondary school students (six gifted and six non-gifted) from different cities in the Black Sea Region of Türkiye. The data were collected through clinical interviews regarding the solutions developed by the students for a problem-posing activity developed by Balka (1974). Each student was interviewed twice over a two-week period. Prior to the interviews, the students were asked to pose as many different and varied problems as possible. In the clinical interviews, the students' solutions were discussed deeply without evaluating their correctness. Using the theoretical framework developed by Taşkın (2016), data were analyzed using fluency, flexibility, and originality indicators of creativity. The results revealed no clear difference between gifted and non-gifted students in terms of fluency indicators, but gifted students generally pose problems more creatively and flexibly than their non-gifted peers. It has been suggested that problem-posing activities be used to compare the creativity of gifted and non-gifted students. The indicators of originality and flexibility can also be weighted differently for calculating students' final scores of mathematical creativity because they are more effective at distinguishing gifted from non-gifted students.

Keywords: Mathematical modeling; Model eliciting activities; Primary school; Teaching experiment

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1. Introduction

The rapid advancement of technology and knowledge has led to a shift in expectations for the characteristics that individuals should have. With this in mind, the growing need for people who are qualified to adapt to the new era and who produce knowledge beyond knowledge has placed creativity at the center of education. In this context, numerous studies have been carried out in the international arena to identify the 21st century skills (e.g. Partnership for 21st Century Skills [P21], Organisation for Economic Co-operation and Development [OECD] Project of Definition and Selection of Competencies: Theoretical and Conceptual Foundations [DeSeCo], EnGauge, Assessment and Teaching of 21st Century Skills [ATCS], International Society for Technology in

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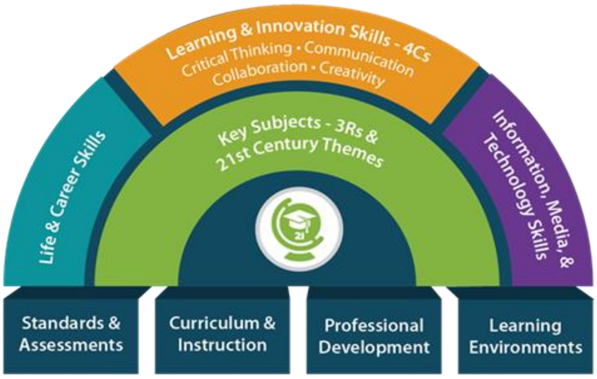
Education [ISTE], Assessment and Teaching of 21st Century Skills [ATCS]). Regarded as one of the most significant, P21 has developed a common vision acknowledged as 21st Century Learning Framework for the 21st century student attainment in the new global economy by accruing business circles, educational leaders and decision mechanisms. With a view to preparing students for the future, this vision emphasizes the importance of creativity, critical thinking, communication, and collaboration. Furthermore, creativity and innovation are considered to be important learning and innovation skills (see Figure 1).

Figure 1
Framework for 21st Century Learning (Battelle for Kids, 2019)



Likewise, "Transformative Competencies", indicating that 2030 students should be innovative, responsible and aware based on the DeSeCo project in the OECD Learning Framework 2030 report prepared in 2018 by the OECD, defined three competencies such as creating new value, reconciling tensions and dilemmas as well as taking responsibility. The report suggested the constructs that underpin the creating new value competency include adaptability, creativity, curiosity and open-mindedness (OECD, 2018). Therefore, it is most likely to emphasize that creativity plays a significant role in raising individuals with the 21st skills.

In 1950, J. P. Guilford gave a presidential address to creativity (Treffinger et al., 2002). However, there is no single and universally accepted definition of creativity due to its complex structure in nature (Brunkalla, 2009; Chamberlin & Moon, 2005; Haylock, 1987; Leung, 1997; Treffinger et al. 2002). Treffinger et al. (2002) grouped the definitions of creativity as “person”, “cognitive process or operations”, “lifestyle or personal development”, “product” and “interaction among person, process, situation and outcomes”. The definitions referring to the person focus on the characteristics of highly creative people, while those emphasizing cognitive processes or operations are grounded on the creative thinking. Furthermore, the definitions related to lifestyle or personal developments signify one's perceptions of one's own creativity, self-actualization, creative context or setting. As regards the product, the focus is on the creative skills of the products created by the individuals. Finally yet importantly, the definitions on the interaction among person, process, situation (event) and outcomes clarify the factors within the content or tasks. In this regard, creativity may be noted as the interaction among person, process, situation and outcomes.

Although the concept of creativity was generally investigated as a general field skill, this perception has been challenged over time (Haavold, 2013). Namely, various researchers stated that creativity mostly comes to the fore in one field, and thus creativity as domain general and domain specific should be handled separately (Akgül, 2014; Balka, 1974; Haavold, 2013), and that they searched creativity in mathematics separately from general creativity (Balka, 1979; Leikin, 2009; Leikin & Lev, 2013). Creativity as domain general can be defined as the ability to take pre-existing objects or concepts and associate them in different and unusual ways for a new purpose and to think differently about something (Doğan, 2011); creativity as domain specific is expressed in clear and distinct ability to create in one area (for example, mathematics) (Leikin, 2008). Therefore, creativity in mathematics is considered as a specific type of general creativity (Leikin, 2013).

1.1. Mathematical Creativity

Although mathematicians have regarded creativity in mathematics as an essential element of mathematical ability and tried to define creativity in mathematics (Lee et al., 2003), there is no consensus on the definition of creativity in mathematics since there is no universally accepted definition (Akgül, 2014; Brunkalla, 2009; Haavold, 2013; Haylock, 1987; Leung, 1997; Mann, 2005; Sriraman, 2005). For instance, Haylock (1987) defined creativity in mathematics as a concept that embraces a wide range of cognitive strategies, performance categories and outcome types; Sriraman (2004) revealed that creativity in mathematics is the process that results in unusual (unconventional), clear and insightful solutions to a given problem, irrespective of the complexity level. Krutetskii (1976) argued that mathematical creativity was established within a problem-solving framework and associated mathematical creativity in problem-solving with factors such as problem formulation, inventiveness (innovation, invention), independence and originality (Haylock, 1997). On the other, most researchers interpret mathematical creativity together with talent (Brunkalla, 2009), while some famous (eminent) mathematicians (Hadamard, 1945; Halmos, 1968; Muir, 1988) noticed that inventions and achievements in mathematics required creative talent rather than traditional academic ability (Livne & Milgram, 2006). By the same token, experts thought that students with creative talent would be able to solve creative problems (problems that contain a set of dynamic formulas that are nonspecial and not well defined with special component elements), that those with academic talent would be able to solve only the academic problems, and that some creatively talented students would be able to solve both kinds of problems (Livne et al., 1999). Academic ability in mathematics is the arithmetic computational ability that requires to get a high school grades in mathematics; whereas, creative ability in mathematical thinking is to be aware of patterns or relationships using complex and nonalgorithmic thinking and to have the ability of original thinking in more than one solution strategy (Livne & Milgram, 2006). Besides, Chamberlin and Moon (2005) explained mathematical creativity with two significant descriptors: divergent thinking (Guilford, 1956) and evaluative thinking (Fasko, 2001). While divergent thinking is the capability of producing a wide variety of responses, right or wrong, appropriate or not, to solve the problem, evaluative thinking is seeing the world as an ongoing process that results in questioning, reflecting, learning and changing (Kadayıfçı, 2008). In this context, mathematical creativity can be defined as the ability of individuals to produce original, unusual and different ideas or to pose appropriate mathematical problems for the solution of open-ended activities involving real-life problems or situations.

Different definitions and emphases on mathematical creativity have led to the emergence of different ideas about when and how creativity exists in mathematics. Some researchers noted that creativity may be existent when a non-standard solution is created for a problem that may be solved through using an algorithm (Chamberlin & Moon, 2005;Shriki, 2010). Brunkalla (2009) stated that creativity enters mathematics in three important ways: abstraction, connection and research. The creativity of abstraction is related to creating models that reflect real life and can be solved by individually known mathematical tools; besides, the creativity of connection means "awareness", which are known as mathematical tools that can be applied to new problems and enable them to be viewed in a new way (Brunkalla, 2009). Brunkalla (2009) also concluded that the creativity of research is the discovery of new mathematical tools that add available tools to unsolved problems. The common point that many researchers agree on is that creativity manifests itself as new and useful in the production of a creative work (for instance, a new work of art or a scientific hypothesis) (Leikin, 2008). Thus, the concepts of "new" and "useful" emerge as the most prominent features of creativity. What is "new" and "useful" may vary depending on the situation in which creativity exists. Therefore, researchers have outlined that creativity in school mathematics may differ from that of professional mathematicians (Leikin, 2009; Leikin & Lev, 2013; Sriraman, 2005). This difference between school mathematics and professional creativity has brought up the concepts of absolute and relative creativity (Leikin, 2009; Shiriki, 2013; Sriraman, 2004). Absolute creativity is associated with the outstanding historical works of eminent mathematicians, while relative creativity refers to discoveries made by a particular person within a specific reference group (Shiriki, 2013). Leikin (2009) stated that students' creativity in mathematics can be evaluated by reference to their previous experiences and the performances of other students with similar educational backgrounds. Thus, this study was built on the relative creativity of the students in the evaluation of their creativity.

1.2. Mathematical Creativity and Mathematical Giftedness

Upon examining the relevant literature, there are different perspectives on the relationship between giftedness and creativity (Leikin & Lev, 2013; Leikin & Pitta-Pantazi, 2013). While some regard creativity as a specific type of giftedness, some argue that it is a fundamental element of giftedness, while others argue that these are two independent characteristics of human beings (Hershkovitz et al., 2009; Leikin, 2009; Leikin & Lev, 2013). Furthermore, most researchers settle on a positive relationship between giftedness and creativity (Hershkovitz et al., 2009). Treffinger et al., (2002) reported that creativity is not a single and separate type of giftedness, but an important element in all areas and it is a topic that includes many definitions of giftedness. Likewise, Renzulli (1978) also considers creativity as one of the basic elements of giftedness. This disparity among views on the relationship between creativity and giftedness has led to the development of various models to express the relationship between giftedness and creativity (Leikin & Pitta-Pantazi, 2013). For example Renzulli (1978) expresses giftedness as the interaction of three components, which he describes as above-average ability, task commitment, and creativity, in his three-ring giftedness model. In this model, creativity includes factors such as flexibility, originality of thought, fluency, willingness to take risks and openness to experience (Haavold, 2013). Sternberg's (1985) the three-element model (The Triarchic Theory of Intelligence) argues tha high level of intelligence is a necessary but not a sufficient criterion for a high level of creativity (Leikin, 2008) and defines creativity as "the ability to produce unexpected, original works that are useful and adaptive" by adding usefulness and adaptation features to the definition of creativity, and also sees creativity as one of the basic elements of intelligent human behaviour (Leikin & Pitta-Pantazi, 2013). Livne and Milgram's (2006) "The 4x4 Structure of the Gifted Model" regards giftedness as a result of the complex interaction of cognitive, personal-social and sociocultural factors and explains it as including four different ability types and four different ability levels.In the model, where creativity is considered as a type of giftedness, there are two general abilities (general intelligence and general creative thinking) and two domain-specific abilities in mathematics (domain-specific academic ability in mathematics and domain-specific creative ability in mathematics). Therefore, unlike the others, in this model creativity is considered as two different types of abilities in the context of both general and domain-specific abilities, and includes different levels of giftedness ability (Arabacı, 2022). Like Livne and Milgram (2006), Usiskin(2000) put forward another classification that provides an opportunity to explain the relationship between giftedness and creativity in mathematics and defined giftedness at different levels. Usiskin's (2000) model, where giftedness ranges from level 0 to level 7, paved the way for the fact that creativity in mathematics includes giftedness, yet giftedness does not mean creativity (Haavold, 2013).

Despite the difference of opinions between the relevant literature and the models above, most researchers are in agreement that giftedness and creativity have a positive relationship (Leikin, 2009). As a matter of fact, creativity is one of the most important attributes expected of gifted students, who are thought to be able to make discoveries and inventions in a variety of fields and contribute to humanity, especially if they develop their potential. Budak (2007) emphasized creativity with regard to giftedness as one of the values students should have, indicating that students' motivation and creativity abilities need to be boosted as well as their mental abilities. Considering the consensus definition of giftedness in Türkiye, creativity is regarded as one of the characteristics of gifted students. The Science and Art Center (SAC), where gifted students are educated in Türkiye, defines gifted students as follows:

> An individual who learns faster than his peers; who is the leader in creativity, art and leadership capacity, who has special academic abilities, who can understand abstract ideas, who likes to act independently in areas of interest and performs at a high level (Ministry of National Education [MoNE], 2015, p.16).

By the same token, many different researchers have pinpointed the importance of creativity in gifted students (Akgül, 2014; Chamberlin & Moon, 2005; Sriraman, 2005). Hence, creativity in mathematics appears as one of the characteristics that gifted students should hold, which makes it necessary to investigate the potential existence of creativity in mathematics in these students, as in other non-gifted students.

1.3. Problem-Posing Tasks and Mathematical Creativity

To reveal students' creativity in mathematics, Balka (1974) suggested using convergent and divergent production activities. Convergent thinking refers to the ability to focus on the most appropriate or correct answer. Divergent thinking is the ability to generate knowledge from the information given, asserting the variety of answers and the quality of outcomes (Balka, 1974). Likewise, Alder (2004) describes the characteristics of creative thinking as fluency in thinking, flexibility in thinking, originality, being able to see or be sensitive to problems, producing reasonable answers, redefining, going into detail, eliminating ambiguity, interest in convergent thinking, interest in divergent thinking, desire to be different and defy convention, high degree of self-discipline, high standard of excellence and willingness to take risks; moreover, the researcher indicated that convergent and divergent thinking are the characteristics of creative thinking. A number of researchers (Haylock, 1987; Haavold, 2013; Livne & Milgram, 2006; Mann, 2005; Sriraman, 2005) confirmed that divergent thinking activities are much more effective in determining mathematical creativity. The most important feature of divergent thinking tests is that problems or situations in these activities have many different answers (Haavold, 2013). In this regard, Haylock (1987) defined three types of divergent production activities: problem-solving, problem-posing and redefinition, which include open-ended situations that can be used in divergent thinking tests. Many researchers have stated that problem-solving and problem-posing are related to creativity, especially in school mathematics (Balka, 1974; Leung, 1997; Mann, 2009; Silver, 1997; Sriraman, 2005). Thus, problem-posing activities serve as one of the tools that may be used to reveal students' mathematical creativity.

According to Kontorovich et al. (2011), the word creativity originates from the Latin creare, which means to create, as well as to create new mathematical problems. Problem-posing can also be defined as the generation of new problems and mathematical questions along with the reformulation of the problem, in which the problem-solver rephrases or creates a given problem in any way or makes it more accessible for solution within the process of solving a given problem (Nicolaou & Philippou, 2007). Many researchers noted that creativity is inherently related to problem-posing (Korkmaz & Gür, 2006; Lee et al., 2003; Leung, 1997; Silver, 1997; Siswono, 2011; Van Harpen & Sriraman, 2013; Yuan & Sriraman, 2010), and that problem-posing is an important element of creativity (Haavold, 2013). Hence, it is likely to mention that problem-posing activities are an effective tool to examine students' creativity. Leung (1997) concluded that individuals' creativity may be examined based on the answers when they are requested to pose a problem by giving a task that does not have a single solution and that can be expressed in different ways (verbal, graphic, etc.). In addition, Lee et al. (2003) described problem-posing as a feature of creative activities. Haylock (1987) stated that such activities may provide significant opportunities for students to expose their creativity. Therefore, this study employed the proble- posing activity for being an effective tool in revealing mathematical creativity.

1.4. Importance of the Study

Although the significance of creativity in mathematics has been stressed by many researchers (Brunkalla, 2009; Chamberlin & Moon, 2005; Haylock, 1987; Leikin& Pitta-Pantazi, 2013; Livne& Milgram, 2006; Mann, 2009), little has been accomplished to develop the concept (Chamberlin &

Moon 2005; Leikin & Pitta-Pantazi, 2013). Despite an increasing interest, a limited number of studies were conducted on identifying creatively talented students in mathematics (Akgül, 2014; Chamberlin & Moon, 2005). However, organizing and adapting mathematics curricula according to the needs of creative students may only be possible by identifying students with creative potential in mathematics (Akgül, 2014; Balka, 1974). It is of great importance to determine students' current potential for the purpose of understanding the nature of their creative thinking skills and evaluating their efforts to develop their creative potential (Akgül, 2014). Upon examining the current studies, students were identified to use general expressions about their creativity in mathematics, especially in making comments in relation to indicators, yet they did not provide sufficient information about concrete behaviours that can be expressed as the characteristics of creativity in the process. In other words, studies explained students' creativity with certain scoring and/or partial categorizations, and these statements are insufficient to provide concrete evidence about how (with what behaviours) students' creativity in mathematics emerges, namely, to characterize their creativity in mathematics. Although the importance of creativity for gifted students (Akgül, 2014; Chamberlin & Moon, 2005; Sriraman, 2005) and the necessity of examining the existence of mathematical creativity as a character in gifted students (Akgül, 2014;Budak, 2007) have been analysed by different researchers, a constraint number of studies are available in the literature.

The studies on creativity in mathematics are mostly grounded on determining creativity in mathematics (Akgül & Kahveci, 2016; Balka, 1974), examining the characteristics and creative thinking levels of creative individuals in mathematics (Amaral & Carreira, 2012; Livne et al., 1999; Mann, 2009; Siswono, 2011; Sriraman, 2004), tools that can be used to reveal creativity in mathematics (Gür & Kandemir, 2006; Leung, 1997; Williams, 2002) and the development of creativity in mathematics (Ayvaz & Durmuş, 2021; Brunkalla, 2009; Kandemir, 2006; Shriki, 2010). However, fewer studies were carried out on the creativity of gifted students in mathematics (Akgül, 2014; Ayvaz & Durmuş, 2021; Chamberlin & Moon, 2005; Kattou et al., 2011; Lee et al., 2003; Livne & Milgram, 2006; Pitta-Pantazi et al., 2011). The results suggested that challenging problems and multiple solution activities (Kandemir, 2006; Kattou et al., 2011; Lee et al., 2003; Livne et al., 1999; Williams, 2002) were used both in announcing and developing creativity in mathematics, specifically problem-posing activities can be used (Leung, 1997). Moreover, a significant relationship was noted across the creativity levels of the gifted students and their problem-solving skills (Tekin & Karasu, 2007 as cited in Taşkın, 2016), and that they recommended more effective and original solutions than their peers (Kattou et al., 2011). Nevertheless, no concrete examples were found about which creative behaviours the students exhibit in mathematics, and what kind of behaviours they demonstrate in terms of which indicator of creativity. However, reporting more concretely in which behaviours the ideas produced by students differ across fluency, flexibility and originality indicators may help better discern the concepts of creativity and giftedness in mathematics. In this context, this study differs from those on gifted and non-gifted students in terms of the data collection tools and the theoretical framework used during data analysis.

Studies on creativity in mathematics generally include developing a test/scale to measure creativity in mathematics (Akgül & Kahveci, 2016; Balka, 1974; Livne et al., 1999), how creativity exists in mathematics (Sriraman, 2004) and identifying the characteristics of creative people (gifted or non-gifted) (Akgül, 2014; Amaral & Carreira 2012; Mann, 2009; Siswono, 2011), examining the creativity of gifted students in mathematics (Kattou et al., 2011; Lee et al., 2003). The studies on problem-posing and creativity determined the relationship between problem-posing activities and creativity (Leung, 1997), and the effect of problem-posing activities on improving the mathematical creativity of the gifted students (Ayvaz & Durmuş, 2021). Sriraman (2004) worked with five mathematicians to identify how creativity serves in mathematics. Mann (2009) examined various factors in the educational environment (success in mathematics, attitude towards mathematics, self-perception of creative ability, and teachers' perceptions of mathematical ability and creative ability) by means of existing tools in order to reveal the indicators of creative potential in mathematics. In another study conducted to determine the characteristics and levels of creative people in mathematics, Siswono (2011) centered on students' personality traits for each level. Amaral and Carreira (2012) focused on the cognitive behaviours exhibited by students during the problem-solving process. When the studies of Siswono (2011) and Amaral and Carreira (2012) are compared, the first one is related to personality while the second focuses more on the cognitive dimension. Although fluency, flexibility and originality indicators of creativity were taken into account in both studies, each indicator was discussed in more detail in the second study. Therefore, it may have the potential to reveal more concrete results in addressing the characteristic existence of creativity in mathematics. In the related study, mathematical creativity was discussed within the context of problem-solving, and no such a study was found in terms of problem-posing. As stated above, the undeniable relationship between problem-posing and creativity in mathematics necessitates understanding how mathematical creativity emerges in problem-posing activities. On the other, the fact that the studies in the field of creativity in mathematics continue to be updated and the importance given to creativity increases day by day shows that the studies need to be handled from different perspectives and examined in terms of different variables (Akgül, 2014; p.34).In this regard, this study attempts to examine the mathematical creativity of the gifted and non-gifted students within the context of an open-ended and multi-solution problem-posing activity related to daily life. Thus, the research question is "How do the mathematical creativity of the gifted and non-gifted students differ in terms of creativity indicators across problem-posing?". The following research questions were devised to attain this goal:

RQ 1) How do the gifted and non-gifted students differ across the fluency indicator of creativity?

RQ 2) How do the gifted and non-gifted students differ across the flexibility indicator of creativity?

RQ 3) How do the gifted and non-gifted students differ across the originality indicator of creativity?

RQ 4) How do the gifted and non-gifted students differ across the general creativity?

2. Method

2.1. Research Design

This study employed the qualitative research design to analyse the mathematical creativity of the gifted and non-gifted students through problem-posing activity. Since the mathematical creativity of the students was examined in depth, this study used a particular case study. Gall et al. (2003) reported four characteristics of case study research: the study of phenomena by focusing on specific instances, that is, cases; an in-depth study of each case; the study of a phenomenon in its natural context and the study of the unique perspectives of case study participants. Based upon these characteristics, this study focused on different particular instances, including gifted and non-gifted students. This study was carried out within the educational institutions where the students studied; therefore, each instance was analysed within its natural context. Besides, each case was examined in depth with the help of clinical interviews and that the cases were analysed from their own perspectives by taking into account the students' own statements. This study utilized a holistic multiple-case design since multiple cases were examined in order to explore the similarities and differences between cases (Baxter & Jack, 2008).

2.2. Participants

The study was carried out with a total of 12 secondary school students who were gifted and non-gifted. One of the groups (six students in total) consisted of the gifted students registered to different SACs; the other (six students in total) included those who attended primary schools affiliated to the MoNE and who were non-gifted. Purposive sampling method was used for the selection of the students. Purposive sampling method is a technique widely used in qualitative research for the identification and explanation of facts and cases (Coyne, 1997; Yıldırım & Şimşek, 2008). Detailed information regarding the students in both groups is presented below. A total of 6 non-gifted students, three of whom were in the 7th grade and 3 were in the 8th grade participated in the study. These students were selected from different schools affiliated to the Ministry of National Education. Since they did not receive the SAC exam, they were named as "non-gifted students" within the scope of the study. The reason for choosing students from different schools is to prevent them from exchanging ideas with each other during the activity process as each student's creativity was examined individually. It was also ensured that the achievement levels of the non-gifted students were at least moderate. This may be because students who do not have mathematical knowledge and skills and who are below a certain level of proficiency do not show their creativity in mathematics since they do not have sufficient knowledge and experience to express their creative thinking (Haavold, 2013; Haylock, 1987; Mann, 2004). Therefore, the pilot study was carried out with low, medium and high-achieving students determined by consulting teachers' views. This paved the way for the fact that creativity could not be observed or very little could be observed in low-achieving students due to the lack of secure basis. Teachers were asked about the students' attainment levels. Accordingly, they recommended the students in line with their academic success and their performance in in-class activities.

The students were determined on the basis of voluntariness. In Turkey, the process and procedures regarding the identification of students to be registered in SAC are carried out by the Ministry, the provincial diagnostic examination commission, SACs and guidance and research centres in line with the guide published by the Ministry (MoNE, 2015). The diagnosis process takes place in 3 stages: "nomination, group screening and individual examination". After the students who are thought to be special talents in the fields of general mental ability, visual arts and music are nominated for SACs based on their diagnosis age or class level determined by the Ministry, they are administered to the group screening exam according to the criteria determined by the Ministry (MoNE, 2015). During the identification calendar period, the list of the students who perform at or above the criteria determined in the group screening is sent to the provincial diagnostic examination commission by the Ministry, and individual examination of the students is made by the provincial diagnosis examination commission through using objective and standard measurement tools in conjunction with the criteria identified by the Ministry (MoNE, 2015). Following the diagnosis process, the registration of the students who deserve to be enrolled in SAC is made by their parents according to the calendar specified in the diagnosis guide. Hence, this study was also conducted with the gifted students who passed the diagnosis process described above and enrolled in SAC affiliated to the MoNE. The gifted students are admitted to the training programs of Adaptation, Support training, Recognizing individual talents, Developing special talents and Project production and management in SACs (MoNE, 2015). Following the completion of the individual talent recognition program, the students are evaluated by the teachers' board with the multiple evaluation method and directed to the special talent development program areas (MoNE, 2015). Therefore, the field-specific abilities of the students are determined by the teachers at the end of the "Recognizing Individual Talents (BYF)" program. The working group of the study consisted of a total of six students, one seventh and one eighth grader, who were attending SACs in 3 different provinces (Trabzon, Ordu and Amasya) and who were determined as gifted in mathematics from each SAC. Voluntariness was also taken as a basis for student selection at SACs. The purpose of choosing students from different SACs is to ensure sample diversity and to prevent students from exchanging ideas with each other during the implementation of the activities. In addition, the reason for choosing students at different grade levels is to examine whether mathematical creativity varies across their grade level.

Table 1 depicts the information regarding the grade levels of the students and the educational institution they are registered to.

Table 1
Information regarding the grade levels of the students and the educational institution they are registered to

	7th Grade	8th Grade	Total
SAC	3	3	6
MoNE	3	3	6
Total	6	6	12

Codes were used to represent the students by avoiding the use of their real names for ethical concerns. Thus, the gifted students were coded as G1, G2, G3, G4, G5 and G6; non-gifted students were coded as S1, S2, S3, S4, S5 and S6. Besides, the first 3 codes represent the 7th grade students, and the 4th, 5th and 6th codes refer to the 8th grade students for both groups.

2.3. Data Collection Tools

The data were obtained in two stages. The first of these is the model building activity and the second consists of clinical interviews conducted with students during the process. The data collection tools are detailed below.

2.3.1. Problem-posing activity: Aircraft production

The scenario of the problem-posing study was adapted from the "Creative Ability in Mathematics" test developed by Balka (1974). Used as a problem-posing activity within the scope of the study, this scenario is an item that requires divergent thinking, developed in accordance with the criterion of "the ability to divide general mathematical problems into special subproblems" and expressed as the ability to generate knowledge from the given information. With this criterion, Balka (1974) emphasized the ability of students to produce problems based on a general situation in the given scenario, while divergent thinking puts the emphasis on the diversity of the answers produced and the quality of the outputs. The problem-posing activity was first adapted into Turkish to ensure validity and reliability. For this purpose, the activities translated into Turkish by the researcher were examined by one language and three field experts. The activity, which was organized in line with the experts' feedback, was reviewed by the same experts and the activities got their final versions. Afterwards, a pilot study of the problem-posing activity was conducted with a total of 11 students with different academic achievement levels (low-medium-high) and one gifted student. Individual interviews were conducted with each student, and thus the students were identified to experience difficulties in understanding some sentences. Therefore, these parts were noted during the interviews and necessary corrections were made. The data collection tools were revisited by the experts and the activities were finalized with their new version. The students were required to solve the problems by posing as many different and various problems as possible (focusing on different variables) by taking into account the different variables in the problem scenario given to them. The purpose of asking students to solve problems is to understand more clearly what they aim at in the problems they pose. In fact, Haylock (1987) also stated that asking students to answer the questions they created is important in order to understand their goals more clearly. Students were also warned not to wander from the scenario and add different variables. A total of 2 weeks was provided to the students to solve the activity, and clinical interviews were conducted with each student once a week and twice in total.

2.3.2. Clinical interviews

Clinical interviews, first used by Jean Piaget to examine the mental and moral development of children (Searle, 2002), are an effective tool used to reveal how and why students do what they do rather than what they do (Güven, 2006). Thanks to clinical interviews, data on the same subject can be collected from each participant, and thus comparisons can be made between individuals (Searle, 2002). These interviews may also provide the researcher with the opportunity to obtain extensive information about the students' thinking style and reasoning skills, conceptual knowledge, learning style, attitude, beliefs and the reasons behind them (Legard et al., 2003; MandacıŞahin, 2007).

This study used clinical interview technique (1) to determine the mathematical creativity of students by focusing on factors such as what ideas they come up with in the solution process of two different activities, what kind of strategies they prefer, how they determine these strategies, how many different solutions they can develop, and (2) to compare students' mathematical creativity in terms of the components of creativity. Interviews were held once a week for 2 weeks, with each student a total of 4 times. Interviews were conducted on a suitable day and time in a quiet environment in the schools where the students were studying in order to make them feel comfortable and each interview was video-recorded with the permission of the participants in order to explore the solution and thinking processes of the students in their own words and to prevent data loss.

The clinical interviews were carried out on the problems posed by the students and the solutions they brought to the problems. For this purpose, the students were given a problem-posing activity before the interviews, they worked on this activity, and the interviews were held the following week. No comments were made on the correctness or falsity of the problems posed by the students during the interviews, and questions similar to the following questions were asked to spark their views and ideas in the problem-posing process.

1) Did you make any preparations before starting the activity?
2) How did you start the activity?
3) How did you go about solving the activity?
4) How can you be sure that your solution (problems you have posed) is correct?
5) How can you be sure that the problems you pose are solvable?
6) Can a different problem be created?

The duration of the interviews with the students varies across the solution of each student, so they lasted approximately 15-30 minutes.

2.4. Data Analysis

The difference between creativity in school mathematics and professional creativity (Leikin, 2009; Shriki, 2013; Sriraman, 2005) revealed the concepts of relative and absolute creativity. Absolute creativity is associated with the extraordinary historical work of eminent mathematicians (for example, the studies of Fermat); relative creativity indicates discoveries made by a specific person within a specific reference group (Leikin, 2009; Lev-Zamir & Leikin, 2011; Shriki, 2013). Therefore, students’ situation in the reference group should be taken into consideration when evaluating their creativity. Therefore, the students’ relative creativity was envisioned in the evaluation of their creativity. At first, great attention was paid to the mathematical correctness of the problems posed by the students during the analysis of the problem-posing activity. Because an answer can be highly unusual or original, but it also has to be mathematically correct (Haavold, 2013). Hence, the problems that were determined to be mathematically correct (the concepts and operations were used in accordance with their definitions and could be solved) were first analysed qualitatively. Theframework developed by Taşkın (2016) in accordance with the nature of the problem-posing activity through use of the framework developed by Amaral and Carreira (2012) was used. The instrument includes knowledge, indicators and descriptors sections. The knowledge dimension was named as problem-posing in this instrument. The indicators are originality, flexibility and fluency that each of them consists of a coded descriptor-novelty, representation and communication- associated to a numbered list of different cognitive resources (Amaral & Carreira, 2012). The the theoretical framework developed by Taşkın (2016) is presented in Table 2.

Table 2
Theoretical framework used in the analysis of the problems posed by the students within the scope of the problem-posing activity

Indicator	*Descriptors/Resources codes*
Originality (O)	Novelty (ON) 1) Creates original figures, diagrams, tables, etc. and poses problems for their interpretation (ON1) 2) Creates problems that require the use of unusual and original strategies (ON2) 3) Creates unusual and original problems by presenting a different perspective to the existing data (ON3)
Flexibility (Fx)	Representations(FxR) 1) Construct a suitable mathematical problem through using different variable(s) (FxR1) 2) Creates problems with more than one solution (FxR2) 3) Poses a problem that requires associating the variables in the scenario with each other and in line with the purpose (FxR3) 4) Poses a problem that includes examining different situations for the variables in the scenario (FxR4) 5) Constructs a different problem by rearranging a previously established problem (FxR5)
Fluency (Fn)	Communication(FnC) 1) Contains an appropriate problem statement that requires the use of mathematical concepts and procedures (FnC1) 2) Creates an appropriate problem that requires the development and exploration of mathematical concepts and procedures (FnC2) 3) Presents the variables and concepts used in the problem statement clearly and consistently (FnC3) 4) Communicates (expresses) the problem statement by arranging variables/data (FnC4).

The problems posed by the students were analysed and examined in terms of indicators within the context of the descriptors in Table 2. The problems posed by each student were coded and codes with similar structures were brought together and themes were created with the aim of examining the problems more easily in terms of the indicators of creativity. Afterwards, it was determined how many students created the problem for that code. In this manner, it was possible for each student to see the problems in different categories (FxR1) and to interpret the original or unusual problems (ON2, ON3). Besides, codes and themes created for the problems provided the researcher with the opportunity to see the problems with similar and different structures more easily, making it easier for the researcher to score the problems. To exemplify the problems posed by the student coded G2 is as in Table 3.

The codes in the table above are related to the problems posed by G2, and the themes refer to the variables included in the problems. This table was prepared for all students. The relevant table helped the researchers in making the scoring explained below. After the indicators that emerged in the problems were analysed qualitatively in the context of descriptors, the indicators of creativity such as fluency, flexibility and originality scores, and creativity scores were calculated through using the scoring system adapted from Leikin (2009).

Table 3
The codes and themes related to the problems posed by G2 for the Aircraft production activity

Themes and Codes	*f*	f_t
Aircraft type - profit		
➢ Profit from the production of a certain number of 3 types of aircraft	1	5
➢ Profit to be obtained from a certain number of two/three types of aircraft as a result of a certain amount of change in the profit of the aircraft	3	1
➢ How is the profit from a given number of aircraft of one type equal to the profit from the number of aircraft of the other type?	1	3
Maintenance base-aircraft type		
➢ Area occupied by a certain number of two/three types of aircraft at the maintenance base	3	1
➢ The number of other types of aircraft that the maintenance base can accommodate in case of a change in the type and number of aircraft it can accommodate	2	1
Production price, profit and aircraft type		
➢ Can the profit from a certain number of three types of aircraft pay for itself?	1	1
➢ Profit to be obtained in case of the change in the production prices of the aircraft and the amount of profit obtained from the aircraft	1	1
Aircraft type-profit-number of pilots		
➢ Profit from a given number of two types of aircraft, taking into account the number of pilots	1	1

Note. f: The number of problems that the student has created for the specified code; f_t: The number of students who created problems with the specified code

The same score was assigned to all descriptors that emerged for a problem during the scoring stage. The descriptors in the problems posed by the students were evaluated according to three different scores, namely 10, 1 and 0.1. For each student, the first problem posed by the student is 10 scores, and each subsequent problem is scored as follows.

10 point: If the new problem posed by the student is different from those posed previously; that is, if the same/different variables are used with any previously established problem and the solution of the problem requires the use of different concepts and procedures, score 10 can be given to each descriptor in this problem.

1 point: If the new problem posed by the student belongs to any problem posed previously; namely, a different/same variable is used with the previously posed problem, the solution of the problem requires the use of similar concepts and procedures, but has a minor distinction such as the use of an additional operation or concept, score 1 is given to this problem and each descriptor in the problem.

0.1 point: If the new problem posed by the student is of the same nature as any problem posed previously; that is, the same variable is used as the previously established problem and requires the use of the same concepts and procedures; only the names/numbers in the problem sentence have been changed or;

If the solution of the problem can be seen directly from the scenario without taking any action, score 0.1 is given to this problem and each descriptor.

For instance; The first problem the student poses is "What is the total price of three DC-10s, two 707s and four 747s?". All descriptors of this problem were given 10 points. Considering this problem, the following problems are scored as follows.

A different variable (the area covered by the aircraft at the maintenance base) was used from the previously mentioned one within the problem “How many 747s can the maintenance base accommodate?”, and it had a different structure from the previous problem. In addition, the solution of the problem requires that the areas occupied by the aircraft at the maintenance base should be associated with each other. Therefore, it necessitates the use of different concepts and procedures. Thus, score 10 was given to this problem, and all the descriptors were scored with 10 points.

"What is the average total price of three DC-10s, two 707s and four 747s?" problem is similar to the previous one. Unlike the previous problem, the problem requires the average of the total price. Therefore, the solution of the problem requires the use of the concept of mean as well as the use of concepts and procedures similar to the previous problem. For this reason, this problem was scored with 1 point, and all the descriptors were scored with 1 point.

"What is the total price of five DC-10s, three 707s and one 747?" problem has exactly the same structure as the first problem, yet only the number of aircraft in the problem sentence was changed. Therefore, the solution of the problem requires the use of the same concepts and procedures. Accordingly, this problem was given a score of 0.1, and all the descriptors were scored with 0.1.

At this point, the students' total fluency, flexibility and originality scores and creativity scores were calculated as follows: Fluency score (Fn): The total score obtained from the descriptors related to the fluency indicator in all the problems posed by the student / 4; Flexibility score (Fx): The total score obtained from the descriptors of the flexibility indicator in all problems posed by the student / 5; Originality score (O): The total score obtained from the descriptors of the originality indicator in all the problems posed by the student / 3; Creativity score: Fn+Fx+O.

2.5. Reliability

In qualitative research, reliability refers to the consistency of responses between more than one coder (Creswell, 2013). To ensure scoring reliability among coders, two methods can be used. A first method involves examining the coding reliability of the researcher by coding the data obtained at two different times; a second method involves calculating the reliability between two different scorings by consulting experts (Miles & Huberman, 1994). Therefore, consistency in scoring the problems posed by students is crucial. In order to accomplish this, the researcher analysed the data and scored the problems of each student again three and six months later. While the consistency of the scoring after three months was 82%, this rate increased to 92% after the second analysis. The scores were consistently above 80% in both analyses. In addition, expert opinions were sought to ensure consistency. Initially, the experts were informed about the purpose, method, and data analysis of the study. Then, each expert was asked to score the problems posed by two students, one of whom was diagnosed as gifted, the other not. As a result, two students' problems were scored by six researchers, each of whom is an expert in mathematics education. When deciding the final scores for each student's problems, the reliability between the expert and researcher's scores was checked. If the scoring reliability for a student is 70% and above, the scoring is regarded as consistent (Miles & Huberman, 1994). If it is below 70%, the problems posed by the same student were scored by a different expert, and the scores of the three researchers were compared. The most predicted score was assigned by the researcher and two experts for each problem with different scoring. Thus, all problems were scored by different experts and intercoder consistency was ensured.

3. Findings

This section compares the mathematical creativity of the students in both groups (gifted and non-gifted students) regarding the problems they posed for the problem-posing activity with the average scores obtained for each indicator. Besides, each indicator was discussed separately and a comparison was made within the context of descriptors. In this regard, the creativity indicators that emerged in the problems developed by the students in both groups for the problem-posing activity and the average scores of these indicators as well as the total creativity score of each student are depicted in Table 4.

Table 4

Creativity indicators resulting in problems posing problems by the gifted and non-gifted students and the scores related to descriptors of these indicators

				Originality (O)				*Flexibility (Fx)*					*Fluency (Fn)*					
			Novelty (ON)					Representations (FxR)					Communication (FnC)					Total
Students		PS	ON1	ON2	ON3	ON_a	ET1	FxR2	FxR3	FxR4	FxR5	FxR_a	FnC1	FnC2	FnC3	FnC4	FnC_a	
Gifted 7th Grade	G1	10/3	0	30	70	33.3	40	10	40	20	10	24	100	0	70	0	42.5	99.8
	G2	16/3	0	0	10.1	3.36	30	20.1	40.2	10.1	0	20.08	82.3	0	52.3	10	36.15	59.59
	G3	18/0	0	0	20	6.67	51	10	60.1	0	0	24.22	112.5	0	72.4	30	53.73	84.62
Gifted 8th Grade	G4	11/0	0	15	25	13.33	31	20	36	0	16	20.6	56	14	24	0	23.5	57.43
	G5	18/1	0	0	0	0	21	0	30.1	0	0	10.22	73.8	0	63.8	0	34.4	44.62
	G6	10/0	0	0	21.3	7.1	31	0	41.3	0	31	22.46	61.3	21.3	41.3	0	30.98	58.74
Non-Gifted 7th Grade	S1	15/0	0	0	0	0	23	10	20	0	0	8.6	55.5	0	42.5	10	27	35.6
	S2	14/0	0	0	0	0	31.1	0	10	0	0	8.22	45.5	0	33.5	10	22.25	30.47
	S3	21/3	0	0	20	6.67	11	0	42.1	0	0	10.62	75.9	0	62.9	21.3	40.03	57.32
Non-Gifted 8th Grade	S4	34/1	0	0	0	0	32	1.1	35.1	0	2	14.04	78.1	0	64.4	32.7	43.8	57.84
	S5	5/1	0	0	0	0	21	0	21	10	0	10.4	41	0	41	10	20.5	30.9
	S6	31/0	0	0	0	0	34	0	10.1	0	0	8.82	68.8	0	47.2	11.2	31.8	40.62

Note. PS: Number of solvable problems /number of unsolvable problems; ON_a : Average score of originality indicator; FxR_a: Average score of flexibility indicator; FnC_a: Average score of the fluency indicator; Total: Total creativity score.

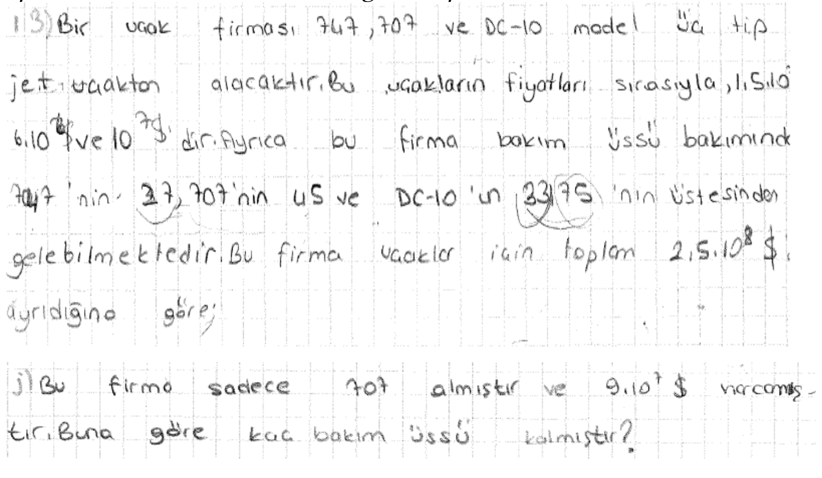
Table 4 displays that the students posed a number of problems between 5 and 35. Furthermore, non-gifted students were identified to create a relatively higher number of problems. While S5, a non-gifted student, posed the fewest problems, S4, a non-gifted student, had the highest number of problems. Besides, most of the problems posed by the students were used in accordance with the definitions of concepts and operations, and that they posed mathematically correct and solvable problems. However, the numbers presented in the PS category indicated that G1 and G3 posed problems by adding three new variables each, and G5, G3, G4 and G5 also posed problems with mathematical errors. In this vein, one out of 19 problems posed by G5, three out of 24 problems posed by G3, one out of 35 problems created by G4 and one out of five problems created by G5 were noted to have mathematical errors. These findings are presented and emphasized in the table due to their significance in the interpretation of the fluency indicator and the relationship between the number of problems and the fluency indicator. The findings for each indicator of mathematical creativity are displayed in detail.

3.1. An Analysis of the Students' Mathematical Creativity in terms of Fluency Indicator

Upon analysing the average scores of the students regarding the indicators, the indicator with which all students got the highest score was fluency, the most prominent in the problems posed by all students. As regards the comparison of the students' creativity in terms of fluency indicator, no group was dominant despite the gifted students were in the forefront. Four of the first six students with the highest scores (G3, G4, G1, G3, G2, G5, respectively) are gifted, while two of them are non-gifted. It is noteworthy that S4 posed the highest number of problems, while G3 had the highest fluency score. When the problems posed by S4 are examined, it is seen that S4 had a tendency to pose more than one problem with similar codes. To exemplify, the student posed 6 problems regarding the code "The area remaining after one/two/three types of aircraft that can be purchased with a certain budget are placed in the maintenance base". The first problem that S4 posed for this problem is illustrated in Figure 4.

Figure 4

The first problem that S4 posed for the code "The area remaining after one/two/three types of aircraft that can be purchased with a certain budget are placed in the maintenance base"

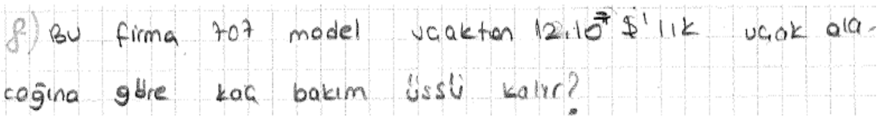


[Translation: An aircraft company will purchase three types of jet aircraft, model 747, model 707, and model DC-10. The prices of these planes are $\$1.5x10^6$, $\$6x10^6$ and $\$10^7$, respectively. Besides, this firm also achieves 27 out of 747, 45 out of 707 and 33.75 of DC-10 in terms of maintenance base. Since this firm allocates $\$2.5x10^8$ for airplanes;
j) This company only bought model 707 and spent $\$9x10^7$. Accordingly, how many maintenance bases are left?]

Based on the information above, S4 posed 5 more problems with the same solution as this problem. An example of such problems is suggested in Figure 5.

Figure 5

A different problem that S4 posed for the code "The area remaining after one/two/three types of aircraft that can be purchased with a certain budget are placed in the maintenance base"


8) Bu firma 707 model uçaktan 12.10⁷ $'lık uçak alacağına göre kaç bakım üssü kalır?

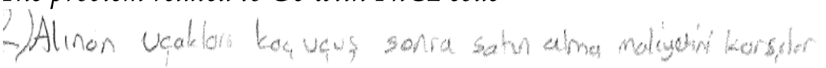
[Translation: When this company buys 707 model aircraft with 12.10⁷$, how many maintenance bases will remain?]

As is seen in Figure 5, this problem posed by S4 was only created by changing the numerical data of the aircraft type and the amount of money spent. Since this problem requires the use of the same variable and same concepts and procedures as the previous problem and only a change was made on the nouns/numbers in the problem sentence, it was scored with 0.1. The same score was given to the other problems related to this code. Besides, the score 78.1 that S4 obtained from the FnC1 descriptor were calculated as the sum of $7x10 + 6x1 + 21x0.1$. This total suggests the sum of only seven of the 34 problems posed by the student, namely, the solution of the problem requires the use of different concepts and strategies; moreover, 21 problems had exactly the same structure and solution with the problems the student has previously established. On the other hand, when the problems posed by G3 were examined, it was seen that the 18 problems posed by G3 were gathered under 12 different codes, that is, the problems posed by the problems posed by G3 mostly belonged to different codes, which is an indication that the student was trying to pose problems with a different structure. Even though G3 posed fewer problems, higher fluency score also suggested the problems s/he posed. A similar pattern is also valid for the problems posed by other students, which explains the difference between the number of problems the students pose and the fluency score that emerges in the problems.

Considering the scores obtained by the students from the fluency indicator in terms of their grade levels, the 7th grade students were found to have higher scores than the 8th graders in parallel with the total creativity score, yet that is not the case for the non-gifted students. When the fluency indicator available in the problems was examined in terms of the descriptors, the fluency mostly emerged with the descriptor coded as FnC1, which was followed by the FnC3 code descriptor, meaning that students posed appropriate mathematical problems and could explicit most of these problems in a clear and understandable way.However, in terms of grade levels, neither of the groups standed out clearly for either of the two descriptors. Gifted students at the 7th grade level had higher scores than the others only in terms of the descriptor coded as FnC1. A similar finding is valid in the descriptor coded FnC3 except for G2. FnC2 was determined as the least identified descriptor in the problems posed by the students. While the related descriptor appeared only in the problems posed by G4 and G6, the problems posed by the non-gifted students were free from this descriptor. Therefore, the problems posed by the students were mostly those that require the direct use of familiar concepts and procedures. The problem with FnC2 indicator is presented as follows.

Figure 6

The problem related to G6 with FnC2 code


2-) Alınan uçakları kaç uçuş sonra satın alma maliyetini karşılar?

[Translation: How many flights will the aircraft meet the purchase cost?]

Since G6 asked the problem presented in Figure 6 by relating it to the previous problem, the previous stage of the problem cannot be seen in the figure. The student stated the problem of determining the number of aircraft and calculating the total profit amount for each aircraft type in the previous problem; therefore, he only asked how many flights these aircraft would cover the total amount of money spent for production based on the amount of profit. The solution of the problem requires the calculation of the number of planes that can be purchased with the budget, the amount of money spent for these planes, the total amount of profit from a single flight of these planes and the determination of the number of flights by dividing the total amount of money spent on the planes to the total amount of profit to be made in a single flight. Thereby, the solution of the problem requires the correlation between different variables such as aircraft production prices, profit and budget. The solution of this problem posed by G6 necessitates the development of different procedures rather than the direct use of familiar concepts and procedures, referring to the FnC2 code of the fluency indicator. In addition, considering that this descriptor addresses the development of new procedures based on familiar concepts and procedures, it is remarkable that this problem was established merely by the 8th grade gifted students. All the same, the descriptor coded as FnC4 were found more in the problems posed by the non-gifted students, which indicates that non-gifted students pose a problem by first solving the problem or organizing the data. Although no significant difference was noted across the grade levels in terms of this descriptor, it was relatively more common within the problems posed by the 8th grade non-gifted students.

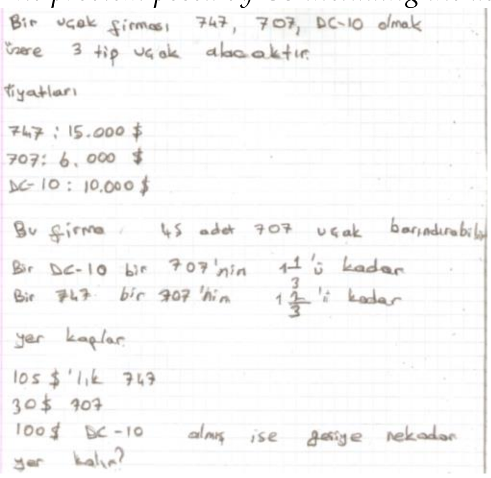
3.2. An Analysis of the Students' Creativity in terms of Flexibility Indicator

Considering the average scores of the indicators that emerged in the problems, the flexibility indicator had the second highest score for all students except for G1. Besides, most of the gifted students had higher flexibility scores than non-gifted students. Only G5's average flexibility score was below those of some non-gifted students (S3, S4 and S5). While G3 had the highest flexibility score, the lowest average belonged to S2. This signals that gifted students think more flexibly in problem-posing activities and that they pose different types of problems. As regards the flexibility scores in terms of grade levels, no clear difference was identified in both groups. However, one seventh grade student had the highest flexibility score among the gifted students, while it belonged to the 8th grade non-gifted student.

Upon examining the flexibility indicator within the context of the descriptors, the FxR3 coded descriptor came to the fore in the problems posed by most of the students. FxR3 had a higher score only in the problems posed by S1, S2 and S6. In addition, the FxR1 coded descriptor mostly had the second highest scores. Therefore, the flexibility indicator in the problems posed by the students was mostly observed in the form of posing problems for associating the variables with each other, which was followed by the problems focusing on different variables. Here is a problem posed by G3 including the descriptors FxR1 and FxR3.

Figure 7

The problem posed by G3 including the descriptors FxR1 and FxR3



[Translation: An aircraft company will purchase 3 types of aircraft 747, 707, DC-10. The price is as follows:
747: $15.000
707: $6.000
DC-10: $10.000
This firm can accommodate 45 707 modeled aircraft.DC-10 occupies $1\frac{1}{3}$ of 707, 747 occupies $2\frac{2}{3}$ of 707.]
If the firm bought 747 with $105, 707 with $30, DC-10 with $100, how much space would be left?]

With regard to the problem presented in Figure 7, the student posed a problem for calculating the number of aircraft that can be purchased with a certain budget for each type of aircraft and calculating the total area covered by them in the maintenance base, instead of asking the number of aircraft to be purchased directly and the areas they cover at the maintenance base. Therefore, this problem requires that the variables be associated with each other rather than using them directly, which represents the FxR3 coded descriptor of the flexibility indicator. What is more, the related problem includes the FxR1 coded descriptor, thus it belongs to a different category as it contains different variables from the problems that the student has created previously.

The least observed descriptor in the problems posed by the students was determined as the FxR4 coded descriptor, referring to the fact that the students posed few problems for the evaluation of the data in the scenario from different perspectives. Each descriptor is explored in detail as following.

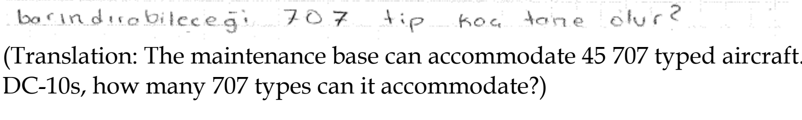
The FxR1 indicator represents to what extent the problems posed by students differed from each other. In other words, it explains the students' consideration of different variables in the problems they pose for problem-posing activity. This study revealed that the problems posed by the students were mostly gathered in four or five categories. Accordingly, G3 had the highest score, meaning that G3 mostly included problems in a variety of structures with different variables in the problems. Although the problems posed by S6 were grouped under eight different categories, the flexibility score was found to be lower compared to G3 and G1. Despite the use of different variables, this student used these variables in the problems with similar structures. S3 possessed the lowest score for the FxR1 coded descriptor. As is seen in Table 4, S3 had the lowest flexibility score despite having posed 21 problems, indicating that the student mostly focused on the same variables in the problems.

The FxR2 descriptor touches upon that students pose problems with more than one solution. This descriptor mostly emerges in the problems of the gifted students with higher scores. The 7th grade students in both groups held higher scores with reference to the FxR2 coded descriptor. Hence, gifted students were determined to use such problems with more than one solution. Similarly, these problems were mostly mentioned by the 7th grade students.

Considering the scores of *the FxR3 descriptor*, the gifted students were found to mostly have higher scores than the others. Only S3's score of the related descriptor was higher than the others and S4's score was higher than G5. Namely, the problems posed by the gifted students were of the type requiring more correlations between variables than others. Though the FxR3 coded descriptor mostly had higher scores in terms of the problems of the 7th grade students, neither of the groups came forward in terms of grade levels.

The FxR4 was the least observed descriptor that includes students' examination of the variables in the scenario according to various situations. Two gifted students and only one non-gifted student posed a problem that needed the examination of different situations. Taking the scores of G1 and G2 into account, this descriptor was found in both students' problems, however, G2 posed problems with the same structure, while G1 with different structures. The problem posed by G2 containing the FxR4 coded descriptor is presented below.

Figure 8
The problem posed by G2 containing the FxR4 coded descriptor

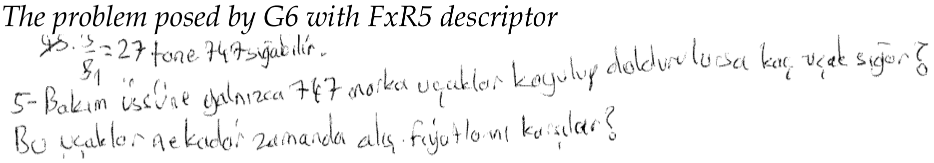

Bakım üssü 45 tane 707 tip barındırabiliyor.
Eğer bakım üssü 45 tane D.C. 10 barındırabilse
barındırabileceği 707 tip kaç tane olur?

(Translation: The maintenance base can accommodate 45 707 typed aircraft. If the maintenance base can accommodate 45 DC-10s, how many 707 types can it accommodate?)

When examining the problem presented in Figure 8, G2 had a different perspective and examined the number of aircraft that can be accommodated in case the area occupied by the maintenance base is different instead of using the information given in the scenario directly. G2 aimed at analysing the case when the capacity of the maintenance base is different, rather than directly asking about the area it will occupy in the maintenance base, which is a descriptor of the flexibility indicator (FxR4). Flexibility also arises in this problem as the solution requires interrelating the areas occupied by the aircraft at the maintenance base (FxR3).

The FxR5 descriptor is one of the least observed descriptors. Indeed, only one of the non-gifted students and three of the gifted students posed this type of problem. G6 had the highest score of the relevant descriptor. Given this descriptor expresses that students create a new problem by bringing a different perspective to the problems they have previously established, G6 had the highest score (40 points) although G4 had the highest number of problems (24.1 points). In this regard, it is evident that G4 created new problems by making a small difference to the problems that have been previously established, and that the problems G6 posed had a different structure based on the previous problems. Below is an example of the problem posed by G6 with this descriptor.

Figure 9
The problem posed by G6 with FxR5 descriptor



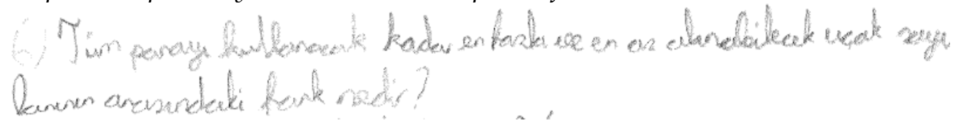
[Translation: How many planes will be in the maintenance base if only 747 planes are placed? How long does it take for these planes to meet the purchase prices?]

G6 established the problem in Figure 9 as a continuation of the previous problem. Moreover, the problem was similar to those that the student had previously created for the code "*Number of flights required to meet the purchase prices of the maximum number of aircraft that can be purchased with the budget*", still it differently focused on the number of aircraft that the maintenance base could accommodate rather than the budget variable. This shows that the student posed a new problem by adapting the previously established problem to a different situation, namely, s/he thinks flexibly (FxR5). Flexibility also arises when the problem is in a different category and the solution of the problem requires associations between variables (FxR1, FxR3).

3.3. An analysis of the students' creativity in terms of originality indicator

Table 4 depicts that the originality indicator had the lowest score for all students except for G1. The originality indicator had a higher score than the flexibility indicator for the problems posed only by G1. Besides, a significant difference was identified between gifted and non-gifted students in terms of originality indicator. In fact, the originality indicator was found in the problems of all students except for G5 among the gifted students, it was vice versa for the non-gifted. Particularly, only the problems posed by S3 had an indication of originality, meaning that gifted students posed more original problems than those who are non-gifted. As regards their grade levels, no clearly prominent group was noted for the gifted students. Nonetheless, the highest originality score belonged to the 7th grade gifted student. When the originality indicator was examined within the context of descriptors, originality emerged especially with the ON3 coded descriptor. While the ON2 descriptor was observed only in the problems posed by two students, the ON1 was not found in any student's problem. This clarifies that originality in the problems posed by the students arises when the problems contain original interpretations, and that original or unusual strategies are required to be developed in some problems posed by the two students. G1 had the highest score for both ON2 and ON3 descriptors. The ON3 descriptor emerged in 7 problems of both G1 and G4 coded gifted students. As can be understood from the scores, all of the problems that G1 posed are of a different nature, while two of the problems posed by G4 had a different structure, and five of which had a similar structure and contained a minor differences. The same is true for the descriptor coded ON2. The scores suggested that the ON2 coded descriptor appeared in 3 problems of G1 and 6 of G4, yet G1 got a higher score due to the different structure of the problems. Below is an example of an original problem posed by G1.

Figure 10
The problem posed by G1 with the descriptors of ON2 and ON3



(What is the difference between the maximum and minimum number of planes that can be bought through using all money?)

G1 attempted to find the minimum and maximum number of aircraft that can be purchased with the entire budget in this problem. The solution of the problem also is grounded on making a correlation between the production prices of the aircraft and the budget, which requires the use of reasoning and a unique strategy that the minimum number of aircraft can be purchased if they are purchased from the aircraft with the highest price, and the maximum number of aircraft can be purchased in the opposite case (ON2). In addition, the related problem was created only by G1 and that the problem is unique according to the student's own age group considering the condition of completing the entire budget (ON3).

3.4. An Analysis of the Students' Creativity in terms of General Creativity Scores

Upon analysing Table 4 in terms of the students' total creativity scores, the majority of the gifted students were determined to have higher scores than the non-gifted students. Of all the non-gifted students, only S3 and S4's creativity scores were higher than some gifted students (G4 and G5). While G1 had the highest creativity score, S2 had the lowest. In relation to the students' total creativity scores in terms of their grades, the 7th grade gifted students were found to have higher scores than the 8th graders. However, this is not the case for the non-gifted students. In plain English, the 8th grade S4 had highest creativity score followed by the 7th grade S3.

4. Discussion and Conclusion

This section covers the findings related to the general creativity and the scores obtained by each indicator of creativity from the problems that gifted and non-gifted students posed within the context of problem-posing activity.

4.1. Students' Problem-Posing Creativity in terms of General Creativity Scores

The results revealed that most of the gifted students were more creative in problem-posing activities than non-gifted students. Upon examining the relevant literature, similar results emerged in most studies, indicating that gifted students are more creative than non-gifted peers (Kattou et al., 2011; Leikin, 2009; Leikin & Lev, 2007; Leikin & Lev, 2013). Kattou et al. (2011) conducted a study on comparing the creativity of the gifted and non-gifted students in mathematics with multiple production activities; as a result, they concluded that the students in both groups were able to produce more than one solution for the multiple solution activities; however, gifted students were more creative than non-gifted students and produced more correct answers in which more qualified mathematical ideas were integrated. Likewise, Leikin and Lev (2007) attempted to examine the creativity of the gifted and non-gifted students in mathematics with multiple solution activities and determined that the creativity of the gifted students was higher than non-gifted students with high academic achievement, and the creativity of students with high achievement was higher than those with normal attainment. However, the present study suggested that some non-gifted students were much more creative than the gifted, which may be due to individual differences. In other words, the lower creativity scores of some gifted students than the others may be because these students are academically superior but not creatively gifted as Haavold (2013) pointed out. Haavold (2013) stated that gifted students are also divided into two as gifted in terms of academic and creativity and that academic superiors are not always superior in terms of creativity, yet creative superiors are also academically superior. Besides, this may arise from the perceptions of the teachers working in SACs with gifted students since the students in the working group are enrolled in different SACs, and that most of the students in SAC, where the gifted students' total creativity score in mathematics is lower than the others, are evaluated as gifted in mathematics. While the number of the gifted students in mathematics is 6 in one of the SACs, that of the gifted students in mathematics is 30 in SAC which includes the student with a lower creativity score in mathematics. The fact that the number of students with special talents is so high may be because the teachers working in this SAC perceive every academically gifted student as gifted in mathematics. However, students can be creative in various domains, but this does not mean that they are creative in mathematics (Yıldız & Baltacı, 2018).Therefore, this study assumes that the gifted student with a lower total mathematics creativity score than the others may be the one who is academically superior but not gifted in the mathematical creativity.

The results also demonstrated that most of the non-gifted students attached more importance to the number of problems than the structure and nature of the problem. Indeed, the interviews with the students affirmed this view with such a statement "The more, the better.". This result is congruent with those in the relevant literature. Kattou et al. (2011) stated that non-gifted students focused only on the visual features of the problem and cannot see the deep structures of mathematical concepts; whereas, gifted students tended to seek deeper and more complex relationships beyond the superficial nature of the activities.

The results of the current study confirmed that the gifted students at the 7th grade level (except for G2) had higher creativity in problem-posing scores than the 8th graders. Given that the students learn more concepts and experience more different types of problems and activities as the grade level increases, they are expected to produce more creative solutions to the activities. However, the opposite is valid in this study. Akgül (2014) carried out a study with the gifted students and concluded that the creativity of the 5th grade students in mathematics was significantly lower than that of all the 6th, 7th and 8th graders, but no significant difference was noted across the other grade levels. Therefore, this result is partially in conjunction with those obtained by Akgül, yet contradicting with the results of the studies conducted by Tekin and Karasu (2007, as cited in Taşkın, 2016) and Haavold (2013). No clear difference was identified across the total mathematical creativity scores of the non-gifted students in terms of their grade levels. This may be related to the period in which the implementation was conducted as the actual implementation was carried out in the second semester of the academic year, and that especially the 8th grade students focused on the Transition from Basic Education to Secondary Education [TEOG] exam, which is used for transition to secondary education in Turkey and which 8th grade students attend. It has been noticed that they do not want to deal with it and spend time on it. Considering that motivation triggers the students' productivity and potential (Budak, 2007) and contributes significantly to the birth of talent (Gagne, 1985; Renzulli, 1999); some 8th grade students who are preparing for TEOG are thought to perform below their normal performance and that their lack of motivation may prevent their creative abilities in mathematics. Similarly, Mann's (2005) reported that a certain level of attention is required for the birth of creativity.

4.2. Students' Creativity in Problem-posing in terms of Fluency Indicator

The average scores of the indicators (fluency, flexibility and originality) suggested that the fluency indicator had the highest score. It may be wise to mention that the fluency indicator had the greatest effect on students' mathematical creativity scores, referring that students developed appropriate strategies and used concepts and procedures. However, they were determined to make fewer attempts to pose unique problems that required the development of different strategies as well as the use of different concepts and procedures. This result is consistent with that of Ersoy and Başer (2009). They concluded that the average of the 6th grade primary school students' fluency levels was higher than that of flexibility and originality levels; moreover, the students showed their ability to produce a large number of ideas, but could not use them in terms of coping with the different aspects of events.

No significant difference was noted across the gifted and non-gifted students' creativity in terms of fluency. Both groups included the students with high and low scores. While the 7th grade gifted student had the highest fluency score, the 8th grade non-gifted student had the lowest. Therefore, students in both groups were found to develop and apply appropriate mathematical concepts and procedures and that they posed problems that require the use of these concepts and procedures. This result is not extraordinary as the working group consists of those who are gifted or academically successful. The relevant literature (Akgül, 2014; Kıymaz, 2009) affirmed that all students above the average are successful in producing mathematical ideas. Nevertheless, this result is not similar to the differentiation between the general creativity scores of the students. The average scores of the indicators suggested that flexibility and originality indicators are more effective in the differentiation between the creativity scores of the students. In other words, the differentiation among groups resulted from the diversity and originality of the ideas. Most of the studies indicated that the fluency indicator is mostly scored to express only the number of ideas put forward (Akgül, 2014; Balka, 1974; Haavold, 2013; Kıymaz, 2009; Tekin & Karasu, 2007). Besides, a variety of researchers stated that fluency indicator is less effective in determining creativity than flexibility and originality indicators (Leikin & Lev, 2013), and lower scores can be assigned to this indicator (Shiriki, 2013). Thus, this study employed a different scoring system to prevent problems with similar structures from being equally effective in problem-posing activity. The deficiency expressed by the scoring system was obstructed to a great extent and the problems posed by the students could be evaluated qualitatively.

Another result of the present study showed that the gifted students at the 7th grade had higher scores than those at the 8th grade, but a similar case was not clearly observed for the non-gifted students. The study also revealed high and low scores in terms of fluency indicator for students at both grade levels. Given that the fluency indicator is related to the number of ideas produced by the students; 7th grade gifted students were noted to put forward more mathematical ideas than the 8th graders, while no significant difference was identified across their grade levels in terms of the number of ideas and the problems non-gifted students put forward. This result regarding the fluency indicator is in parallel with the students' general creativity scores in mathematics. However, the number of ideas that students put forward, namely, their fluency scores was expected to increase due to the increase in their knowledge level as the grade level increases, whereas the opposite result was found in the present study. This result is in contradiction with those of the study conducted by Leikin and Kloss (2011) with the 8th and 10th grade students. The reason, as stated before, may be because this study was conducted in the second semester of the academic year, and the 8th grade students are not motivated enough as they prepared for TEOG, and hence they gave the right answer as soon as possible to complete the activity rather than generating more ideas.

Fluency in problem-posing activity emerged especially in terms of posing appropriate problems and secondly, expressing problem sentences clearly and comprehensibly (See Table 4). On the other, the students were determined to pose quite a few problems by organizing data and requiring the discovery of mathematical concepts and procedures in problem-posing activity. It emerged at the least level in terms of discovering appropriate procedures and organizing data, meaning that students used mathematical concepts appropriately and could explain their solutions with appropriate expressions, but they fell short in posing problems that require the development of different strategies based on familiar concepts and procedures. The ability of the gifted students to pose appropriate problem statements that require the use of appropriate mathematical concepts and procedures is in line with the result of Amaral and Carreira (2012). This may be due to the fact that they present problems that require the use of more familiar concepts and procedures in the curriculum, and in parallel, teachers include such activities in schools (Özmen et al., 2012). Likewise, Özmen et al. (2012) reported that the teachers used the questions in the source books without any special preparation and that they used the short problems that do not contain much numerical data more frequently in their lessons.

4.3. Students' Creativity in Mathematics in terms of Flexibility Indicator

The flexibility was determined as the second most prominent indicator. The results highlighted that the gifted students had higher scores than the other students in problem-posing activity (except for G5) in terms of flexibility indicator. On analysing the students' flexibility scores in the problem-posing activity within the context of the descriptors, the FxR3 coded descriptor was identified to have the most significant difference across the groups. All gifted students had a score of 40 and above for the FxR3 code descriptor except for G5, while one student had a score above 40. The FxR3 coded descriptor refers to the problems that require variables to be associated with each other. Therefore, it is remarkable that gifted students attached more importance to problem-posing that requires correlation between variables rather than independent operations for different variables. Most of the non-gifted students posed problems that require either the use of a single variable or these variables, which require independent operations even if they use different variables. This may be because gifted students perceive such problems as more difficult. It is also most likely that gifted students think more flexible than the others considering the problems that students pose are related to their thinking skills.

The students in both groups were determined to take into account different variables within the scope of problem-posing activity and tended to pose problems involving different variables. Upon analysing the scores of the students for the FxR1 coded descriptor, only the problems posed by a non-gifted student (S3) were grouped under 3 categories, and those posed by other students were divided into 4 to 8 categories. Even if the students took into consideration different variables in the context of the flexibility indicator just as the fluency indicator, they still used these variables in problems with a similar structure to the previous problems. No difference was noted across grade levels in terms of the flexibility indicator, which is opposed to the result obtained from the students' general creativity. A significant difference was identified across the students' general creativity in mathematics for both activities in favour of the 7th grade students. In line with Haavold's (2013) study, it is likely that the flexibility indicator has less effect on students' general creativity scores in mathematics.

4.4. Students' Creativity in Mathematics in terms of Originality Indicator

The originality indicator was the least determined indicator in the problems posed by both the gifted students and the others. Therefore, it is evident that the originality indicator generally has the least ratio on creativity scores. Various researchers (Amaral & Carreira, 2012; Haavold, 2013; Haylock, 1987; Leikin, 2009) implicated that creativity is the most decisive indicator in terms of difference across groups. In fact, there was no indication of originality in the problems posed by only one of the gifted students, while only one non-gifted student posed original problems. Although similar results were obtained for other indicators, the differences in the other indicators were not as evident as in the originality indicator. Thus, it is most probable that gifted students mostly differed from the others in terms of originality indicators, namely, they posed more original problems. Similar results emerged in the studies conducted by many researchers (Leikin, 2009; Leikin & Lev, 2013; Kattou et al., 2011). Kattou et al. (2011) emphasized that gifted and non-gifted students could spark different suitable solutions, yet gifted students suggested more correct answers containing more advanced mathematical ideas and developed ideas that were more effective and original than their peers.

This study endorsed that the originality indicator mostly emerges in the form of posing a problem by making different interpretations regarding the existing data. ON1 indicator was not observed in the current study, which may raise the question of why this indicator was taken into consideration. As stated in the method section, the theoretical framework was constructed together with the pilot study and the actual implementation. Therefore, the relevant code represents a behaviour observed in the pilot study. Despite unobserved in actual implementation, there is still the possibility that the theoretical framework can be used in different problem-posing activities and the relevant code may emerge in different problem-posing activities or in different samples. Hence, the relevant code has not been removed from the theoretical framework. This result is not in accordance with that of Amaral and Carreira (2012). The originality emerged mostly with the use of schemas. This difference is thought to be related to the type of activity used in the study. Indeed, Amaral and Carreira (2012) deployed problem-solving activity in their study, while this study used problem-posing activity.

Last but not least, this study examined as to whether the creativity of the students in mathematics varied across their grade levels in terms of originality and determined that the 7th grade students came to the fore for gifted students. This is not the case for non-gifted students except for one student. This result is inconsistent with Haavold's (2013) study. Haavold (2013) reported that upper-class students produced more original solutions. The similarity between grade levels in terms of the originality indicator of the non-gifted students stems from the fact that none of the students except one student poses an original problem. This may be because non-gifted students are not familiar with the problem-posing activity used in this study. Haavold (2013) stated that problem-posing is the least understood and most overlooked part of creativity in mathematics. Similarly, showing more interest in problem-solving rather than problem-posing both in schools and in different studies may cause students to have less experience with problem-posing activities and thus thinking more confinedly.

5. Limitations and Future Directions

Based upon the research findings, some suggestions were recommended. First, the relevant literature suggests that problem-solving activities are mostly used to determine the creativity of both the gifted and non-gifted students in mathematics. However, this study revealed that problem-posing activity played a significant role in determining the difference between the creativity of the gifted and non-gifted students in mathematics. Thus, it is recommended to conduct more research on problem-posing activities in the tests developed to identify gifted students and determine their creativity. Second, the results of the study suggested that gifted students in mathematics were more creative in problem-posing than their peers who were non-gifted. Given that students are more familiar with problem-solving activities than problem-posing, it is most likely that gifted students are able to think more creatively and produce more creative solutions when they encounter different types of activities than their non-gifted peers do. Therefore, the use of different activities, which students are less familiar with, is expected to be more effective in revealing the difference across the creativity of the gifted and non-gifted students in mathematics. Third, the study results also indicated that creativity in mathematics emerged mostly in terms of fluency and least in terms of originality. Referring that students are able to produce appropriate mathematical ideas, but are less successful in generating original ideas, this result may result from the deficiencies in teachers' classroom practices. Thus, mathematics teachers working in both SACs and secondary schools affiliated to the Ministry of National Education should include different activities related to daily life, open-ended activities that will allow them to spark original ideas, as well as problems that require students to directly tell the result and put forward ideas, which is thought to improve their original thinking. Last but not least, the fluency indicator was identified to be most evident in the use of appropriate mathematical concepts and the clear and concise presentation of the procedures used to solve the problem (appropriate use of mathematical language). Fluency has emerged at least in the form of communicating through the discovery of new procedures and organizing data based on familiar concepts and procedures. This may be because students were provided with problem-solving and posing opportunities that required the direct use of familiar mathematical concepts and procedures, and that students were not faced with the activities that provided an opportunity to explore new procedures. Hence, it is recommended that teachers offer students a chance to engage in different kinds of activities in which they can discover new procedures based on these concepts and procedures, rather than the direct use of familiar concepts and procedures in their classroom practices.

Based upon the research results, the following recommendations may be provided for future studies research. First, further studies may focus on different types of activities and examine how students' creativity in mathematics differs across these activities. In addition, the number of activities may be increased and the study may analyse how effective the activity is in revealing students' creativity, and whether students' creativity in mathematics varies across different applications of the same activity type. Studies may be carried out with similar applications on how effective these activities are in revealing the difference between the creativity of the gifted and non-gifted students in mathematics. Second, further studies may also analyse whether the students' creativity varies across situations with or without the condition of solving the problems they posed, and thus it can be examined whether solving the problem they pose has an effect on their problem-posing. Third, in the present study, the students realized the solutions of the activities only during the clinical interviews in the pilot study phase, while they were allowed to work in the time period they wanted in order to produce more comfortable solutions, and the clinical interviews were conducted over the solutions that the students had previously realized in the actual implementation. This practice is effective in helping students think creatively, generate different and original ideas. Therefore, giving students a chance for spending time on the activities on their own to determine their creativity is expected to provide an opportunity for them to come up with more creative solutions.

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