Tracking down gifted students’ creative thinking in solving mathematics problems

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Abstract. Gifted students have unique and diverse traits. Most of them are easily identified when they do things differently and enjoy solving problems. The uniqueness of ideas they propose is essential to be explored. Particularly in Mathematics, gifted students usually come up with novel ideas in accomplishing problems. Therefore, this study is aimed to know the gifted students creative thinking in solving Relation and Function problem. This qualitative research conducted in one of private schools in Makassar, South Sulawesi, Indonesia by taking the gifted students from the eighth grade. There were two gifted students chosen to participate in this study. The research was carried out using several stages. First, the researchers established an instrument in a test form and gave it to the teacher in the school who wanted to test the gifted students. Problems in the test were in accordance with the indicator of creative thinking which consisted of fluency, flexibility, originality, and elaboration. Furthermore, students solved the problems and wrote it in the students work paper. Teacher would do a brief interview with the participants related to the answers in the work paper. After that, the researchers executed the data and analyzed it. Lastly, the results of analyzing data were presented in the form of writing description. As a result, four problems were solved by the gifted students. Although solutions of two problems were more likely similar, the remaining solution problems were vary. Overall, both of students are able to solve all the questions which means that the gifted students meet all the indicators of creative thinking in solving problems. They are creative in using multifaceted ways in delivering answer.

1. Introduction

Being gifted is a general intellectual potential that individuals take for granted and thrived as an optimization of individuals' talent [1, 2]. Issues and debates on how to focus on gifted students is now considered by numerous numbers of educational experts around the globe. They become more interested in the mind which gifted individuals have. Yet, many studies have been conducted on giftedness and gifted education program. However, some teachers, especially in Indonesia, seemingly do not take giftedness as an essential consideration in the educational system of their country. This is due to the fact that program of gifted education counted almost never in Indonesia. Beside that, many teachers also have less much concern on their gifted students in school.

It is still a questioning on why we have to look at the students’ giftedness? Actually, there is no certain criteria to point out individual who has giftedness. However, some practitioners say that recognition of achieving unique accomplishment and creative contributions in terms of above-average ability, task commitment, and creativity are the traits of being gifted person [3]. Those three aspects become important to see whether students are gifted or not. First aspect is related to the effort of students in performing their ability which peak about one-third of the top representative percentage.
Second aspect can be linked to students’ motivation in working or solving problem where the motivation tends to several specific commitments such as persistence, resistance, and self-confidence [3]. The third aspect is creativity as a mental process which can produce novelty and variety of solution toward certain given problems [4]. Beside the mentioned criteria, Gagne proposed the meaning of giftedness as the students’ key potential to succeed at a level significantly beyond age-peers [5]. In school, giftedness is coming from students who are capable of expressing novel solution or new way to solve the problem being given [6]. According to the elucidation above, giftedness in this paper is related to the ability of students at the above average of their school mates which show unique ways in solving mathematics problems.

Students categorized as gifted are pivotal to be investigated because they solve the mathematics problem differentiate from other students. It leads to a sustainable creative idea or solution in which, in a broad domain, can be useful to tackle the problems in this and the next century ahead. Furthermore, Krutetskii highlighted that gifted students are able to see the world through the mathematical lens where the students can taking generalization rapidly to the broad mathematical relations, operations, and flexibility of mental processes [7]. In addition, gifted students are expected to be the leader who are able to either leading for innovation in vary ways on all fronts of human endeavor [3].

According to the nature of giftedness, creativity is the most common aspect often appears as an integral part of being gifted individual. Giving advanced thinking process, such as creative thinking skill, to gifted students is of great importance because of the relation between giftedness and creativity cannot be separated [8]. Humans require creativity, originality, flexibility, complex problem-solving and other soft skills in order to maintain the longlife span with the use of technology in the following years and to fulfill the demand for future employment [9]. By considering the gifted students creativity in accomplishing problems, teachers will enable to flourish another creative gifted students who can take over the challenges in the future. A considerable number of literatures have been published on studying students creative thinking skills in solving mathematics problems [10, 11, 12, 13], but when considered the context of gifted students alongside specific mathematics subject like Relation and Function, it is still unavailable. Therefore, it is imperative to know how gifted students solving its Mathematics problems in order to shed light on broaden thought about creative thinking of gifted students in grasping with mathematics problem.

To notice the creative thinking of gifted students in working with mathematics problem, four indicators elucidated by Munandar which are utilized as fluency, flexibility, originality, and elaboration [14]. Fluency indicator is based on how students are able to cause varying ideas, many answers, different ways of solving problem; propose questions directly; and thinking out of one solution. Indicator of flexibility related to how students can produce opinion, answer or different questions; see problem from another point of view; search for several alternative ways from different path; and change the conceptual thought or approach. Moreover, originality indicator can be seen if students are able to promote new and unique expressions; can ponder about unusual way; can create innovative combination from some separated parts. Lastly, elaboration emerged when students can enrich and develop an opinion or product; can enhance or give details from object, idea, or situation so as problem will be more attractive.

2. Method
The method applied in this study was descriptive qualitative research which was administered in one of private schools in Makassar, South Sulawesi, Indonesia. The school utilized Singapore curriculum program in the process of teaching. There were two eighth grade gifted students participated in this research. Both subjects were chosen due to their higher ability in solving mathematics problems among other students in the eighth grade.

In relation to the data collection procedures, several steps were completed. First, students got a test which consisted of four Relation and Function problems reflecting the creative thinking indicators shown in the Table 1. Two problems of the test were taken from an interesting book [15] and the remaining problems were adapted from the site popular on the internet about creative thinking on mathematics education. In this case, testing was conducted when the students had been taught about
Relation and Function. The interview in this study was done by the teacher as the students felt more communicative to explain their answer to their teacher instead of answering the researchers’ questions. After obtaining the students answers, the teacher did a brief interview with her students regarding on the answer which students made. Moreover, the students’ answer and the result of the interview were analyzed and presented in the form of research results.

| Creative Thinking Indicators | Problems |
|-----------------------------|----------|
| Fluency                     | 1. Write two similarities and two differences between one-to-one correspondence function and not one-to-one correspondence function. Give your explanation. |
| Flexibility                 | 2. Aisyah’s time reading hour at night in a week are as the following table: |
| Originality                 | 3. If \( f(1) = 9 \) and \( f(x+1) = 3 \cdot f(x) \), then determine the value of \( f(2018) \) |
| Elaboration                 | 4. Ali pays $155 dollars in advance on his account at the health club. Each time he visits the club, $4 is deducted from the account. Write an equation that represents the value remaining in his account after \( x \) visits. Find the value remaining in the account after 16 visits. |

3. Results and Discussions
Regarding the tests which were given to the two gifted students, the researchers obtained results as well as discussions elucidated in the following descriptions.

3.1 Gifted Students’ Responses for the Fluency Indicator
The first problem was proposed to see the gifted students’ creative thinking in the indicator of fluency. The Figure 1 and 2 are the representations of students’ writing as a result of responses to the question.

![Figure 1](image-url)  
**Figure 1.** The first gifted student’s answer on the problem 1
Both gifted participants showed answers more likely to be the same between one to another. They illustrated the similarities and the differences with ideas which was almost identical. However, we found that they utilized a different term in defining one-to-one correspondence function. The first gifted student used bijection function, while the second still employed one-to-one correspondence function which appears in the sentence of the problem 1. From the students’ response, we found that the gifted students were able to express various ways in presenting their answer. This is in line with the fluidity indicator outlined by Munandar [15].

3.2 Gifted Students’ Responses for the Flexibility Indicator

The second indicator of creative thinking is flexibility that is related to the second problem. According to the gifted students’ answers, students already met the flexibility indicator. They were able to construct another problem which was relevant to the subsequent problem. Both of gifted students drew appropriate questions and answers toward the second problem. The following Figure 3 and 4 are the capture of the gifted students’ responses.

Taking a closer look at the figures above, we found that students could think creatively in solving the first problem which meant that the flexibility indicator has been fulfilled. However, there are different level of creativity which students have. One of them were able to have a higher level of creative thinking than another. The level of creativity is vary, but from the researchers perspectives, the first student is more creative than another in terms of associating cognitive knowledge fluently. She constructed a question like in the Figure 3 by making relation between the day and the number of hours counted with the concept of function correspondence.

On the other hand, the second student showed a slight different answer compare to the first student. Although she drew mapping which was attractive, we still categorized her as less creative. This is because she only show us about his knowledge of domain and co-domain which is a very basic knowledge that should be understood in learning the subject of Relation and Function.
3.3 Gifted Students’ Responses for the Originality Indicator

Turning to the third indicator on students creative thinking, the originality of the gifted participants was elaborated by using a non-routine problem which already had been discussed with their teacher in advance of giving the test. The gifted subjects responses were compatible with the researchers prediction. They were able to accomplish the asking problem by determining pattern in which leading them into the final answer. Both students evidenced their originality as one of creative thinking indicators.

Based on the teacher interview with the respondents, we found that the gifted students were facing trouble in the problem 3 which appealed as unfamiliar type of questions in students mind. The students complained about the answer that would be too much in counting. Thus, they were confused on how to write the answer precisely. The first gifted student even wrote the ‘question mark’ in her work, shown in the Figure 5. It illustrated that she got cognitive conflict in her mind on how to finish the answer. Meanwhile, the other student was already optimistic with her answer, presented in the Figure 6.

Cognitive conflict in the first student mind appears due to a lack of interconnection between prior knowledge with new concept that has been taught which is possible to lead the students undergo a conceptual change [16]. Teacher said that the first participant feels her answer was not finished yet. In accordance with it, the researchers narrow down a conclusion that the first student was creative but having a little trouble on calculating the solution. The students might be think that the solution should be as a whole, not breaking into whole number and exponential number.

The following scripts of a brief interview between teacher and the first gifted student underpin how the gifted student was unbelieve with her finding.

Teacher: Why you write a question mark in this solution? [teacher was pointing the mark on the student’s paper]
The first student: I got a problem mam since I could not calculate the answer without using calculator.
Teacher: No, you did not need it. I thought your answer was correct.
The first student: Oh really! Just until this mam? (pointing the solution $f(2018) = 3^{2017} \cdot 9$)
Teacher: Yes, of course.
The first student: I am happy for that.

![Figure 5](image5.png) The first gifted student’s answer on the problem 3

![Figure 6](image6.png) The second gifted student’s answer on the problem 3

3.4 Gifted Students’ Responses for the Elaboration Indicator

The last indicator of creative thinking is elaboration which contains in the problem 4. The gifted students were expected to show their elaboration by developing information known in the question and using it to elaborate the next solution. The participants’ response were completely similar, except the ways of writing numbers on the multiplication part. Their answers in the figure 7 and figure 8 depicted that they literally understood the word problem being given as well as the ways of solving it step by
step. In this problem, the elaboration indicator were achieved by the participants without having any doubts.

\[ f (x) = 185 - 4x \]
\[ f (4) = 185 - 16 \cdot 4 = 185 - 64 = 91\]

So, after 16 visits, Ali has \$91 in his account.

**Figure 7** The first gifted student’s answer on the problem 4

\[ f(x) = 195 - 9x \]
\[ f(6) = 195 - 9(6) = 195 - 54 = 141 \]

So, \$141 money after 6 visits is \$141.

**Figure 8** The second gifted student’s answer on the problem 4

4. Conclusion
To sum up, all four indicators of creative thinking have been fulfilled by the gifted students in solving Relation and Function problem. Although the results and discussions are merely very inadequate to track the ways of gifted students in solving mathematics problem, some findings conclude that the gifted students think creatively in searching for a way delivering answer, study the mathematics pattern, also find and generalize mathematics solution. Teacher has to ponder it as a learning in order to deliver more advance instructions to boost other students creativity. Henceforth, the researchers suggest the prospective study to re-look at more detailed about the ways of gifted students creative thinking in solving mathematics problem. It is proper to use challenging problem so as to trigger the occurrence of the gifted students creativity. Beside that, the further research should amplify the testing of categorizing students as gifted since it becomes a paucity in this study.

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