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MAGIC FORMS AND THE MATHEMATICAL CREATIVE THINKING ABILITY OF SECONDARY SCHOOL STUDENTS

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ABSTRACT

A growing body of literature has shown that mathematics learning is expected to facilitate students to develop creative thinking abilities. In reality, students' creative thinking abilities are not fully accommodated through mathematics learning. Therefore, this research aims to explore middle school students' mathematical creative thinking abilities based on learning experiences with Magic Forms. This qualitative research with an explorative approach focuses on the participation of three class VII students at a state junior high school in Jakarta (MA, LS, and YC). Data collection techniques used in this study were learning outcomes tests and interviews. Data analysis techniques in this study used data reduction, data presentation, and drawing conclusions. Based on the results of the study, it was found that: MA meets the four indicators of mathematical creative thinking ability, MA felt helped by the experience of learning with Magic Forms and challenged by the experience of working on the ability to think creatively. LS met the four indicators of mathematical creative thinking ability, LS also felt helped by the experience of learning with Magic Forms and amazed by the experience of working on the ability to think creatively. YC met the four indicators of mathematical creative thinking ability, for the subject's authenticity indicator reached a percentage of 68.75% (higher indicator). Moreover, YC did not feel helped by the experience of learning with Magic Forms and was confused by the experience of working on the ability to think creatively.

Keywords: Magic Forms, Mathematics Creative Thinking, Qualitative

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PRELIMINARY

Mathematics is a universal knowledge and plays a major role in the development of science, technology, and information. For this reason, the purpose of studying mathematics is to develop thinking skills, one of which is the ability to think creatively (Apriza, 2019; Hasratuddin, 2014; Sholehah et al., 2018; Sukendraa & Sumandya, 2020). Thus, mathematics learning is expected to be able to accommodate the growth and development of students' mathematical creative thinking skills. This is in line with what was stated by Arvyati et al. (2015) that the process of learning mathematics is the first step that needs to be considered in an effort to cultivate mathematical creative thinking skills.

However, several findings state that mathematics learning in secondary schools mostly only provides understanding, concepts and explaining theories (Arini, 2017; Österman & Bråting, 2019), formulas or quick ways to make it easier to answer the practice questions given (Azhari & Somakim, 2014; Jonsson et al., 2014), providing procedural memorization (Hormadia & Putra, 2021; Jonsson et al., 2014), as well as developing skills in carrying out arithmetic operations, or solving abstract problems that are not related to reality (Aladwan et al., 2023; Saidah, Dwijanto, 2020). The whole process does not contribute to the growth and development of middle school students' mathematical creative thinking abilities.

The mathematics learning conditions mentioned above have a clear impact on the condition of secondary school students' creative thinking abilities which are not yet optimal. This is in line with what was stated by Kadir et al. (2022) which states that secondary school students lack creative thinking. Then the undeniable fact can also be seen from the TIMSS (Trends in International Mathematics and Science Study) scores which always show that the majority of Indonesian students cannot do category questions that *high* and *advance* which requires creative thinking skills (Budiwiguna et al., 2022; Ismara & Halini, 2021; Prastyo, 2020; Utami & Kunaeni, 2016).

The efforts to develop creative thinking skills are not an easy task. It requires serious and continuous coaching (Amidi & Zahid, 2016). One effort intended to stimulate student creativity is by using manipulative media as teaching aids or learning aids (Bergeson, 2000; Rahmani & Widyasari, 2017; Sari & Manurung, 2021).

Manipulative media is media that is used to represent objects or events with various kinds of changes (manipulation) according to needs, for example changing the size, speed, color, and the presentation can also be repeated (Anawati & Isnaningrum, 2020; Noryati, 2014; Saefudin, 2012). Manipulative media (materials) function to simplify difficult or difficult concepts, present relatively abstract material, to make it more real, explain meaning or concepts more concretely, explain certain properties related to calculating and the properties of geometric shapes. (Namukasa et al., 2009; Tran et al., 2017). Several studies state that manipulative media is an effort to improve students' creative mathematical thinking abilities (Listrianti et al., 2022; Palupi, 2021). One of the media that is expected to stimulate the development of students' creative mathematical thinking abilities is magic forms.

Magic forms What was designed was a mixture of massive spatial construction props, spatial framework props and transparent spatial props which aims to facilitate understanding of the basic forms of spatial construction. Magic forms is a modification of previously existing geometric teaching aids such as those used by Fitrianti et al., (2020); Meilanda et al. (2022); Meryyani (2003); Sintawati et al. (2020) which has been used in previous studies.

Research related to the use of geometric learning aids or teaching aids has indeed been widely used (Fitrianti et al., 2020; Hidayah et al., 2020; Isnaniah & Imamuddin, 2020; Meryyani, 2003; Sintawati et al., 2020), but research related to the use of the magic forms also has novelty. Firstly, because magic forms themselves are new teaching aids, that is, they are a combination or mixture of several types of geometric props. Secondly, the use of magic forms or learning experience with magic forms also associated with the mathematical creative thinking abilities of middle school students.

Thus, this research aims to examine in depth how middle school students' creative thinking abilities are based on learning experiences using magic forms. Furthermore, this study is important as initial research to build the mathematical creative thinking abilities of mathematical middle school students so that based on the research findings later, appropriate learning models can also be designed to facilitate the maximum development of mathematical creative thinking abilities.

METHODS

This research examines in depth how middle school students' creative thinking abilities are based on learning experiences using magic forms. To explore the research objectives, a qualitative study was used in this research as stated by Kumar.R & James (2015). The approach used in this research is an exploratory descriptive approach. This approach allows the use of data in the form of student expressions in completing mathematical creative thinking tests. Questions addressed to research participants are open and investigative because research participants will have the opportunity to respond using their own answers or language (Alwadai, 2014).

This research was conducted at one of the state junior high schools in DKI Jakarta. The reason is, at this school there are research participants who learn using assistive devices of Magic Forms and in this school there has been no research regarding students' mathematical creative thinking abilities based on learning experiences with the Magic Forms. The participants in this research were three middle school students in class VIII.

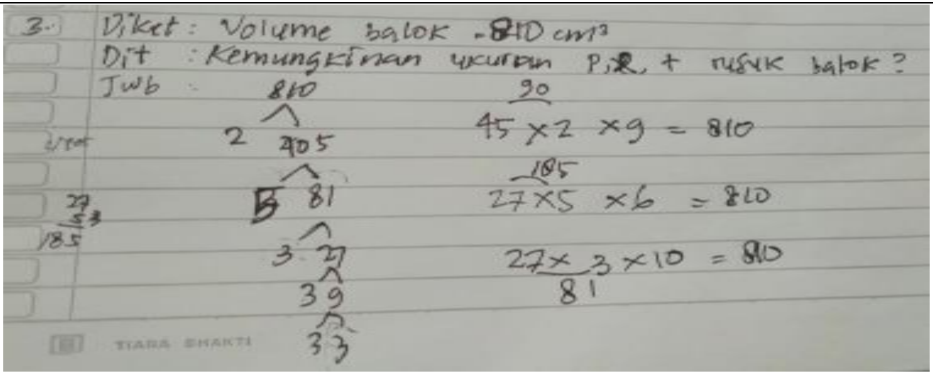
Data collection in this research was carried out in several ways, first by testing creative thinking abilities. This test contains 4 descriptive questions which are carried out to determine students' mathematical creative thinking abilities based on learning experiences with magic forms. Second, interviews were also held to confirm students' answers during the test and explore student responses related to mathematical creative thinking abilities and learning experiences with the Magic Forms and experience working on mathematical creative thinking skills.

A total of one class of class VII students at a State Middle School in the City of Jakarta studied using magic forms teaching aids and took a well-validated mathematical creative thinking ability test. The next step, the researcher selected three students based on input from the class teacher to become participants in this research. The selected participants came from a variety of score ranges and the students selected were students who could cooperate and were suitable to be research subjects, which that students who expressed willingness and had a communicative attitude. The answers from these three students will be studied in more depth in the discussion section of this research. Once research participants are selected, interviews are conducted to confirm their written answers. The interview lasted 45 to 60 minutes. Interviews were recorded and transcribed. Since the researcher is the main research instrument, The researcher then analyzed the students' work independently. The next step is data triangulation by comparing the results of written tests on students' mathematical creative thinking abilities with the answers at the time of the interview. The researcher ended the research data analysis process marked by drawing conclusions from the research findings based on the triangulation process.

RESULT AND DISCUSSION

The following are some research results that have been documented. The results will be presented sequentially for the three research participants. In the mathematical creative thinking test, one of the questions and the answer was :

Sebuah balok memiliki volume 810 cm^3 carilah kemungkinan – kemungkinan ukuran Panjang, lebar dan tinggi rusuk balok tersebut, minimal tiga ukuran yang berbeda.
A block has a volume of 810 cm^3 Look for the possible lengths, widths and heights of the beam's ribs, at least three different sizes.



3. Known : Volume of the block = 810 cm^2
Asked : The possible P, L, T of the beam's blok?

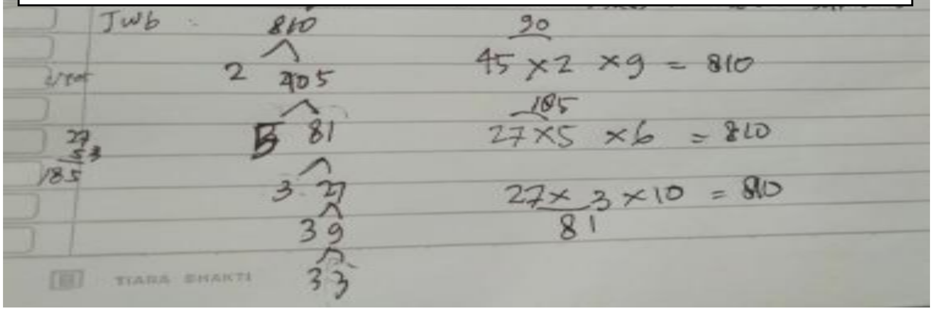


Figure 1. MA's Answer Result

From Figure 1 above, it appears that MA is trying to explore possible rib sizes using the factor method. After obtaining answers from the MA, an interview process was carried out, the results of which can be seen in script below.

P : *Apa yang kamu fikirkan setelah membaca soal tersebut*
What do you think after reading the question?

MA : *Saya memikirkan bahwa ada sebuah valok dengan volume 810, kemudian saya harus mencari kemungkinan rusuk yang dimiliki oleh balok tersebut. Mencari 3 bentuk ukuran*.
I thought that there was a block with a volume of 810, then I had to look for possible edges that the block had. Looking for 3 shape sizes.

P : *Lalu setelah berpikir begitu, apa yang kamu lakukan?*
Then after thinking about it, what do you do?

MA : *Saya coba dengan mencari factor dari 810 bu*
I tried looking for the factor of 810 ma'am

P : *Kemudian bagaimana?*
What Then?

MA : *Setelah didapat faktor dari 810, di coba coba dengan 810 dibagi dengan 9 hasilnya 90 nah dibagi lagi jadi 45 kali 2. di dapat 9 x 45 x2, lalu kedua dengan melihat faktor dari 810 diambil salah satu angka untuk dicoba saya ambil angka 27 nah bisa dengan 27 x 5 x 6 dan 27 x 3 x 10*

After getting the factor of 810, try dividing it with 810 by 9, the result is 90, then divide it again to 45 times 2. You get 9 x 45 x2, then secondly, by looking at the factor of 810, take one of the numbers to try, I take the number 27, okay? with 27 x 5 x 6 and 27 x 3 x 10

P : *Kenapa harus dengan cara mencari factor dari 810? Gak ada cara lainkah?*

Why do you have to find the factor of 810? Is there no other way?

MA : *Mungkin ad acara yang lain bu, tapi saya baru kepikiran cara yang memfaktorkan itu dulu.*

Maybe there are other events, ma'am, but I just thought about how to factor that in first.

Based on the results of the MA interview in script above, the first step taken by the MA was to look for the factors of 810, then from the factors obtained, 2 numbers were chosen and compared to one of the ribs of a beam and then multiplied to get the number 810. The MA subjects worked on the questions 3 easily because of doing trial and error and learning experience with Magic Forms. It was helped MA to solve the problem. From the data triangulation that has been carried out, the final result for MA is that MA is able to provide a relevant idea and the answer is correct so that it meets the fluency indicators. Furthermore, being able to provide answers in one way, the calculation process and results are correct, thus meeting the flexibility indicator. MA subjects are able to provide their own way, the calculation process is correct, the answer results are correct, and they are able to detail the problem solution well. So that it meets the indicators of authenticity and elaboration. So it is concluded that MA fulfills four indicators of good mathematical creative thinking ability, namely fluency, flexibility, authenticity and elaboration.

The next display of results is the LS participant's answer. The answers displayed are answers to the mathematical creative thinking test by LS research participants for the following questions:

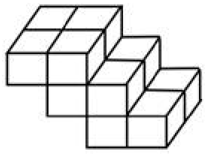
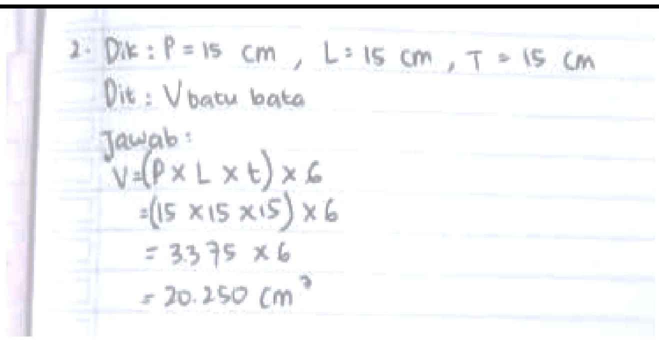
Sejumlah batu bata di susun seperti gambar disamping ini, setiap batu bata tersebut berukuran Panjang 15 cm, lebar 15 cm serta tebalnya 15 cm. lalu jika kita ingin menghitung volume seluruh batu bata yang ada, maka berapa batu batakah yang harus di hitung?	
a number of bricks are arranged as shown in the picture below, each brick measures 15 cm long, 15 cm wide and 15 cm thick. then if we want to calculate the volume of all the existing bricks, then how many bricks must be counted?	

Figure 2 below is the answer from LS participants. It can be seen from Figure 2 below that LS finds the total volume of the block using the block volume formula p x l x t multiplied by 6 blocks. This is of course wrong because the total number of blocks is 12 blocks, not just 6 blocks. Then LS also did not explain in detail and systematically what the question wanted.



2. Known : P = 15 cm, L = 15 cm, T = 15 cm

Asked : V of the Brick

Answer : V = (P x L x T) x 6

= (15 x 15 x 15) x 6

= 3375 x 6

= 20.250 cm^3

Figure 2. LS's Answer Result

After obtaining answers from LS, an interview process was carried out, the results of which can be seen in script below.

P : *Apa yang kamu pahami setelah membaca soal tersebut*
What do you understand after reading the question

LS : *Saya memikirkan bahwa gambar ini punya ukuran batu bata yang sama yaitu Panjang 15 cm, tinggi 15 cm serta lebarnya juga 15 cm. dan ukuran ini sama* *untuk semua batu bata di soal ini. Terus ditanya volume untuk semua batu batanya*

I think that this picture has the same brick dimensions, namely 15 cm long, 15 cm high and 15 cm wide. and this size is the same for all the bricks in this problem. Keep asking for the volume for all the bricks

P : *O, pertanyaan di soal itu ya maksudnya,*

Oh, the question in that question is what it means,

LS : *Iya bu, kan biasanya memang soal ditanya volumenya. Makanya say acari aja semua volumenya dengan rumus volume balok karena batu bata kan bentuknya balok, terus saya kalikan semua batu bata yang ada di gambar. Kan di gambar ada 6 batu bata.*

Yes ma'am, it's usually a matter of asking about the volume. That's why I just find all the volumes using the block volume formula because bricks are shaped like blocks, then I multiply all the bricks in the picture. In the picture there are 6 bricks.

P : *Masa sih semua batu bata Cuma 6?*

When are all the bricks only 6?

LS : *Iya bu, di gambar Cuma ada 6.*

Yes ma'am, there are only 6 in the picture.

P : *Coba hitung lagi semuanya ya.*

Try calculating everything again, okay?

LS : *O iya bu, ternyata ada tumpukan batu bata yang ketimpa dengan atasnya. Saya gak hitung yang itu bu*

Oh yes, ma'am, it turns out there is a pile of bricks that are overlapping with the top. I didn't count that one, ma'am

P : *Terus ada berapa total batu batanya jadinya?*

So how many bricks are there in total?

LS : *Ada 12 Bu*

There are 12 ma'am

Based on the results of the interview above, LS participants answered the mathematical creative thinking test questions with their own ideas and got results even though they were wrong in the calculations. LS counted 6 bricks in the picture in the question, this indicates that LS was not yet able to use his thinking power to be creative.

Based on the data triangulation that has been carried out, the final result for LS is that LS is capable to provide a relevant idea even if the answer is wrong, and has not reached the maximum score for the fluency indicator. Furthermore, the LS flexibility indicator is able to provide answers in one way, the calculation process and results are wrong, but have not yet reached the maximum score. For the authenticity indicator, the LS subject was able to provide answers in his own way, but there were errors in the calculation process resulting in the results, and for the elaboration indicator, he got a score of 2 because there were errors in answering, and he was not able to detail the problem resolution well. Based on data triangulation, it was found that LS meets four indicators of mathematical creative thinking ability, namely fluency, flexibility, authenticity and elaboration but is not optimal.

Lastly are the research results for the YC subject. The answers displayed are answers to the mathematical creative thinking test by LS research participants for the following questions:

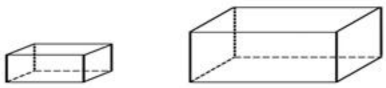
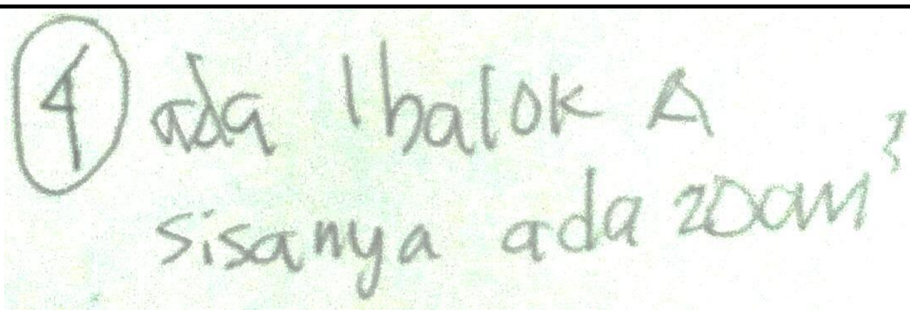
Perbandingan volume dua buah kubus dibawah ini adalah 3 : 5. Jika kubus B bisa di isi oleh beberapa kubus A, berapa banyakkah kubus A yang diperlukan untuk memenuhi kubus B? apabila ada sisa ruang pada kubus B, berapakah sisa ruangan tersebut?
The volume comparison of the two cubes below is 3 : 5. If cube B can be filled by several cubes A, how many cubes A are needed to fill cube B? if there is a residual space on cube B, how much is the residual space?


Figure 3 below is an illustration of the answers given by YC. It appears that YC has not explored the questions given. YC seemed to be in a hurry to give an answer without trying several ways or methods to use to answer the existing questions.



4. there is 1 block A

The remaining is 20 cm^3

Figure 3. YC's Answer Result

Then an interview process was carried out to confirm and explore YC's creative thinking. The results of the interview can be seen in script below.

P : *Kamu mengerti maksud soalnya?*
Do you understand what that means?

YC : *Bingung bu, Volume balok 3 : 5. Tapi kan saya ga tau berapa volumenya jadi saya bingung bu*
Confused ma'am, Volume of blocks 3 : 5. But I don't know what the volume is so I'm confused ma'am

P : *Tapi itu kamu nulis jawabannya, maksudnya gimana itu?*
But you wrote the answer, what do you mean by that?

YC : *Iya bu, jadikan saya buingung, ya udah saya kalikan aja masing – masing dengan 10. Jadi setelah dikalikan hasilnya jadi 30 sama 50 terus itu dijadikan volumenya jadi tinggal dikurangi aja 50-30 trus sisanya 20 deh*
Yes, ma'am, it makes me confused, so I just multiplied each by 10. So after multiplying the result becomes 30 and 50 then the volume is used, so just subtract 50-30 then the remaining 20.

P : *Dari mana dikali 10 itu?*
Where does that times 10 come from?

YC : *Saya gak paham bu, saya random aja, saya kalikan 10 biar cepat selesai*
I don't understand ma'am, I'll just do it randomly, I'll multiply it by 10 so it's done quickly

Based on the results of the interview above, information was obtained that YC had not been able to provide new ideas in solving problems. YC experienced confusion in interpreting the meaning of the questions, let alone thinking about the answers by exploring his creative thinking.

Based on triangulation, an explanation was obtained that YC had not been able to provide a relevant idea for fluency indicators. In the flexibility indicator, YC is also only able to provide answers in one way. For the authenticity indicator, YC can provide answers in his own way, even if the results are wrong, and for the elaboration indicator, YC completes the answer with details but the details are not detailed enough. It can be concluded that YC has not been able to meet the four indicators of mathematical creative thinking ability, namely fluency, flexibility, authenticity and good elaboration.

The data that has been explained previously is combined again in a table like table 1 below. The presentation is based on indicators of mathematical creative thinking abilities established in this research.

Table 1. Research Results

Indicators of Creative Thinking Ability	**Research Participants**		
	MA	**LS**	**YC**
Fluency	able to provide relevant ideas and answer smoothly	able to provide relevant ideas and correct answers	Not yet able to provide relevant ideas
Flexibility	able to answer in more than one way, and the result is correct	able to answer in one way, even though the results are still not correct	able to answer in one way, but the result is wrong
Authenticity	able to solve questions in his own way and answer correctly.	able to solve questions in his own way and the answer is wrong	Not able to solve the problem on your own
Elaboration	Subjects answered correctly and explained in detail	The subject was able to answer but was not able to explain it well	Not yet able to detail it well

From the discussions above, it was found that students still made several mistakes and encountered several difficulties in developing their creative thinking abilities. Among the mistakes made by students include not having a good understanding of the questions being asked. This is in line with Amalia et al. (2020); Irmayanti & Putra (2023); Nurazizah et al. (2022); Putra (2016) findings that students were unable to read and understand the questions asked carefully. They often make misperceptions, lazy to think further, and less careful and do not clarify their understanding. So the the understanding of the question is wrong before find the answer.

Furthermore, the research results show that students are less able to use unique strategies due to the weak aspect of originality. This result is in line with the research results of Junaedi et al. (2021) that achievement in the originality aspect is the lowest of the three existing aspects of mathematical creative thinking ability, namely fluency, flexibility and originality. Arista & Mahmudi (2020) reinforced that students' mathematical creative thinking abilities are basically related to students' knowledge of problem formulation or problem solving in mathematics so that students can use unique strategies and creative problem solving steps.

The results obtained in this research reveal that students have quite good mathematical creative thinking abilities, students need to be more facilitated in developing these abilities, especially in solving problems that can develop mathematical creative thinking abilities, for example PISA type questions. Several previous studies have recommended alternative strategies that can be used by teachers to facilitate the development of students' creative mathematical thinking abilities, starting from implementing certain learning models (for example, Apino, 2016; Fitrianawati & Hartono, 2016; Maskur et al., 2020; Rochani, 2016), getting students used to solving open-ended problems (for example, Arista & Mahmudi, 2020; Kwon et al., 2006), to utilizing learning technology (for example, Calder, 2018; Dhayanti et al., 2018; Isnaniah & Imamuddin, 2020; Tran et al., 2017).

Finally, interesting things were also revealed from the research participants about the learning experience using teaching aids, in this case using magic forms. Students feel that understanding the geometric concepts being studied becomes easier and helps students in learning mathematics. This is in line with research from Amidi & Zahid (2016); Calder (2018); Lithner (2017); Palupi (2021).

Apart from that, students become more challenged to do things related to creative thinking because they feel that creative thinking questions are new things so they are more excited to do. These creative thinking questions also include open-ended questions and non-routine questions, as conveyed by Maskur et al. (2020) who stated that open-ended questions can improve students' creative thinking abilities and Arista & Mahmudi (2020) who also said that non-routine questions can stimulate students' creative mathematical thinking.

Furthermore, Table 2 id the details of learning experiences of research participants regarding their experience of learning mathematics using assistive devices magic forms. Table 5 shows the results of the students' learning experiences, including the experience of answering mathematical creative thinking test questions.

Table 2. Results of Student Learning Experiences

Student Learning Experience	**Research Participants**		
	MA	**LS**	**YC**
Learning experience with*Magic Forms*	MA felt that it was helpful to understand the material for building flat-sided spaces with learning experiences with*Magic Forms*	LS felt that it was helpful to understand the material for building flat-sided spaces through learning experiences with*Magic forms*	YC lacks understanding in the learning experience with magic *form*s because the subject pays less attention to learning activities in class.
Experience working on mathematical creative thinking skills	MA was challenged with creative thinking skills and felt that he rarely looked at the questions given.	LS was challenged with creative thinking skills and felt that he rarely looked at the questions given.	YC does not understand what is meant by questions in the experience of working on mathematical creative thinking ability questions because YC subjects feel that they rarely see the questions given.

CONCLUSION

The conclusion of this research is that MA participants fulfill four indicators of mathematical creative thinking ability well, namely fluency, flexibility, originality and elaboration. Then LS participants met four indicators of mathematical creative thinking ability, namely fluency, flexibility, originality and elaboration but were not optimal. And YC participants have not been able to meet the four indicators of mathematical creative thinking ability, namely fluency, flexibility, originality and good elaboration. Learning experience with*Magic Forms* conveyed by two participants, namely MA and LC, who felt very helped and felt excited, as well as YC participants who felt a little helped. The experience of working on mathematical creative thinking ability questions made the research participants challenged by the questions and felt that they rarely encountered mathematical creative thinking ability questions in the process of learning mathematics at school.

This study proposes several recommendations for further research. For instance, a new learning aid can be developed to help student increase their mathematical creative thinking. Additionally, future research can focus on the process of mathematical creative thinking for the student based on their learning experience. This research can be useful for teachers in enhancing the learning experience in subsequent meetings. However, as this study is qualitative in nature, there are limitations to the generalizations that can be made. The research sample was limited to participants that met specific criteria. To produce a more comprehensive study, there is a need for further methods and sample development.

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