

Student's creative thinking based on study level, learning style, gender, and combination of the three

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ABSTRACT

All students from every level of education should have excellent and adequate creative thinking, but in Indonesia students' creative thinking is still low. There are a lot of factors that affect creative thinking, such as learning styles. This study aimed to investigate the comparison of students' creative thinking based on study level and learning styles, gender, and the combination of the three to determine which factor or type of students needs to be improved. This research uses a statistics descriptive method. The participants of this study were 38 senior high school students, 35 students of the teacher professional program (PPG), 24 undergraduate students (S1), and 12 master program students (S2). The instrument used in this study is a learning styles Learning style test to determine the student's learning styles and creative thinking questions to classify the students. The results of this study are i) Students' level of study does not determine their creativity level; ii) Based on gender, female is more creative than a man; iii) Based on the learning style, visual students is the best, followed by kinesthetic and auditory in order; and iv) *Merdeka* curriculum of Indonesia, nowadays, is essential to make the best learning process to improve students' creative thinking.

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1. INTRODUCTION

Creative thinking is an important issue in every countries [1]–[3]. Creative thinking plays an important role in mathematics learning for students, undergraduate students, postgraduate students, and students of teaching professional programs [4]. Creative thinking is a thinking skill that generates new ideas by combining existing ideas to solve problems using non-algorithmic, unusual, and unique methods [5], [6]. Students must have creative thinking skills in solving mathematical problems using various alternative solutions [7], [8].

All students from every level of education should have good and adequate creative thinking skills. The importance of creative thinking for each level of education has been discussed in research by education experts. One of the goals of education is to develop students' creative thinking skills, so that students have creative attitudes and behaviors in solving mathematical problems [9]. Creative thinking skills are also needed in developing higher order thinking skills and mathematical reasoning [10], [11]. The ability to think creatively is very much needed in dealing with technological sophistication in the 4.0 and 5.0 era, as well as

facing the 21st century, where every line of work requires creative workers. These workers should be trained starting from school; which is the ability to think creatively and mathematically [12].

However, students' creative thinking skills are still low especially in Indonesia. The 2015 global creativity index stated that the level of creative thinking in Indonesia still ranked 115th out of 139 countries with a score of 0.202, lower than some of other countries in Southeast Asia [13]–[15]. Moreover, students are not able to generate varied strategies in solving mathematical problems [16], [17]. Furthermore, high school students and university students experience difficulties in developing creative ideas for solving mathematical problems [18]–[21].

Many factors influence the creativity of students. The factors can be internal and external [21]. Internal factor of the creative thinking is the students' initial knowledge obtained through previous learning, spontaneous knowledge, and their experiences (the cognitive abilities they have) [22]. For the external factors, students' creative thinking is influenced by the learning process, friends, and the environment [23]. Because of the importance of the learning process in students' creative thinking, there are many studies that have been done. The learning process includes constructivism learning and problem-based learning (PBL) [24], [25]. Furthermore, using IT-based media learning models is also improve students' creative thinking abilities [26], [27]. Another external factor which is also important for students' creative thinking abilities is learning styles. Studies have examined the relationship of students' learning styles and creative thinking. Espericueta *et al.* [28] found that students' learning styles and didactic strategies are considered to have an impact to students' creative thinking. Ozturk and Karakus [29] looked at the creative thinking abilities of junior high school students with different social backgrounds and learning styles and found that the achievements of learning outcomes in aspects of creative thinking skills for each learning style were different. Ardianik *et al.* [30] revealed that visual students have better creativity than students with other learning styles, followed by auditory and kinesthetic in order.

The gender of the students also determines the students' creative thinking level. Male students have creative thinking that tend to be on the aspect of fluency and female students have creative thinking that tend to be on the aspect of flexibility. The research by Purwasih *et al.* [31] found that female students are more creative than male students. The variation of male creative thinking is slightly superior to the variation of the creative thinking of the female [32].

As the answer of the problem of students' creative thinking, as an innovation of previous researches, this research tried to investigate the comparison of creative thinking based on the external factors which are study level, learning styles, gender and the combination of the three. In this study, based on the comparison the order of creative thinking will be revealed. This creative thinking level order can be a guideline to help teachers evaluate their learning process and serve better learning activity.

2. RESEARCH METHOD

This research is using a statistics descriptive method. Simple statistics analysis was conducted first, followed by the description for each data to see the comparison of creative thinking of students based on the study level, learning style, gender, and combination of the three. The participants in this study were 38 (17 male, 21 female) senior high school students (SMA), 24 (3 male, 21 female) undergraduate students (S1), 13 (2 male, 11 female) master program students (S2), and 35 (4 male, 31 female) students of teacher professional program (PPG). The sample of this study was chosen using purposive random sampling [33]. The sample of this study is small sample because of several consideration, which are the research time (students' doing the test), and there is only 1 class of PPG and S2 mathematics education students that can be participant in this study. For each level of study, the subject chosen is one class to make the number of students is not too different for each level of study. The number of the male and female also not equal, it is because in fact of the number female students is much greater than male students.

The research was conducted in two stages: i) giving a learning style test to review the learning styles of the students; and ii) giving creative thinking test questions to the students. Based on the students answer, the students will be divided into three groups (low, middle, and high). These three groups of students will be analyzed on every aspect (study level, learning style, and gender). The comparison of the students' creative thinking skill will be based on percentage of the low, middle, or high, which are: i) if the percentage of low creativity students of a group is lower than others, then it is better; ii) if the low creativity students have same percentage, then if the percentage of the middle creativity students is lower than others, then it is better; and iii) if there is a condition that does not fulfill and then mathematical estimation is conducted.

The instruments used in this study are learning style test and creative thinking test. Learning style tests were used to classify the students' learning styles and creative thinking test were used to assessed students' creativity. The learning style test contains 30 questions and creative thinking test contains seven questions. Instruments used in this research can be seen in Table 1.

Table 1. Research instruments

No	Type instrument	Instrument	Data analysis techniques
1	Learning style test	The learning style test used is a valid and tested instrument by the experts. The test can be accessed at https://akupintar.id/tes-gaya-belajar .	Every student from SMA, S1, S2, and PPG learning styles was classified based on results of the Learning style test after they filled it. The example of the result (learning style can be seen in Figure 1). After identifying the learning styles, the learning styles of students were tabulated and presented in a table with the level of education and gender.
2	Creative thinking test	<p>The questions of the test used are a valid and reliable creative thinking questions. The questions are:</p> <p>Near Indonesia's Independence Day, Mr. Eko (descendant of Indonesia independence veteran) will receive guest at a living room that the ceramics arranged colored red and white as in Figure 2. In making the living room before, Mr. Eko said that he bought ceramics per dose. Size One the ceramics is 40cm x 40 cm. Price one ceramics per dose is IDR 86,000. 1 Dos can be loaded approximately 1 square meter. The Amir that heard the story and saw the living room said that the Mr. Eko's living room is spacious.</p> <p>Question:</p> <p>Do you agree with the opinion the Amir? Give explanation!</p> <p>Main question</p> <p>1) Can you answer the question without any additional information?</p> <p>2) How is your answer to this question?</p> <p>Advanced questions</p> <p>3) Will your answer be different If any other information is added?</p> <p>4)What information do you need?</p> <p>5) If you are allowed to ask other information, what kind of questions would you ask?</p> <p>6) Why is that your question?</p> <p>7) Apart from what you have written down, write anything else you still want know more and what is the question?</p>	Every answer from students for each level of education was scored and categorized into three categories: high, medium, and low. Next, the data were interpreted for each category at each school level, learning styles, and gender.

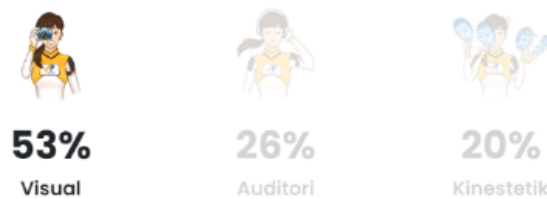


Figure 1. Result of learning style learning style test example

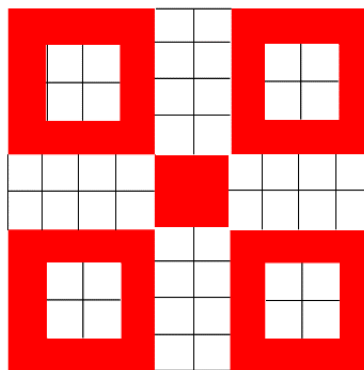


Figure 2. Ceramic pattern of Eko's living room

The creativity test questions had been tested to undergraduate students as the median of the study level. The purpose of the test is to find the validity and reliability. Moreover, the validity and reliability test were conducted using statistical package of social sciences (SPSS) application. The result of the validity test is can be seen in Table 2.

Table 2. Validity test result

Questions number	Validity test result
Question scale 0-1	
1	0.842
3	0.328
Question scale 0-3	
2	0.265
4	0.953
5	0.953
6	0.953
7	0.503

The validity test is divided into two group because of the different scale of mark. For question 1 and 3, the scale is 0-1 and for other questions are 0-3. The validity result shows that question 2 and 3 are not valid because the result is lower than the value of t_{table} , which is 0.404 for 5% level of significant. However, based on the expert, the question still can be used to guide the idea of the students to answer other questions. Furthermore, the test is reliable because of the reliability test show the result value 0.777, which is bigger than t_{table} (0.404 for 5% level of significant and 0.515 for 1% level of significant).

3. RESULTS AND DISCUSSION

3.1. Students' creativity

Based on the learning style test and creative thinking test, students were grouped. In each group the number of the students in high, middle and low level is shown. The students' creativity level is can be seen in Table 3.

Table 3. Students' creativity level

		High		Total high	Middle		Total middle	Low		Total low	Total
		Male	Female		Male	Female		Male	Female		
SMA	Visual	0	0	0	1	5	6	4	8	12	18
	Auditory	0	0	0	1	1	2	3	1	4	6
	Kinesthetic	0	0	0	0	2	2	8	4	12	14
	Total SMA	0	0	0	2	8	10	15	13	28	38
S1	Visual	0	1	1	0	5	5	0	9	9	15
	Auditory	0	0	0	0	2	2	0	2	2	4
	Kinesthetic	0	0	0	0	1	1	3	1	4	5
	Total S1	0	1	1	0	8	8	3	12	15	24
S2	Visual	0	1	1	0	0	0	0	4	4	5
	Auditory	0	0	0	0	0	0	0	1	1	1
	Kinesthetic	0	0	0	0	0	0	2	5	7	7
	Total S2	0	1	1	0	0	0	2	10	12	13
PPG	Visual	0	1	1	0	2	2	3	8	11	14
	Auditory	0	0	0	0	2	2	0	6	6	8
	Kinesthetic	0	2	2	0	2	2	1	8	9	13
	Total PPG	0	3	3	0	6	6	4	22	26	35
Total		0	5	5	2	22	24	24	57	81	

For the high-school level, the students were mostly categorized as low creativity students. This condition is caused by two possible reasons: the question is too hard or the creativity of the SMA level students is actually low. After a small interview, one of the students with low creativity said that the question was not that hard. This means the result of this study is true; the students at the SMA level have low creativity. In the gender aspect, the female students were relatively more creative than male students at SMA level. Moreover, based on the learning style, students with visual and auditory have equal creativity and higher than students with kinesthetic learning style at SMA level. Based on the learning style and gender, the creativity of the students at the SMA level is female auditory>female visual>female kinesthetic>male auditory>male visual>male kinesthetic.

For the S1 level, the students were mostly categorized as low creativity students. In the gender aspect, the female students were relatively more creative than the male students at S1 level. Moreover, based on the learning style, the students' creativity: visual learning style>auditory>kinesthetic at the S1 level. Based on the learning style and gender, the creativity of the students at S1 level is female visual>female auditory=female kinesthetic>male kinesthetic.

For the S2 level, the students were mostly categorized as low creativity students. In the gender aspect, the female students were relatively more creative than the male students at S2 level. Moreover, based on the learning style, the students' creativity: visual learning style>auditory=kinesthetic on S2 level. Finally, based on the learning style and gender, the creativity of the students at S2 level is female visual>female auditory=female kinesthetic=male kinesthetic.

For the PPG level, the students were mostly categorized as low creativity. In the gender aspect, the female students were relatively more creative than the male students at PPG level. Moreover, based on the learning style, the students' creativity: kinesthetic learning style>visual>auditory on PPG level. Finally, based on the learning style and gender, the creativity of the students at SMA level was female kinesthetics>female visual>female auditory> male visual=male kinesthetic.

The order of students' creativity based on the level of study is PPG>S1 >SMA>S2. For the gender in every level of studies, the female students were more creative than the male students. For the learning styles of every level of studies, the creativity of students is visual>kinesthetic>auditory. The order of students' creativity based on the level of study and gender is female S1>female PPG>female SMA>male SMA>female S2>male S1=male S2=male PPG. The order of students' creativity based on the level of study and learning styles is kinesthetic PPG>visual S1>visual PPG>visual S2>auditory S1>visual SMA=auditory SMA>auditory PPG>kinesthetic S1>kinesthetic SMA>auditory S2=kinesthetic S2. The order of students' creativity based on the level of study, gender, and learning styles is female kinesthetic PPG>female visual S1>female visual PPG>female visual S2>female auditory S1=female kinesthetic S1=female auditory SMA>female visual SMA>female kinesthetic SMA>female auditory PPG=male auditory SMA>male visual SMA=female auditory PPG>male kinesthetic SMA=male kinesthetic S1=male kinesthetic S2>female auditory S2=female kinesthetic S2=male visual PPG=male kinesthetic PPG.

3.2. The variation of students' answer

There are a lot of variations of the students' answer in the creativity test. The variations are revealed at a crucial question number 5 "If you are allowed to ask other information, what kind of questions would you ask?". In question number 5, each students expected to have their own opinion.

3.2.1. High creativity students

The answer of high creativity students is represented in H1's answer. H1 give three questions, and the main questions that makes H1's answer good is "the information of Amir's living room". H1's answer for question number 5 can be seen in Figure 3.

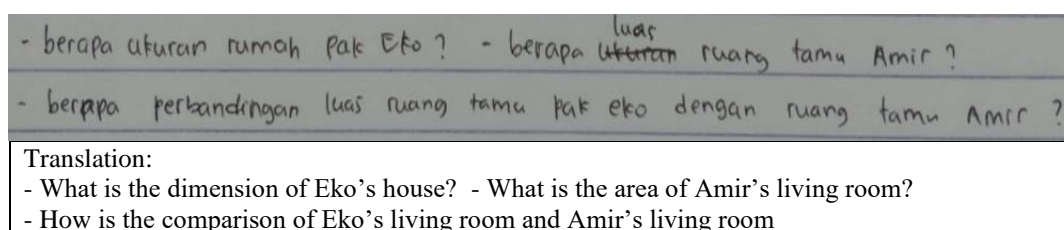
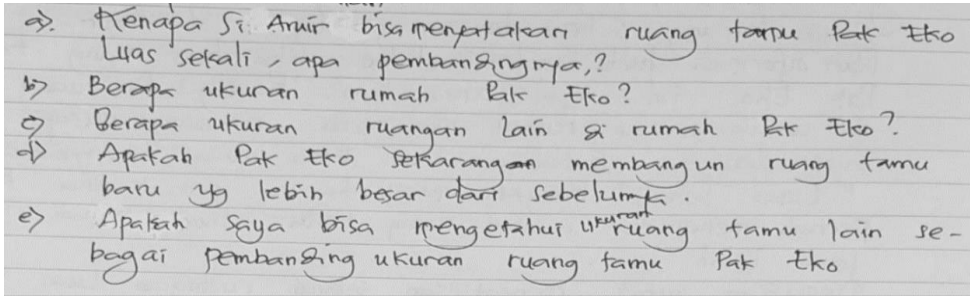


Figure 3. H1's answer (question 5)

H1 said that the reason of her answer is to compare the area of Eko's living room to the area of Amir's living room. This is will make H1 can see the Amir's perspective. Furthermore, most of the other high creativity level students also have the same answer with H1.

There are also high creativity students (H2) that answer this question with asking information about Amir's perspective ("Why Amir said that?"), the comparison of the area of Eko's living room with the area of Eko's house, the area of the other rooms in Eko's house, Does Eko's living room now is bigger than other or old living room, and the area of other living rooms as a comparison to the area of Eko's living room. All of the H2 answers are acceptable. The answer of H2 can be seen in Figure 4.



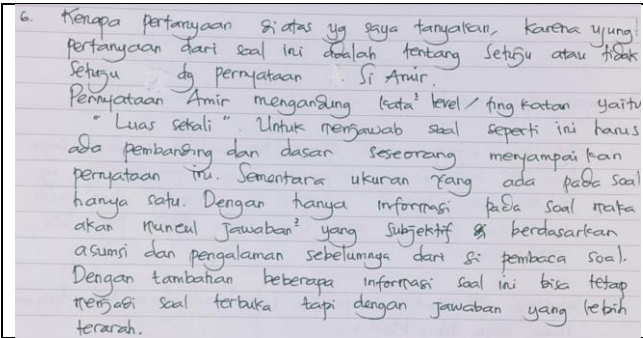
a) Kenapa Si Amir bisa menyatakan ruang tamu Pak Eko
 Luas sekali, apa pembandingnya?
 b) Berapa ukuran rumah Pak Eko?
 c) Berapa ukuran ruangan lain di rumah Pak Eko?
 d) Apakah Pak Eko sekarang membangun ruang tamu
 baru yg lebih besar dari sebelumnya.
 e) Apakah saya bisa mengetahui ukuran ruang tamu lain se-
 bagai pembanding ukuran ruang tamu Pak Eko

Translation:

a) Why can Amir say that Eko's living room is spacious, what is the comparison?
 b) What is the size of Eko's house?
 c) What is the size of the other room in Eko's house?
 d) Has Eko now built a new living room that is bigger than before?
 e) Can I find out the size of other living rooms as a comparison to the size of Eko's living room?

Figure 4. H2's answer (question 5)

The reason of H2 answered question 5 is because the end of the problem, there is a question that ask about agreeing or disagreeing the Amir's statement. H2 said that he needed the reason of Amir for his statement and the comparison of the area of Eko's living room with other room. The reason of the H2's answer in number 5 were stated at answer number 6 that can be seen in Figure 5.



6. Kenapa pertanyaan si atas yg saya tanyakan, karena yung
 pertanyaan dari soal ini adalah tentang setuju atau tidak
 setuju dg pernyataan Si Amir.
 Pernyataan Amir mengandung kata "level / fmg katan yaitu
 "Luas sekali". Untuk menjawab soal seperti ini harus
 ada pembanding dan dasar seseorang menyampaikan
 pernyataan itu. Sementara ukuran yang ada pada soal
 hanya satu. Dengan hanya informasi pada soal maka
 akan muncul jawaban yang subjektif & berdasarkan
 asumsi dan pengalaman sebelumnya dari si pembaca soal.
 Dengan tambahan beberapa informasi soal ini bisa tetap
 menjadi soal terbuka tapi dengan jawaban yang lebih
 terarah.

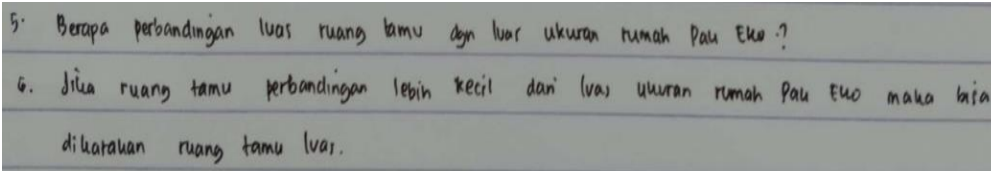
Translation:

Why I am asking the question above, because the end
 of the question in this question is about agreeing or
 disagreeing with Amir's statement.
 Amir's question contains the words level, namely
 "very broad". To answer questions like this, there
 must be a comparison and basis while the size in the
 problem is only one. With only information on the
 question, subjective answers will appear based on the
 assumptions and previous experience of the readers.
 With this additional information, the problem
 becomes more focused.

Figure 5. One of high creativity student's answer (question 6)

3.2.2. Medium creativity student

For the medium creativity, students tend to true but not effective or directly can help to find the question. The example of the answer is the standard of wide area. The representative of this medium creativity students is M1, M1's answer for number 5 can be seen in Figure 6.



5. Berapa perbandingan luas ruang tamu dgn luas ukuran rumah Pak Eko?
 6. Jika ruang tamu perbandingan lebih kecil dari luas ukuran rumah Pak Eko maka bisa
 dikatakan ruang tamu luas.

Translation:

5. What is the ratio of the area of the living room to the area of Eko's house?
 6. If the ratio of the living room and Eko's house is small then the Amir's opinion is true.

Figure 6. Middle creativity student's answer

The answer of M1 on question 5 is good and true, but it does not directly show Amir's perspective. The reason for M1 is "If the ratio is small then Amir's opinion is true". This reason is just the reader's assumption, which means this answer can be categorized as a middle creative answer. There are lot of students using this argument, and they are categorized as the middle creativity students. Different to M1, M2 only answered "The comparison". M2's answer can be seen in Figure 7.

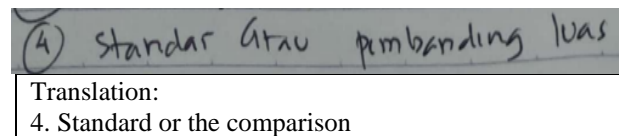


Figure 7. M2's answer

For this type of answer, the students are true, that to answer, readers need the comparison but, in this answer, the comparison is not clarified; the perfect one should be the information of Amir's living room because the problem talked about is Amir's perspective. There are also middle creativity students who wanted information about "the furniture" that can be seen in Figure 8.

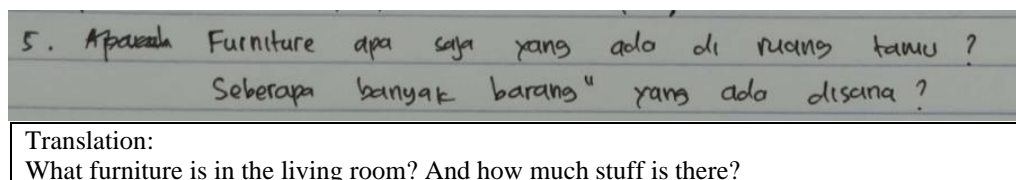


Figure 8. Middle creativity student's answer

For this type of answer, it is categorized middle. This is because the answer is able to determine the space of Eko's living room but still using the reader's perspective, not Amir's perspective. At the end, the idea is good but does not satisfy as much as the High creativity students.

3.2.3. Low creativity students

The students categorized as low creativity have several types of answers and there are also students that did not answer the question. In the low creativity, the students tend to give argument that does not connected to the real answer. The first type of answer can be seen in Figure 9.

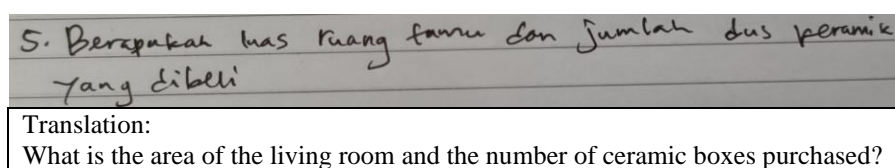


Figure 9. Low creativity student's answer

For this type of answer, the students asked for the area of living room and the number of ceramics purchased. The reason why this answer is at the low creativity level is because the students had no idea to answer the problem, the area of the living room is what they should find by themselves. Next, the students said that they answer "the number of ceramic boxes purchased" is because they want to find the area of Eko's living room using that, but it is not a necessary information because in the problem, the information to find the area of Eko's living room is enough.

The next low creativity students answered "the number of guests to the event". This is actually a good answer but the problem said that the event will happen, not currently happening. If the event is currently happening then the answer will be categorized as middle or even high. The example of this kind of answer can be seen in Figure 10.

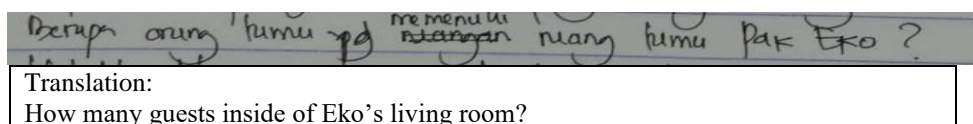


Figure 10. Low creativity student's answer

The last one is the answer that the students want information about the figure at the problem. This kind of answer show the reading error of the students. The problem already shows the readers that "the figure" is the representation of the living room which means it is ready to use for finding the area of Eko's living room. The students' answer for this type can be in Figure 11.

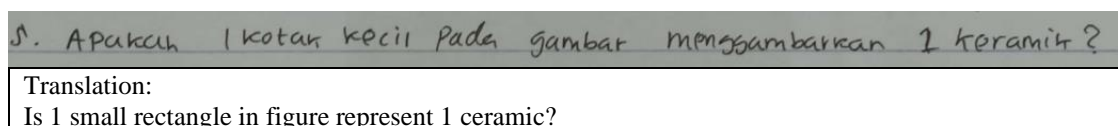


Figure 11. Low creativity student's answer

Based on the result, the findings of this study are new; PPG students have the highest percentage of creative students. This is because the PPG students received some tests before joining the PPG. This also proves that the filter of PPG admission is good. Similar to the PPG students, the S1 students also have good creativity more than SMA and S2 students. This is because the S1 students also had some tests before they got accepted at the university. For the SMA level, the students are at the middle creativity level because senior high schools in Indonesia used zonation system which means a school is just for certain areas, making students very plural starting from the low creativity until the high creativity. Interestingly, the S2 students were dominated by the low creativity students. At the end, the levels of study do not determine students' creative thinking level.

In the gender perspective, this study found that the creativity of female and male students is different. The female creativity is better than male. This finding is different from Nada and Sari [34] found that there is no significant difference between male creativity and female creativity; the differences are in fluency, flexibility, and elaboration indicators. Different to Perdana *et al.* [35] that found that the creative thinking of male students is better than female students. On the other hand, the finding of this study aligns with that of Purwasih *et al.* [31] that female students are more creative than male students.

In the learning style perspective, this study found that visual students have high creativity, more than kinesthetic and auditory. This is in line with Ardianik *et al.* [30] that revealed that visual students have better creativity than students with other learning styles, followed by auditory and kinesthetic in order. Different from this, Marzuki *et al.* [36] found that based on the average creative thinking abilities kinesthetic learning styles students are higher than visual learning students.

The order of students' creativity based on the level of study and gender means that the male of S1, S2, and PPG need more attention of the teachers or lecturers because they are 100% in low creativity level, followed by the female S2 and male SMA. The order of students' creativity based on the level of study and learning styles means that the auditory S2 and kinesthetic S2 need more attention than others because they are 100% in low creativity level followed by the order. The order of students' creativity based on the level of study, gender, and learning styles means that female auditory S2, female kinesthetic S2, male visual PPG, male kinesthetic PPG need the most attention of the teachers or lecturers to improve their creative thinking ability. Furthermore, this order also indicates that the initial analysis to know students' characteristic is a must because the students have different ability, learning styles, and skills [37], [38].

The comparison of combination of levels of studies, gender, and learning styles is a new discovery. For Indonesia especially, this is proving the need of *Merdeka* curriculum that already start serving the learning process for the students based on the students' condition. Learning based on the students' characteristic is called differentiated learning [37]. Based on the study by Dalila *et al.* [39], differentiated learning is effective to help the students to understand the material because the learning process is based on the students' needs. This differentiated learning also can be the base of the learning. Dalila *et al.* [39] were using the differentiated learning in the problem-based learning. Jamaluddin *et al.* [40] were designing lessons using differentiated learning to Moodle learning management system (LMS).

4. CONCLUSION

Based on the result of this study, it can be concluded that i) students' level of study does not determine their creativity level; ii) based on the gender, female is more creative than a man; iii) based on the learning style, visual students were the best followed by kinesthetic and auditory in order; iv) *Merdeka* curriculum of Indonesia, nowadays, is very necessary to make the best learning process to improve students' creative thinking. Based on this study, it is hoped that educational elements all over the world can take this result to make the learning process better, for example conducting research about developing learning process, learning media, and material. It is also hoped that on the further researches, the study can be done to bigger population so the bias of the study can be covered.




REFERENCES

- [1] S. Han and H. Suh, "The effects of shadow education on high school students' creative thinking and academic achievement in mathematics: the case of the Republic of Korea," *Educational Studies*, vol. 49, no. 2, pp. 314–333, Mar. 2023, doi: 10.1080/03055698.2020.1850427.
- [2] S. A. Elsayed and H. M. Nasef, "The effectiveness of a mathematics learning program based on the mind habits in developing academic achievement motivation and creative thinking among prince Sattam Bin Abdulaziz University students," *International Journal of Higher Education*, vol. 10, no. 1, pp. 55–75, Sep. 2020, doi: 10.5430/ijhe.v10n1p55.
- [3] N. Happy, D. Endahwuri, and M. M. L. Chakim, "Mathematics critical and creative thinking skill of student to solve numerical methods problems based on strength typology," *Journal of Physics: Conference Series*, vol. 1663, no. 1, pp. 1–9, Oct. 2020, doi: 10.1088/1742-6596/1663/1/012022.
- [4] M. El-Demerdash, J. Trgalová, O. Labs, and C. Mercat, "Design and evaluation of digital resources for the development of creative mathematical thinking: a case of teaching the concept of locus," in *Technology in Mathematics Teaching*, Springer, Cham, 2019, pp. 145–172. doi: 10.1007/978-3-030-19741-4_7.
- [5] A. R. Sya'roni, P. A. Inawati, E. Guswanto, Susanto, and Hobri, "Students' creative thinking skill in the flipped classroom-blended learning of mathematics based on lesson study for learning community," *Journal of Physics: Conference Series*, vol. 1563, no. 1, pp. 1–11, Jun. 2020, doi: 10.1088/1742-6596/1563/1/012046.
- [6] H. E. Rudyanto, A. Ghufro, and Hartono, "Use of integrated mobile application with realistic mathematics education: a study to develop elementary students' creative thinking ability," *International Journal of Interactive Mobile Technologies*, vol. 13, no. 10, pp. 19–27, Sep. 2019, doi: 10.3991/ijim.v13i10.11598.
- [7] A. Andriani, I. Dewi, and P. N. Sagala, "Development of blended learning media using the mentimeter application to improve mathematics creative thinking skills," *Journal of Physics: Conference Series*, vol. 1188, no. 1, pp. 1–6, Mar. 2019, doi: 10.1088/1742-6596/1188/1/012112.
- [8] N. Anaguna, S. Suhendra, and Rahmadani, "Tracking down gifted students' creative thinking in solving mathematics problems," *Journal of Physics: Conference Series*, vol. 1211, no. 1, pp. 1–7, 2019, doi: 10.1088/1742-6596/1211/1/012059.
- [9] P. R. Dewi, M. Erna, and R. Rasmiwetti, "The development of assessment instruments with problem posing methods to measure students creative thinking ability in Acid base materials," *Journal of Educational Sciences*, vol. 4, no. 2, pp. 334–346, Apr. 2020, doi: 10.31258/jes.4.2.p.334-346.
- [10] Isnani, S. B. Waluya, and Rochmad, "Problem posing in the proof process identifying creative thinking in mathematics," *Journal of Physics: Conference Series*, vol. 1657, no. 1, pp. 1–7, Oct. 2020, doi: 10.1088/1742-6596/1657/1/012066.
- [11] D. Ismunandar, F. Gunadi, M. Taufan, D. Mulyana, and Runisah, "Creative thinking skill of students through realistic mathematics education approach," *Journal of Physics: Conference Series*, vol. 1657, no. 1, pp. 1–7, Oct. 2020, doi: 10.1088/1742-6596/1657/1/012054.
- [12] M. A. Kencana, Musri, and M. Syukri, "The effect of science, technology, engineering, and mathematics (STEM) on students' creative thinking skills," *Journal of Physics: Conference Series*, vol. 1460, no. 1, pp. 1–5, Feb. 2020, doi: 10.1088/1742-6596/1460/1/012141.
- [13] M. Megawan and E. Istiyono, "Physics creative thinking measurement using two-tier multiple choice to Support Science, Technology, Engineering, and Mathematics," *Journal of Physics: Conference Series*, vol. 1233, no. 1, pp. 1–7, Jun. 2019, doi: 10.1088/1742-6596/1233/1/012068.
- [14] Mellawaty, Sudirman, S. B. Waluya, and Rochmad, "Creative thinking ability on the integrating mathematical habits of mind in missouri mathematics project learning," *Journal of Physics: Conference Series*, vol. 1315, no. 1, pp. 1–5, Oct. 2019, doi: 10.1088/1742-6596/1315/1/012083.
- [15] Mulyono, S. M. Rosayanti, and R. Kristiawan, "Mathematics creative thinking ability based on student's cognitive style by using Knisley learning models," *Journal of Physics: Conference Series*, vol. 1567, no. 3, pp. 1–6, Jun. 2020, doi: 10.1088/1742-6596/1567/3/032015.
- [16] N. Nahrowi, Susanto, and Hobri, "The profile of student's creative thinking skills in mathematics problem solving in terms of adversity quotient," *Journal of Physics: Conference Series*, vol. 1465, no. 1, pp. 1–5, Feb. 2020, doi: 10.1088/1742-6596/1465/1/012064.
- [17] Rasmuin, E. Jais, and Sardin, "The effect of mathematics learning with using reciprocal teaching model on mathematics creative thinking ability," *Journal of Physics: Conference Series*, vol. 1477, no. 4, pp. 1–5, Mar. 2020, doi: 10.1088/1742-6596/1477/4/042041.
- [18] E. M. Schoevers, P. P. M. Leseman, E. M. Slot, A. Bakker, R. Keijzer, and E. H. Kroesbergen, "Promoting pupils' creative thinking in primary school mathematics: A case study," *Thinking Skills and Creativity*, vol. 31, pp. 323–334, Mar. 2019, doi: 10.1016/j.tsc.2019.02.003.
- [19] V. Serevina, A. L. Sarah, M. Risniawati, and W. Andriana, "Increasing students' creative thinking skills at 11th grade of mathematics and natural sciences 5, Senior High School 42 Jakarta on subject of Temperature and Heat by applying discovery learning model," *Journal of Physics: Conference Series*, vol. 1481, no. 1, pp. 1–11, Mar. 2020, doi: 10.1088/1742-6596/1481/1/012082.
- [20] S. Setiawani, A. Fatahillah, Dafik, E. Oktavianingtyas, and D. Y. Wardani, "The students' creative thinking process in solving mathematics problem based on wallas' stages," *IOP Conference Series: Earth and Environmental Science*, vol. 243, no. 1, pp. 1–7, Apr. 2019, doi: 10.1088/1755-1315/243/1/012052.




- [21] I. Setyana, T. A. Kusmayadi, and I. Pramudya, "Problem-solving in creative thinking process mathematics student's based on their cognitive style," *Journal of Physics: Conference Series*, vol. 1321, no. 2, pp. 1–5, Oct. 2019, doi: 10.1088/1742-6596/1321/2/022123.
- [22] S. Rahayuningsih, Kartinah, and M. Nurhusain, "Students' creative thinking stages in inquiry-based learning: a mixed-methods study of elementary school students in Indonesia," *Acta Scientiae*, vol. 25, no. 3, pp. 238–272, Jun. 2023, doi: 10.17648/acta.scientiae.7612.
- [23] D. Mi'rajatinnor, E. W. Abbas, R. Rusmaniah, M. Mutiani, and J. Jumriani, "Factors encouraging entrepreneurship for students of the faculty of teacher training and education, Lambung Mangkurat University," *The Kalimantan Social Studies Journal*, vol. 4, no. 1, p. 18, 2022, doi: 10.20527/kss.v4i1.5297.
- [24] E. Susanti and Hartono, "Mathematical critical thinking and creative thinking skills," in *Proceedings of the 2019 International Conference on Mathematics, Science and Technology Teaching and Learning*, New York, Jun. 2019, pp. 63–66. doi: 10.1145/3348400.3348408.
- [25] E. Titikusumawati, C. Sa'dijah, A. R. As'ari, and H. Susanto, "An analysis of students' creative thinking skill in creating open-ended mathematics problems through semi-structured problem posing," *Journal of Physics: Conference Series*, vol. 1227, no. 1, pp. 1–9, Jun. 2019, doi: 10.1088/1742-6596/1227/1/012024.
- [26] D. Yuniar, Hobri, A. C. Prihandoko, K. Aini, and A. K. A. Faozi, "The analyze of students' creative thinking skills on lesson study for learning community (LSLC) based on science, technology, engineering, and mathematics (STEM) approach," *Journal of Physics: Conference Series*, vol. 1538, no. 1, pp. 1–15, May 2020, doi: 10.1088/1742-6596/1538/1/012072.
- [27] D. Yulianti, Wiyanto, A. Rusilowati, and S. E. Nugroho, "Student worksheets based on science, technology, engineering and mathematics (STEM) to facilitate the development of critical and creative thinking skills," *Journal of Physics: Conference Series*, vol. 1567, no. 2, pp. 1–6, Jun. 2020, doi: 10.1088/1742-6596/1567/2/022068.
- [28] M. N. Espericueta-Medina, L. Sanchez-Rivera, T. Muñoz-López, C. D. Mireles-García, and L. R. Reta-Reyes, "Creativity: learning style or teaching strategy?," *Journal Schools of Economic Thought and Methodology*, pp. 17–23, Dec. 2019, doi: 10.35429/jsetm.2019.5.3.17.23.
- [29] O. Yukcu Ozturk and M. Karakus, "Examining learning styles, creative thinking skills, and academic success of eighth-grade students in Middle School," *Educational Academic Research*, vol. 48, no. 1, pp. 42–58, Mar. 2023, doi: 10.5152/aujkef.2023.1036120.
- [30] Ardianik, E. Widayat, N. Izzah, and Kusmiyati, "The level of student's creative thinking through solving open ended mathematics from learning style," *Systematic Reviews in Pharmacy*, vol. 11, no. 9, pp. 207–213, 2020, doi: 10.31838/srp.2020.9.34.
- [31] R. Purwasih, I. W. Anita, and M. Afrilianto, "Junior high school students' mathematical creative thinking ability based on gender differences in plane and solid geometry subjects," *Journal of Physics: Conference Series*, vol. 1315, no. 1, pp. 1–5, Oct. 2019, doi: 10.1088/1742-6596/1315/1/012073.
- [32] Marzuki, E. Cahya, and Wahyudin, "Relationship between mathematical creative thinking ability and student's achievement in gender perspective," *Journal of Physics: Conference Series*, vol. 1521, no. 3, pp. 1–7, Apr. 2020, doi: 10.1088/1742-6596/1521/3/032039.
- [33] L. A. Palinkas, S. J. Mendon, and A. B. Hamilton, "Innovations in mixed methods evaluations," *Annual Review of Public Health*, vol. 40, no. 1, pp. 423–442, Apr. 2019, doi: 10.1146/annurev-publhealth-040218-044215.
- [34] E. I. Nada and W. K. Sari, "Analysis of student's creative thinking ability based on gender perspective on reaction rate topic," *Jurnal Pendidikan Sains Indonesia*, vol. 10, no. 1, pp. 138–150, Jan. 2022, doi: 10.24815/jpsi.v10i1.23064.
- [35] R. Perdana, Budiyo, Sajidan, and Sukarmin, "Analysis of student critical and creative thinking (CCT) skills on chemistry: a study of gender differences," *Journal of Educational and Social Research*, vol. 9, no. 4, pp. 43–52, Oct. 2019, doi: 10.2478/jesr-2019-0053.
- [36] Marzuki, E. Asih, and Wahyudin, "Creative thinking ability based on learning styles reviewed from mathematical communication skills," *Journal of Physics: Conference Series*, vol. 1315, no. 1, pp. 1–7, Oct. 2019, doi: 10.1088/1742-6596/1315/1/012066.
- [37] L. Daniel, T. Doyle, and C. Kaesehagen, "Supporting parents to co-produce differentiated learning opportunities in mathematics," *Education 3-13*, vol. 50, no. 5, pp. 612–626, Jul. 2022, doi: 10.1080/03004279.2021.1878253.
- [38] H. Herlina, "Analysis of differentiated learning needs in mathematics subjects in class 5 of SDN 182 North Bengkulu," *JENTIK: Jurnal Pendidikan Teknologi Informasi dan Komunikasi*, vol. 2, no. 1, pp. 1–8, 2023, doi: 10.58723/jentik.v2i1.137.
- [39] A. A. Dalila, S. Rahmah, W. Liliawati, and I. Kaniawati, "Effect of differentiated learning in problem based learning on cognitive learning outcomes of High School Students," *Jurnal Penelitian Pendidikan IPA*, vol. 8, no. 4, pp. 2116–2122, Oct. 2022, doi: 10.29303/jppipa.v8i4.1839.
- [40] J. E. Jamaluddin, I. Z. Abidin, M. Azree Idris, and U. K. Masrom, "Designing lessons for differentiated learning using Moodle LMS," in *AIP Conference Proceedings*, 2022, p. 030010. doi: 10.1063/5.0098540.

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