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Creative Thinking Ability : Augmented Reality and Visualizer-Verbalizer Cognitive Style

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Abstract

This study aims to describe creative thinking ability assisted with augmented reality view from visualizer-verbalizer cognitive style. According to the previous research, there is no research focused on augmented reality and visualizer-verbalizer cognitive style in creative thinking ability. This type of research is using qualitative descriptive approach. Data were collected from 10th grade at one of Prestasi Prima Senior High School. Subjects in this study were selected 4 students of 52. The data were collected using questionnaire, creative thinking ability test assisted with augmented reality and interview. The process of selecting this subject were analyzed by the Rasch Model analysis using Winstep software. Based on data analysis, creative thinking ability assisted with augmented reality show that the visualizer student's meet all the indicators of creative thinking ability. Therefore, the verbalizer student's only meet fluency indicators or flexible and originality indicators in creative thinking ability.

Keywords: Augmented Reality; Cognitive Style; Creative Thinking Ability

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Introduction

Creativity is the highest order thinking, which leads students to generate new ways to find solution for many unpredictable problems in the future (Fatah et al., 2016; Prihatiningsih & Ratu, 2020; Widana & Septiari, 2021). We know that creativity plays an important role in high thinking level mathematical and creative thinking plays an important role in life that is one of human ability (Puspitasari et al., 2019). The creative thinking ability be possessed by students is one of the goals of mathematics (Ginting et al., 2019). There are some aspect in creative thinking ability which is fluency, flexibility, originality, and elaboration (Swandewi et al., 2019; Wahyudi et al., 2019). Students' abilities are different from each other, which is the creativity of students is needed to express new ideas (Sari & Prabawanto, 2019; Siswono, 2010, 2011).

The problem shown that students cannot improve their creative thinking ability because not all mathematics lessons provide opportunities for that, especially the thinking ability in male students was lower than that in female ones (Goodson, L, FJ. King, & Rohani, 2015; Wahyudi et al., 2019). Eventhough, become creative is one of the objectives of the Indonesian education (Kristen et al., 2019). Also, creative thinking has been stated in learning mathematics by the document of 2013 curriculum (Fatah et al., 2016). The implementation of learning in the classroom is still far from what is expected to show students' creativity (Anggraini & Zulkardi, 2020; et al., 2020). The learning process and student learning outcomes in creative thinking ability are also still be affected by the way the teacher presents the information (Yeh et al., 2019). Teachers tend to teach conventionally and domination makes the students only listen and solve the problem just as the way the teacher does, which causes passive learning to be unable to explore students' creative ideas (Fatah et al., 2016; Fatmawati, 2016; Lince, 2016; Widana & Septiari, 2021).

This condition needs to take education seriously. A change is necessary for packing an appropriate learning model (Wahyudi et al., 2019). Need to know that every student has different abilities to understand mathematics (Hadar & Tirosh, 2019). Normally, teachers only focus on the learning system and did not pay attention to the cognitive styles that students have (Tambunan, 2016). Whereas, to solve the problem with many strategies in creative thinking ability more influenced by cognitive style (Sari & Prabawanto, 2019).

Cognitive style is an important thing to improve student creativity. Characteristics or habits in learning are also called cognitive styles (Faradillah, 2018). It can be said that cognitive style has an important role in learning especially in mathematics learning (Sari & Prabawanto, 2019). Cognitive style is one factor that causes students to have different in the way of organizing and processing information (Sari & Prabawanto, 2019). According to this, incoming information is processed in two ways visually and verbally. Visualizer and verbalizer cognitive style have a direct influences when learning with text and pictures (Koć-Januchta et al., 2017). Visualizer tend to use pictures to process information, whereas verbalizer use preferenced for

word (Thomas & McKay, 2010). In visualization mathematics there is also one technology that can be applied as a medium of learning in education today, namely Augmented Reality (AR).

Augmented Reality (AR) is such a visualisation of the digital content in real time and become the newest technology used in learning or practice class (Clini et al., 2014; Pujiastuti & Haryadi, 2020). Users in this process could interact with virtual 3D objects in a real scenario because this connects virtual objects with the real world (Cai et al., 2020; Chen et al., 2013; Qumillaila et al., 2017). Besides providing a new experiences, AR technology offers multiple benefits that has positive effect on students' learning (Bujak et al., 2013; Cahyono et al., 2020; Del Cerro Velázquez & Méndez, 2021). This technology is a visualization that can be used in learning mathematics, which the visualizer cognitive style emphasizes more on images. Moreover, cognitive style has an important role in increasing creativity. There is no doubt that AR technology effective could improve students' interest which could help them to build better learning (Nincarean et al., 2013; Sahin & Yilmaz, 2020).

Based on the explanation above, creative thinking has different stage of every student's also learning process with visualizer-verbalizer cognitive style cannot be determined which one is excellent because both have their own characteristics, besides learning with AR turns out to produce different outcomes. According to research from (Sophocleous, 2013) about mathematical creative abilities, revealed that students use different strategies in creative math tasks depending on different cognitive style tendencies. Research about visualizer versus verbalizer (Koć-Januchta et al., 2017) findings that visualizer more significantly inspecting to the pictures whereas verbalizer more significantly inspecting to the word. Furthermore, research concern to Augmented Reality, findings that successfully designed on the educational program given meaningful mathematical experience for students (Cahyono et al., 2020). And the research that talk about probability learning in mathematics using augmented reality (Cai et al., 2020), it can be conclude that AR-based applications is a series of positive learning because it would be helpful for students' learning gains and students' attitude.

The difference between the writer and previous studies, there has been no research that analyzes mathematical creative thinking ability assisted with AR and viewed from visualizer and verbalizer cognitive styles in learning mathematics. Previous research only used paper entirely to analyze or provide instrument questions in students' mathematical creative thinking abilities, whereas this research developed assisted with augmented reality technology. Based on the background explanation above, this study aims to determine student's mathematical creative thinking ability with augmented reality viewed from visualizer-verbalizer cognitive styles.

Methods

This study uses qualitative descriptive aiming to identify the characteristics of the levels of students' creative thinking in mathematics. This research was conducted in class 10th grade at one of Prestasi Prima Senior High School. The subject was taken by choosing 52 students.

The research data were taken by questionnaire, test and interview. The cognitive style test in this study used the adopted VVQ (Visualizer-Verbalizer Questionnaire) designed by (Mendelson, 2004) which has been tested for its validity and reliability. The quesionnaire consisting 10 items statements of visualizer and 10 items statements of verbalizer to get subjects who had different cognitive characteristics visualizer or verbalizer. Table 1 shows the grouping the cognitive styles of visualizer-verbalizer.

Table 1. Visualizer Verbalizer Cognitive Style Grouping

Score	Cognitive Style
$VB \geq 40 \; and \; VB - VS \geq 20$	Verbalizer
$VS \geq 40 \; and \; VS - VB \geq 20$	Visualizer
$VB \leq 40 \; and \; VS \geq 40 \; or \; VB - VS \leq 20$	Negligible

The test of the creative thinking ability consisting four indicators which is fluency, flexibility, novelty, and elaboration. This test of the creative thinking ability assisted with augmented reality. The test of the creative thinking ability has been validated by expert validators with some changes form of errors, suggestions, and comments such as improvements to the use of words and the addition of mathematical symbols. The data were analyzed using the Rasch Model (WinSteps) for determine high, medium and low level of creative thinking. The data are collect in Ms. Excel and analyzed with the Rasch Model using the WinSteps software version 3.73 (Chan et al., 2021).

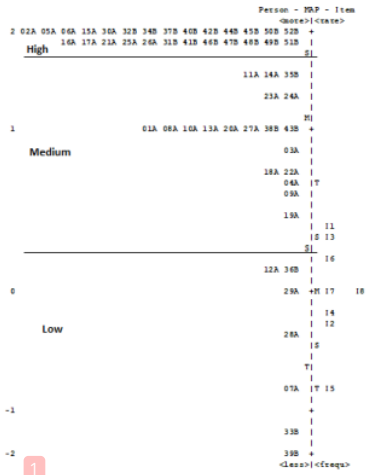


Figure 1. Wright Maps Winstep

The result of the creative thinking ability in item section of Figure 1 show that are 26 students are in the high category, 19 students are in the medium category and 7 students are in the low category. Subjects were specified based on the type of cognitive style visualizer-verbalizer and creative thinking ability. Subjects were then selected based on the creative thinking ability categories, as can be seen in table 2.

Table 2. Creative Thinking Ability Category

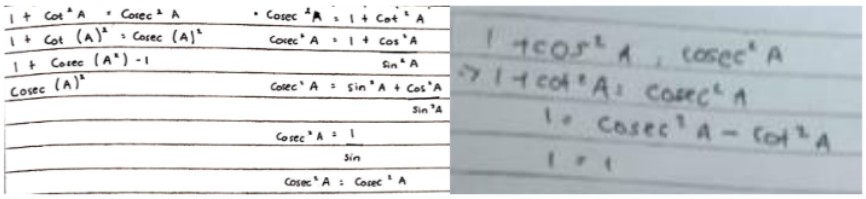
No	Cognitive	Subject	Interpretation	Code
1	Visualizer	ARN	High	Vs1
2	Visualizer	AF	High	Vs2
3	Verbalizer	NAA	Medium	Vb1
4	Verbalizer	DOS	Low	Vb2

Interviews were used to validate the results of creative thinking ability tests and scaffolding processes. Subjects who had been selected took the creative thinking ability test. The instruments consisted of 8 questions of trigonometric that were suitable for use after being validated by the experts. After taking the creative thinking ability test, the students were interviewed by the researcher. Researchers do not ask the same questions for each subject but depend on the amount of information needed by the researcher.

Results

Creative thinking ability is the ability to find various ways to solve mathematical problems. There are four indicators in creative thinking ability, namely fluency, flexibility, originality, and elaboration (Doerr, 1980). On the VVQ the results show that students' cognitive styles have differences between visualizers and verbalizers. The four subject was selected according to their cognitive style, the researcher then analyzed the students' creative thinking ability assisted with augmented reality. The use of augmented reality technology used in question number four, five and six. The results of the research will be described in accordance with the indicators of creative thinking ability.

Fluency



(a) (b)

Figure 2. (a) Visualizer Answer (b) Verbalizer Answer

Based on the results of the visualizer student's answer for question number 1, subjects Vs1 and Vs2 can answer more than one solutions with the correct clear solution. The student could do the problem fluently since the students can generate many problems with correct solutions. This result is in line with previous research (Siswono, 2011) that students show fluency when produce different ideas. The answer are different when they have different concepts or formula.

R : Do you understand question number 2 ? And how did you finish more than one answer ? Explain to me.

Vs1 : Yes, I finish it according to the command question, and for the first step I change cot^2A to $cosec^2A - 1$ and the second step I change cot^2A to cos^2A/sin^2A, so I get the same answer is $cosec^2A = cosec^2A$.

Vs2 : Yes I understand, I answered the question by flipping through the formula miss. For the first step I change $cosec^2A$ to $cot^2A + 1$ and the second step I change $cosec^2A$ to $cosec^2A - cot^2A$, I also thought of other ways besides the first and second way, that is to change $cosec^2A$ to $1/sin^2A$.

Meanwhile the results of the verbalizer student's answer for question number 1, Vb1 and Vb2 can only answer one solutions with the correct answer. This is represented not creative, that students were not able to solve a problem and represent with more than one solution (Siswono, 2011).

R : Do you understand question number 1 ? Explain to me.

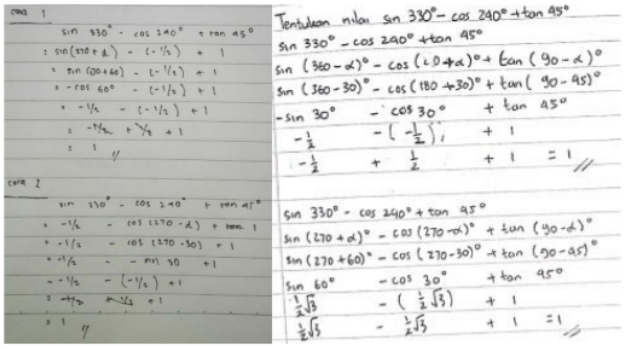
Vb1 : Yes, prove trigonometric identity.

Vb2 : Prove trigonometric identity that $1 + cot^2A = cosec^2A$.

R : Was the problem have many different solutions ? If there was, what is it ?

Vb1 : I think yes, but I don't know.

Vb2 : I don't know miss.



(a) (b)

Figure 3. (a) Visualizer Answer (b) Verbalizer Answer

Based on the results of the visualizer student's answer for question number 2, subjects Vs1 and Vs2 can answer more than one solutions with various answers correctly.

R : Do you understand question number 2 ? And how did you finish more than one answer ? Explain to me.

Vs1 : Yes I understand and I used that way because that is easier. And I'm using quadrant miss.

Vs2 : For number two it uses quadrant miss. So for the first way I change $\sin(330°)$ to $\sin(270° + \alpha)$, then for the second way I change $cos240°$ to $\cos(270° - \alpha)$.

And the results of the verbalizer student's answer for question number 2, Vb1 and Vb2 also can give more than one solutions. This is show that verbalizer students also met indicator fluency.

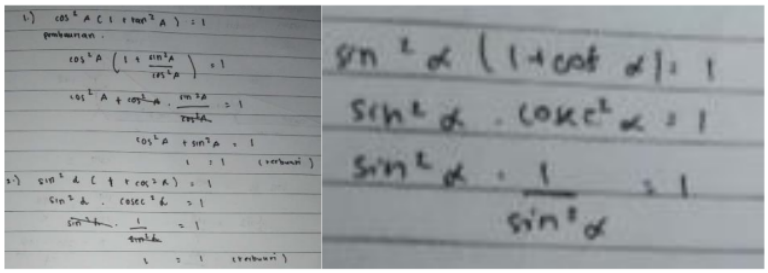
R : Do you understand question number 2 ?

Vb1 : For number two, I'm using the quadrant to find the answer miss.

Vb2 : I'm using quadrant to change sin and cos, and then I'm using table of trigonometric.

It is known that the both students easily to be able to solve the problem. Both visualizer and verbalizer students have similar concept, but the way they use the quadrant in trigonometric is different.

Flexibility



(a) (b)

Figure 4. (a) Visualizer Answer (b) Verbalizer Answer

In this case, visualizer subjects Vs1 and Vs2 can answer question number 3 in different strategies. This indicates flexibility in students ability. Although the strategy is the same, namely using trigonometric identities. The choice of technique employed was to form an trigonometric identities in pythagorean identities to produce a value of 1. Then they solve it correctly.

R : You succees to answer more than one strategies. How did you finish the problem ?

Vs1 : Because I've done things like that before miss, and I think there is more way to answer.

Vs2 : I answer it by changed the trigonometric identity. For the first step i change tan^2A to sin^2A/cos^2A and the second step i change $1 + cos^2A$ to $cosec^2A$

And the verbalizer students, Vb1 and Vb2 only can answer with one strategies.

R : You were only able to answer in one strategies. How did you finish the problem ?

Vb1 : I forgot how I answer the question.

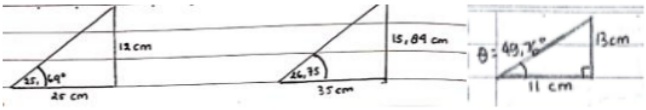
Vb2 : I just know $sin^2\alpha\ (1 + \cot\alpha) = 1$ and I forget what others.

R : Was the problem have another strategies ? If there was, what is it ?

Vb1 : I don't know.

Vb2 : I don't know miss.

Vb1 and Vb2 does not solve the problem in other strategies due to forgetting the material. This problem was very often among students. This is in line with previous research (Faradillah & Humaira, 2021) that forgetting the material is one of several factors for student errors in solving problems. Also, students have difficulty in determining flexible indicators (Siswono, 2011).



(a) (b)

Figure 5. (a) Visualizer Answer (b) Verbalizer Answer

In this case number 4, visualizer subjects Vs1 and Vs2 can write what they knows and is asked. Vs1 and Vs2 can give more than one answer.

R : You succees to answer more than one. How did you finish the problem ?

Vs1 : I use the help of a calculator miss, and this question is easier with picture.

Vs2 : I also use the help of a calculator at first miss, and when I understand the problem I answer it that way, with triangle like that.

However, the verbalizer students, Vb1 can only write down the example of the question without trying to answer and Vb2 did not answer the question.

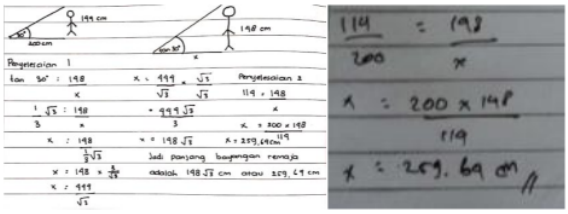
R : Do you understand question number 4 ?

Vb1 : I don't think so.

Vb2 : It seems hard.

This is in line with previous research (Puspitasari et al., 2019) that students with low ability in mathematics difficult in determaining strategies of solving problems.

Originality



(a) (b)

Figure 6. (a) Visualizer Answer (b) Verbalizer Answer

Based on the result, the visualizer student's answer for question number 5, subjects Vs1 and Vs2 can answer correctly. Vs1 and Vs2 could be finding an original solution with two solution, calculation process and correct results. At first, they using trigonometric and then they using mathematical comparasion.

R : Can you explain how you got the results ?

Vs1 : Number 5 I answer using tan 30° miss to get the shadow length. And I draw a picture to solve the problem, because if I did not draw a picture, it's not clear.

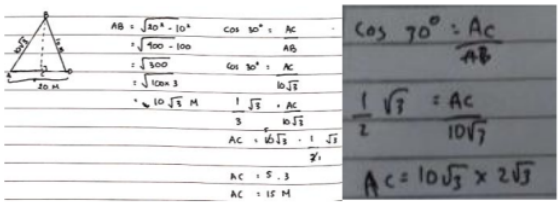
Vs2 : I answer it in two way miss. For the first step I answered directly according to the formula miss with tan 30° to find x. And the second step I used compare the child picture and teenager picture to find the shadow length. And I have to draw an ilustrasion to answer this number.

For the verbalizer students, Vb1 can answer the question briefly using mathematical comparasion and Vb2 did not answer the question. It seem have some difficulties in understanding problems (Puspitasari et al., 2019).

R : Do you understand question number 5 ?

Vb1 : I think yeah, I don't know it's true or not. But I'm compare the child and the teenager to find the shadow lenght.

Vb2 : No, I don't understand miss.



(a) (b)

Figure 7. (a) Visualizer Answer (b) Verbalizer Answer

Based on the result, the visualizer student's answer for question number 6, subjects Vs1 and Vs2 can answer with original solution also calculation process and correct results.

R : Can you explain how you got the results ?

Vs1 : At first I am looking for the length AB, and then I'm using formula cos 30° to find AC.

Vs2 : In the question asked the length AC miss, and ABD triangle is right triangle. First we looking for the length AB with pythagoras. After we found the length of AB, we can use the formula with cos 30° to find AC.

For the verbalizer students, Vb1 can answer the question but incomplete and Vb2 did not answer the question.

R : Can you explain how you got the results ?

Vb1 : I don't know miss.

Based on the interviewed, the verbalizer students dificulty to answer. This is in line with previewed researched (Siswono, 2011) that students who quite creative would say difficult because they make problems mathematically without connecting to real life.

Elaboration

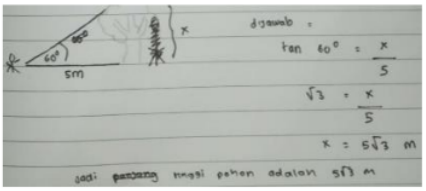


Figure 8. Visualizer Answer

Based on the results of the visualizer student's answer for question number 7, subjects Vs1 and Vs2 can solve the problem in detail. This is represented elaboration that have to explain in detail or answer specific mathematical situations (Lince, 2016). The visualizer students also draw an ilustrations to explaine more.

R : Can you explain how you got the results ?

Vs1 : First, I was asked to find the height of the tree, so I drew an illustration first. and I assume the height of the tree as Y. And then just enter the formula $\tan \alpha$ or $\tan 60°$.

Vs2 : Number seven directly uses the *tan* formula. Because it is known the side and asked the front side. So I use the formula $\tan 60°$.

And the verbalizer students, both Vb1 and Vb2 did not answer the question.

R : Why you did not answer the question ?

Vb1 : I don't understand.

Vb2 : I don't understand.

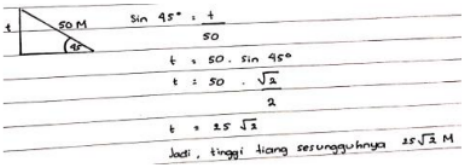


Figure 9. Visualizer Answer

Based on the results of the visualizer student's answer for question number 8, subjects Vs1 and Vs2 can solve the problem correctly. The students also give an ilustration to make triangle to explain the answer and write the conclusion at the end of the answer.

R : Can you explain how you got the results ?

Vs1 : In the problem 45° are known, the question is height and the side is known. after that I assume height as T, then enter the formula into sin 45°.

Vs2 : For number eight I use the formula sin. because sin is front side per hypotenuse, and what is known is the hypotenuse, therefore I use the formula sin 45° to determine the height of the pole.

And the verbalizer students, both Vb1 and Vb2 did not answer the question.

R : Why you did not answer the question ?

Vb1 : I don't understand, I don't have enough time.

Vb2 : I don't understand.

In this case, the verbalizer students need more time to think up the solutions. There is no preparation and not enough time to take the test. This also indicates that verbalizer students have not been able to determine the answer in the question on elaboration indicators.

Discussion

Based on the results of the study, there is a difference between the cognitive style of visualizer and verbalizer on creative thinking ability assisted with augmented reality. On the fluency indicator, the most prominent characteristic is that students can provide more than one relevant idea with a correct and clear solution. This is in line with the previous research by (Firdaus et al., 2018) with the results of his research that the fluency indicator is the highest indicator. For flexibility indicator, the aspect that is seen is to provide answers in more than one way with the correct process and calculation. Just as students determine different strategies in developing existing problems. Next, on the originality indicator is to be able to provide different solutions in general. The characteristics of originality are not only being able to provide good solutions but also being able to provide good and innovative solutions. On elaboration indicator, it can be said to have an elaboration indicator if it is able to explain an idea in detail. students not only give short answers but are also able to give the right reasons in the form of good explanations, so that other people who read will more easily understand the students' answers given.

Visualizer and verbalizer cognitive styles have differences in learning. Students who have a visualizer cognitive style tend to be more proficient in terms of images. Therefore, verbalizer students dominate in words. In using augmented reality technology, there is an affect in learning. This is in line with study by (Acesta & Nurmaylany, 2018) that there is an effect of using augmented reality media on learning outcomes. This means that indirectly interest in learning mathematics increases. However, there are obstacles for researchers such as the use of technology which is relatively new for students. Based on the description above, learning using augmented reality has a positive impact on students' creative thinking ability in mathematics, although there are differences between the cognitive styles of visualizers and verbalizers.

Conclusion

Based on the analysis and discussion results previously presented, it was produce different cognitive styles employed different outcomes in the creative thinking ability assisted with augmented reality. By taking two students with visualizer cognitive style and two students with verbalizer cognitive style then using mathematical creative thinking instrument assisted with augmented reality and processed with the Winstep application. It can be concluded that visualizer students dominate all indicators of creative thinking compared to verbalizer students.

Dealing with the category of visualizer subjects which are Vs1 and Vs2, they did not have any difficulties in understanding the problems given. They are making a step in carefully with any strategies and various ways. And students with a visualizer cognitive style can meet all the indicators of fluency, flexibility, originality, and elaboration.

However, the verbalizer subjects which are Vb1 and Vb2 have difficulty understanding the problems. Their ideas were less in ways and strategies. Also making steps toward the solution they still encountered many obstacles. The verbalizer students only meet fluency indicators or flexible and originality indicators in creative thinking. The elaboration indicator of creative thinking has not emerged yet in the students with a verbalizer cognitive style.

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Describe acknowledgement if any.

Conflicts of Interest

The authors declare that no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely by the authors.

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