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Flipped Classroom Learning: Mathematical Creative Thinking Skills Based on Mathematical Resilience using Augmented Reality

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Abstract: Flipped Classroom Learning: Mathematical Creative Thinking Skills Based on Mathematical Resilience using Augmented Reality. **Objectives:** This study aims to determine the effect of the augmented reality (AR)-based flipped classroom learning (FCL) model on mathematical creative thinking skills (MCTS) in terms of mathematical resilience (MR). **Methods:** This research is a quasi-experimental quantitative research. The population of this study were students of SMAN 105 Jakarta with the research sample being the experimental class students and the control class selected purposively. Data analysis in this study used the Mann Whitney U Test, Cohen's d Effect Size Test and Spearman Correlation to determine the difference. **Findings:** Subjects on experimental group have mathematical creative thinking skills that are superior to subjects with conventional mathematics learning. **Conclusion:** The AR-based FCL model has a significant effect on the MCTS owned by subjects. In addition, KBKM has a significant relationship with MR.

Keywords: flipped classroom learning, mathematical creative thinking skill, mathematical resilience, augmented reality.

Abstrak: Flipped Classroom Learning: Kemampuan Berpikir Kreatif Matematis berdasarkan Resiliensi Matematis menggunakan Augmented Reality. ***Tujuan:*** *Penelitian ini bertujuan untuk mengetahui pengaruh model flipped classroom learning (FCL) berbasis augmented reality (AR) terhadap kemampuan berpikir kreatif matematis (KBKM) berdasarkan resiliensi matematis (RM).* ***Metode:*** *Penelitian ini merupakan penelitian kuantitatif kuasi eksperimen. Populasi penelitian ini adalah siswa SMAN 105 Jakarta dengan sampel penelitian adalah siswa kelas eksperimen dan kelas kontrol yang dipilih secara purposive. Analisis data dalam penelitian ini menggunakan Mann Whitney U Test, Cohen's d Effect Size Test dan Spearman Correlation untuk mengetahui perbedaannya.* ***Temuan:*** *Subjek pada kelompok eksperimen memiliki kemampuan berpikir kreatif matematis yang lebih unggul dibandingkan subjek dengan pembelajaran matematika konvensional.* ***Kesimpulan:*** *Model FCL berbasis AR berpengaruh signifikan terhadap MCTS yang dimiliki subjek. Selain itu, KBKM memiliki hubungan yang signifikan dengan MR.*

Kata kunci: *flipped classroom learning, kemampuan berpikir kreatif, resiliensi matematis, augmented reality.*

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INTRODUCTION

Creative thinking skills is one of the components to support 4C skills in the 21st century that must be possessed by all roles in the world of education, especially for challenges in learning mathematics (Ayele, 2016; Mantra et al., 2022; Miatun & Khusna, 2020). Mathematics can equip students for competencies for 21st century learning that are needed in several countries, one of which is the creative thinking skills (Care & Lou, 2016; S. Tan et al., 2020). Mathematical creative thinking ability is an intellectual skill that students have to understand a problem with the problem solving process using imaginative (divergent) and factual (convergent) strategies. (Kadir et al., 2017; S. Y. Tan & Halili, 2015; Yazar Soyadý, 2015).

In learning mathematics, mathematical creative thinking skills (MCTS) help students express their opinions on a problem with various new and unique solutions, besides that creative thinking skills are useful for facing challenges in the future (Muthaharah et al., 2018; Purwasih, 2020). From this, the ability to think creatively has many uses in learning mathematics. However, behind the many uses of MCTS, there are still many studies that find that students' creative thinking skills are still low. the low percentage of creative thinking skills in students lies in the originality indicator (12.5%) (Abidin et al., 2018; Sugiyanto et al., 2018). The low ability to think creatively is due to the lack of developing creative thinking skills in students. The development of creative thinking skills in students, sometimes students will feel quickly giving up and despair so that other abilities are needed so that students can survive and make themselves more advanced (Purwasih, 2020).

Mathematical resilience (MR) in students is very helpful in solving problems, besides that students who are equipped with resilience abilities will always be motivated in every learning process to achieve academic achievement, MR possessed by students makes the personality will be tough in adapting to face challenges and problems in all situations and conditions, especially in learning (Faradillah & Wulandari, 2021; Rahmmatiya & Miatun, 2020; Zanthy, 2018). Mathematical resilience is a quality attitude in the mathematics learning process which includes: self-confidence in its success, perseverance and desire to practice, self-reflection and willingness to research (Hernandez-Martinez & Williams, 2013; Ishak et al., 2020; Johnston-Wilder, S & Clare, 2010). From this, mathematical resilience has an important role as another supporting ability in developing students' mathematical creative thinking skills. The role of MR has a positive influence on the achievement of creative thinking skills, the higher the level of students' MR causes the higher the achievement of students' MCTS, MR is very suitable for transformative education, especially to develop students' creative thinking skills (Dilla et al., 2018; Lee & Johnston-Wilder, 2017). From this, the development of MCTS and MR in students is needed by designing teaching materials that can be started from learning that utilizes current technology.

Learning that utilizes technology today is an alternative so that students do not feel bored in the learning process. This is in line with students' low mathematical creative thinking skills that can occur because many people think mathematics is a boring subject (Ginting et al., 2019). The learning model that can utilize technology is the flipped classroom learning model. In the application of the flipped classroom learning model, learning will be more flexible because students will be able to learn anytime and anywhere using the technology available in this flipped classroom model, so students can pause, rewind and review the material they are learning *class* (Akçayýr & Akçayýr, 2018; Ozdamli &

Asiksoy, 2016). The flipped classroom learning model can be supported by Augmented Reality (AR) technology (Höllerer & Feiner, 2019). Flipped classroom learning can stimulate students' MCTS with augmented reality (AR) technology, besides that students' MR can be the basis of innovation in flipped classroom learning activities (Al-Zahrani, 2015; Ferrer-Torregrosa et al., 2016; Harris et al., 2016).

Several relevant studies are related to creative thinking skills, flipped classroom learning, and AR. The first study, which was conducted by Al-Zahrani (2015) with the theme of flipped classroom learning and creative thinking skills, showed that flipped classrooms can effectively stimulate students' creativity (Al-Zahrani, 2015). Second, research by Wulandari et al (2020) with the theme of creative thinking skills and AR shows that creative thinking skills are further enhanced by AR-based learning (Wulandari et al., 2020). Then, Hendriana et al's research (2019) with the theme of creative thinking skills, mathematical resilience and problem posing methods showed better creative thinking skills using the problem posing method, and there was no relationship between resilience and creative thinking skills (Hendriana et al., 2019). In this study, there is still no research that combines mathematical creative thinking skills, mathematical resilience of flipped classroom learning models, and AR. Thus, the novelty in this study is that the researcher has the aim of determine how the effect of treatment mathematics learning with the augmented reality (AR)-based flipped classroom learning (FCL) model on creative thinking skills in terms of mathematical resilience.

METHODS

The implementation of this study used an quasi experimental method with a post-test only control group research design and a descriptive quantitative approach.

Table 1. Post-test only control group design (Krishnan, 2019)

Class	Treatment	Post-test
Experimental Class Group	X_1	O_1
Control Class Group	X_2	O_2

Table 1 shows the research design post-test only control group design, where X_1 and X_2 are the treatments carried out, X_1 is the treatment using the AR-based FCL model in the experimental group while X_2 is the treatment in the control class using conventional learning. On the other hand, O_1 and O_2 represent the experimental and control groups, respectively. In this study, the population used was students of SMAN 105 Jakarta. The sampling technique used in this study is the purposive sampling method, purposive sampling is a technique of determining and taking samples determined by the researcher with considerations for certain purposes (Suharsimi, 2019). The sample selection being purposively selected, namely class 40 students from class X_1 MIPA A as the experimental class and 40 students from class XI MIPA D as the control class. This research was conducted for 3 months.

The data generated in this study will go through an analysis process using Cohen's d Effect Size Test and Spearman Correlation whose calculations use IBM SPSS 24 to answer research questions, namely knowing the effect of treating mathematics learning with a flipped classroom learning (FCL) model based on augmented reality (AR). in the experimental group and conventional mathematics learning treatment in the control group. The decision making criteria

in the Effect Size Test uses the interpretation presented in table 3 (Sawilowsky, 2009). Before the Cohen's d Effect Size test was carried out, Mann Whiteney first conducted it. The Mann Whiteney test was conducted to determine whether there were differences in the data groups. The analysis on this hypothesis test was carried out through IBM SPSS 24.

Table 2. Estimated value of effcect size (Sawilowsky, 2009)

Estimated Value	Interpretation
0 - 0.01	Low Effect
0.01 - 0.2	Medium Effect
0.2 - 0.5	High Effect
0.5 - 0.8	Very High Effect

The instrument used is a description test of mathematical creative thinking skills and a non-test instrument in the form of a mathematical resilience questionnaire that has been validated by experts and has been tested for validity. The validated mathematical resilience questionnaire consists of 20 positive statements and 9 negative statements adopted from (Kooken et al., 2016). The indicators of mathematical resilience used are: 1) Value, believes that mathematics is a valuable subject and deserves to be studied; 2) Struggle, the acknowledgment that the struggle with mathematics is universal, it even applies to people with high-level skills; 3) Growth, the conviction that everyone can develop mathematical skills; 4) Resilience, awareness of difficult situations in learning mathematics that produces a positive response (Kooken et al., 2016; Lee & Johnston-Wilder, 2017; Zanthy, 2018).

Table 3. Instrument mathematical resilience

Indicator	Item	Many Items
Value	1, 2, 3, 4, 5, 6	6
Struggle	7, 8, 9	3
Growth	10, 11, 12, 13, 14, 15	6
Resilience	16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29	14
Total		29

Then for the mathematical creative thinking ability test instrument there are indicators: 1) fluency (thinking smoothly) which is being able to find various solutions; 2) flexibility (think flexibly) is to produce or create many answers; 3) originality (thinking authentically) that is being able to create unique answers; 4) elaboration (thinking elaboration), namely elaborating an idea by detailing an idea (Hendriana, H., & Soemarmo, 2014; Prasetiyo & Mubarokah, 2014; Puspitasari et al., 2021).

The validity and reliability of the two instruments were carried out using the Rasch Model in Table 2 below based on the criteria (Sumintono & Widhiarso, 2014). The Rasch model is used because it is considered capable of seeing the interaction between items and respondents simultaneously, so one value is not only seen from the raw score but the logit value that can reflect the probability of selecting an item against a collection of respondents (Muntazhimah, 2019; Ölmez & Ölmez, 2019).

The validation process is carried out by two expert validators and then tested on students to see validity and reliability. Based on the criteria in table 2, the results show that the average of all items on the test and non-test questions are valid and reliable with Cronbach's Alpha for the creative thinking ability test instrument of 0.95 and 0.84 for the mathematical resilience instrument in the very high category (Faradillah & Febriani, 2021). Thus, it can be used to be tested on students in the experimental group and the control group.

Table 4. fit Indicates (Sumintono & Widhiarso, 2014)

Statistic	Outfit Mean Square Values (MNSQ)	Outfit Z-Standarized Values (ZSTD)	Point Measure Correlation (PTMEA-CORR)
Fit Indicates	0.5 – 1.5	(-2.0) – (+2.0)	0.4 – 0.85

RESULTS AND DISCUSSION

Mann Whiteney statistical test in the control and experimental groups using the post test scores obtained on both of the test instruments for the description of mathematical creative thinking skills (MCTS) and mathematical resilience (MR) questionnaires are presented in Table 4.

Table 5. The results of the Mann-Whitney U-Test of MCTS and MR questionnaire

		MCTS		MR	
		Experimental	**Control**	**Experimental**	**Control**
N	Valid	40	40	40	40
	Missing	0	0	0	0
Mean		84.95	51.55	151.73	97.15
Mann-Whitney U		83.50		293.50	
Asymp. Sig. (2-tailed)		.000		.000	

Table 5 shows that the MCTS of students in the experimental class with a mean = 84.95 was significantly higher than the control class students with a mean value of 51.55. Then it is known that the value of Asymp.Sig. (2-tailed) = 0.001 which is below = 0.05 which indicates H_1 is accepted. On the other hand, the students' MR in the experimental class with a mean = 151.73 was significantly higher than the control class students with a mean = 97.15. Then it is known that the value of Asymp.Sig. (2-tailed) = 0.001 which is below = 0.05 which indicates H_1 is accepted. So that it shows that there is a significant difference between the control and experimental groups on students' mathematical creative thinking abilities and mathematical resilience. The results of the calculation of the Mann Whitney test using SPSS in Table 4 between the control and experimental groups on mathematical creative thinking skills (MCTS) and mathematical resilience (MR) show a significant difference, the control class is lower than the experimental class. Based on the research results that have been obtained, it shows that learning with the AR-based FCL model has an influence on students' MCTS. This can be seen through the post-test average score of the MCTS of control group students with conventional learning was less than experimental group students with AR-based FCL learning model (51.55 < 84.95). This is supported by the value of Cohen's d Effect Size test which shows the effect in the large category (1.934). In line with the findings which state that learning with the FCL model has an effect on students' MCTS compared to conventional learning (Al-Zahrani, 2015). besides that, MCTS are further increased with AR-based learning (Wulandari et al., 2020).

Table 6. Cohen's d effect size of the test mcts and mr

Aspect	Control Group		Experimental		d
	Mean	SD	Mean	SD	
MCTS	51.55	17.44	84.95	10.09	2.34
MR	97.15	23.69	151.73	16.81	2.66

Table 6 shows the Cohen's d Effect Size test value based on the total score of the post-test instrument for MCTS and MR. The results obtained that the experimental group on the aspect of MCTS has a d value of 2.34 which is categorized as a large category, then on the aspect of MR it has the most significant effect size with a large effect of 2.66 and is in the large category (Sawilowsky, 2009). This is supported by the value of Cohen's d Effect Size test which shows the effect in the large category (1.934). In line with the findings which state that learning with the FCL model has an effect on students' MCTS compared to conventional learning (Al-Zahrani, 2015). besides that, MCTS are further increased with AR-based learning (Wulandari et al., 2020)

Table 7. Spearman correlation of MCTS and MR

		MCTS	MR
MCTS	Correlation Coefficient	1.000	0.656**
	Sig. (2-tailed)	.	0.001
	N	80	80
MR	Correlation Coefficient	0.656**	1.000
	Sig. (2-tailed)	.001	.
	N	80	80

**Correlation is significant at the 0.01 level

Table 7 shows the results of the Spearman correlation test with the value obtained between the post-test score of MCTS and MR in the experimental class with learning using AR-based FCL of 0.001 less than 0.05. The correlation coefficient value of 0.656 with a percentage of 65.6% shows a very strong correlation between MCTS and MR. So that it shows a significant influence and correlation between MCTS and MR. Based on the results of the Spearman correlation test, it was obtained that the MCTS and MR in the experimental class using AR-based FCL showed a significant effect and correlation between the two ($r = 0.656$, $p < 0.05$) and the percentage was 65.6%. This is based on the findings that result in MR with MCTS to have a very strong relationship and influence or can be said to have a positive relationship (Dilla et al., 2018). The positive relationship between MCTS and MR in the experimental class using AR-based FCL is strengthened by the findings which state that FCL learning with visual aids (AR) can improve students' MCTS (Al-Zahrani, 2015; Ferrer-Torregrosa et al., 2016). In addition, classes with the FCL learning model can be assisted or supported by the MR possessed by students (Harris et al., 2016).

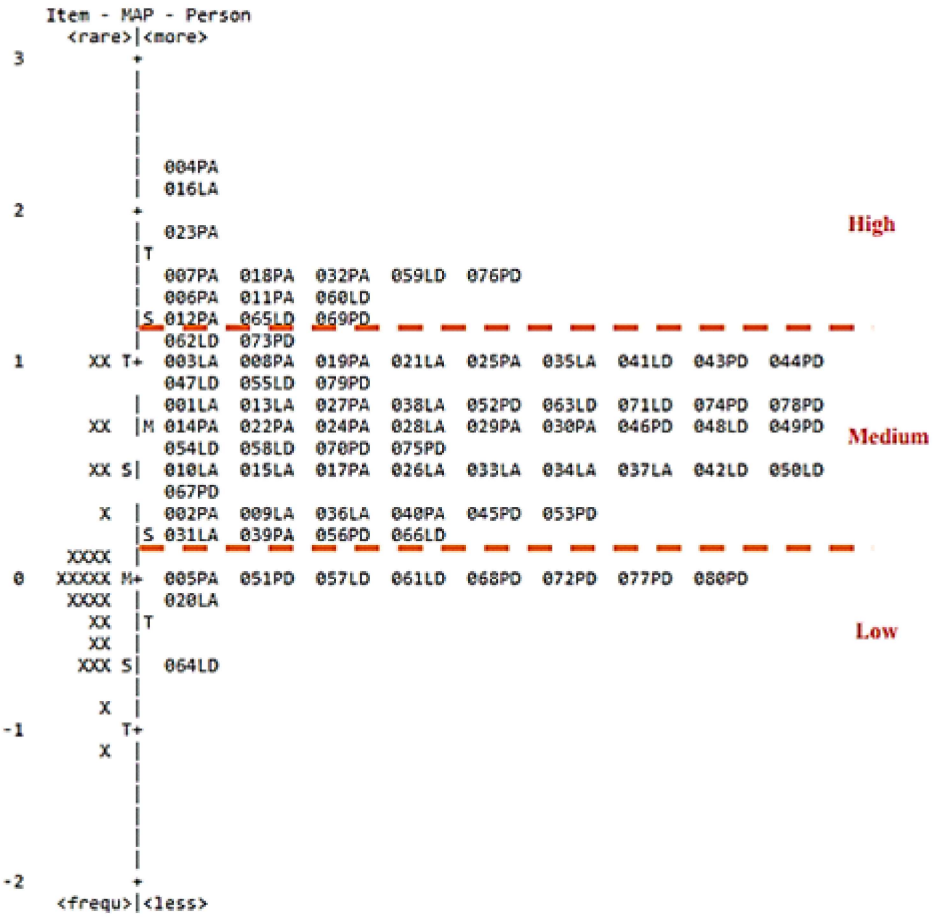

Figure 1. Person wright maps table of mr respondent categories

Figure 1 shows the WinSteps data based on the Wright Maps table. Data came from 80 respondents who filled out a mathematical resilience questionnaire and analyzed using WinSteps. Characteristics of respondents with high, medium, and low resilience shown in the column to the right are given a numeric code indicating the respondent's number and a letter code indicating gender and class. Meanwhile, the distribution of items (questionnaire items) is shown by the left column. The highest distribution of respondents is in the moderate category of resilience with a frequency of 56 respondents and respondents with low resilience categories have the lowest distribution with a frequency of 10 respondents. Students in the moderate resilience category tend to be easily satisfied with what they receive but still have worries and anxiety when faced with situations ('Athiyah et al., 2020; Sari & Untarti, 2021).

Table 8. Quantity of students based on the category of MR

MR Categories	Quantity
High	14
Medium	56
Low	10

Table 8 shows that from 80 students as respondents, there were 10 students who had low resilience in challenges or obstacles in mathematics, in contrast to 14 students who had strong resilience when they had obstacles in mathematics. The distribution of the highest resilience category is in the medium category, namely 56 students. According to the percentage there are 12.5% for students with low resilience category, 17.5% for students with high resilience category, and 70% for students with moderate resilience category.

Based on the results of the Wright Maps MR of students in the group given the treatment of AR-based FCL learning with students with conventional learning in Figure 1, it can be seen that the distribution of the highest student MR categories is in the medium resilience category with a percentage of 70%. Meanwhile, high and low MR students have 17.5% and 12.5%, respectively. Through Wright Maps, it is also seen that the MR of students in the high category is dominated by students with AR-based FCL learning and low MR is dominated by students with conventional learning.

Dilla et al (2018) stated that the relationship and contribution of MR to MCTS was 86.6% (Dilla et al., 2018). Students with low MR categories tend to find it difficult and do not have resilience when given questions about MCTS (Himawan et al., 2021). In addition, there are findings related to students with high MR categories, if conditioned by difficult situations, they will continue to try to achieve their academic achievements (Zanthy, 2018). To find out the distribution of students' mathematical creative thinking skills with AR-based FCL learning, it can be seen through three categories of MR taken from the figure 1 person Wright Maps table.

Soal Post-test Instrumen Kemampuan Berpikir Kreatif	
1. Selesaikan integral dibawah ini dengan dengan menggunakan lebih dari satu cara. $\int 2x(x^2+1)^2\,dx$	2. Tentukan beberapa kemungkinan jawaban dari $\int (x-2)(ax^2-bx+c)^n\,dx$, jika: $a = (6 \times 3) : 9$ $b = (2+4) : 2+5$ $c = bilangan\ ganjil$ $n = angka\ kelipatan\ 3$
3. Sebuah persamaan kurva $y = f(x)$ memenuhi syarat bahwa $\frac{dy}{dx} = 2x - \frac{1}{x^2}$ dan kurva tersebut melalui titik $(1, 4)$ maka tentukanlah persamaan kurva tersebut dengan menggunakan caramu sendiri.	4. Jika diketahui fungsi biaya marginal dari suatu produk: $Mc = f(Q) = 800 + 2Q$ Tentukan biaya total (Tc), jika biaya tetap (Fc) atau K sebesar $Rp.2000$ dan banyaknya barang (Q) adalah 50. Catatan $Fc = K = konstanta\ sembarang$ $Q = banyaknya\ barang$ $Tc = \int Mc\,dQ$

Figure 2. Posttest instrument for MCTS

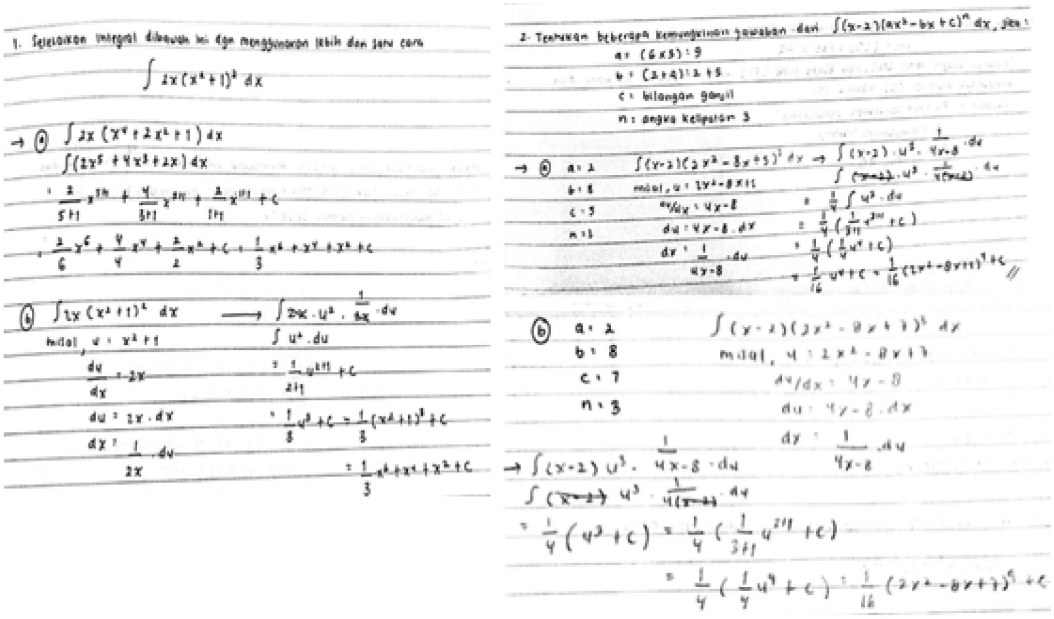

Figure 3. Posttest response results of MCTS with high MR

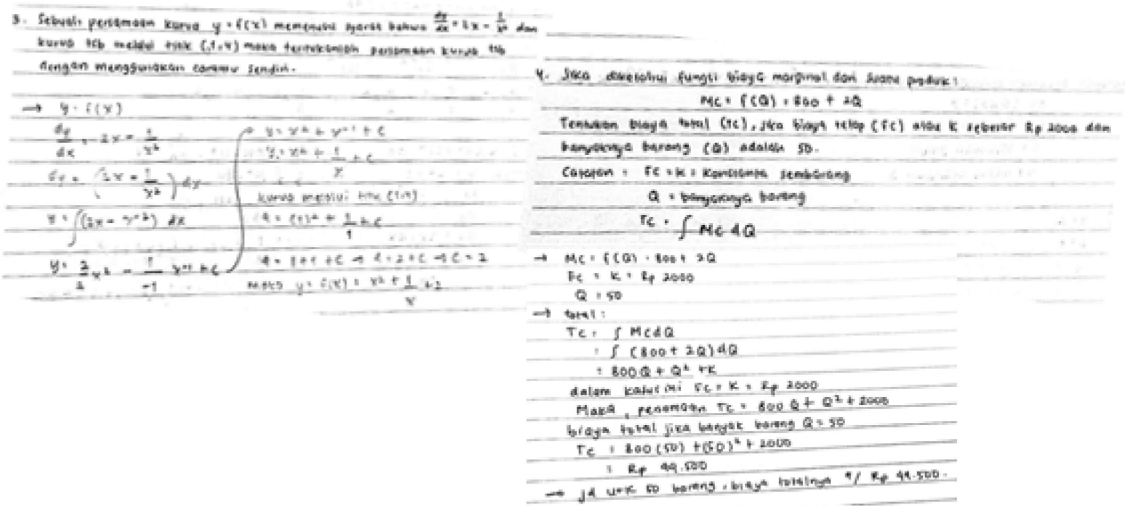

Figure 4. Posttest response results of MCTS with high MR

Figure 3 and 4 above shows the results of students working with code 004PA in the high resilience category who can easily complete the post-test of MCTS. Students whose learning is given the AR-based FCL model are able to fulfill all indicators of fluency, flexibility, originality, elaboration. In the indicators of fluency and flexibility students are able to provide answers to more than one solution (varied) and provide more than one relevant idea and the calculation process for the completion is correct and clear. The originality and elaboration indicators provide answers in their own way and provide correct and detailed answers. This indicates that students with high MR categories, when conditioned with difficult situations, will continue to try to solve problems correctly and appropriately (Dilla et al., 2018; Zanthy, 2018).

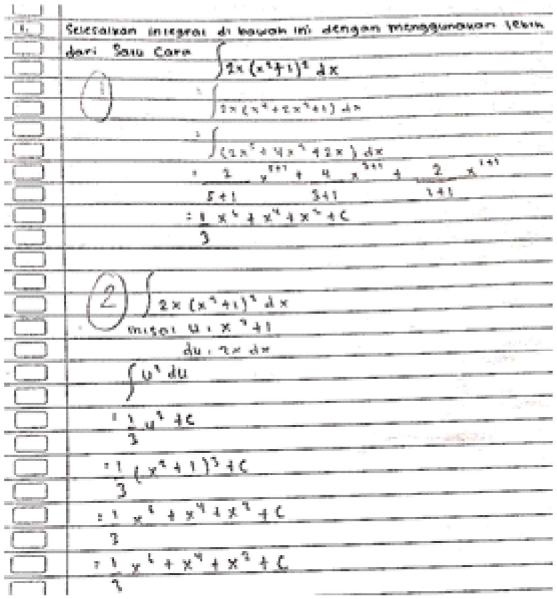

Figure 5. Posttest response results of MCTS with medium MR

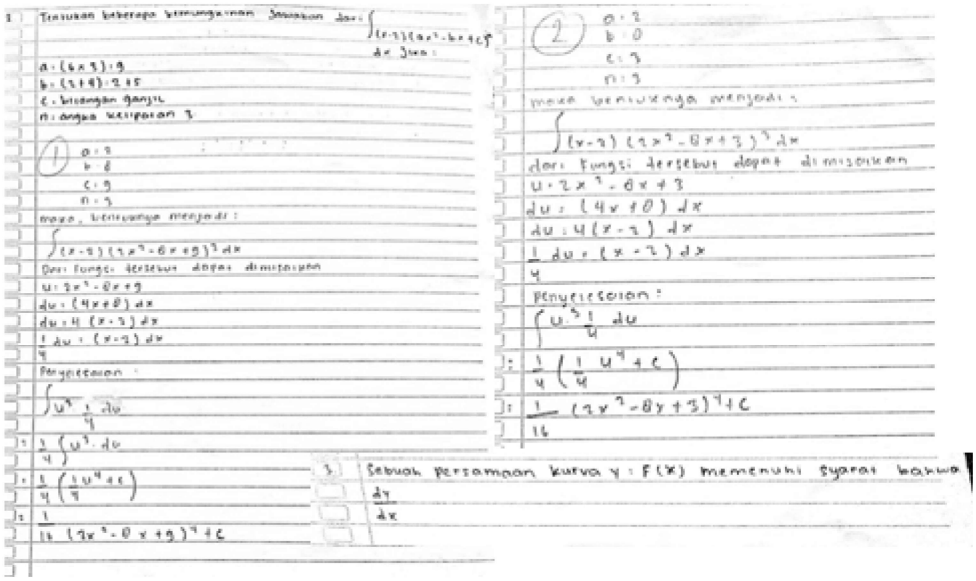

Figure 6. Posttest response results of MCTS with medium MR

Figure 5 and 6 above shows the results of the work of students with code 040PA with the moderate resilience category being able to solve 2 questions, namely those consisting of indicators of fluency and flexibility. Students whose learning is given the AR-based FCL model are only able to meet the fluency and flexibility indicators, students are able to provide answers to more than one solution (varies) and provide more than one relevant idea and the calculation process for the completion is correct and clear. However, on the originality and elaboration indicators, students did not appear to be working on and solving problems. this category of moderate resilience has difficulty answering math problems because of concerns and anxiety when working on questions (’Athiyah et al., 2020; Sari & Untarti, 2021).

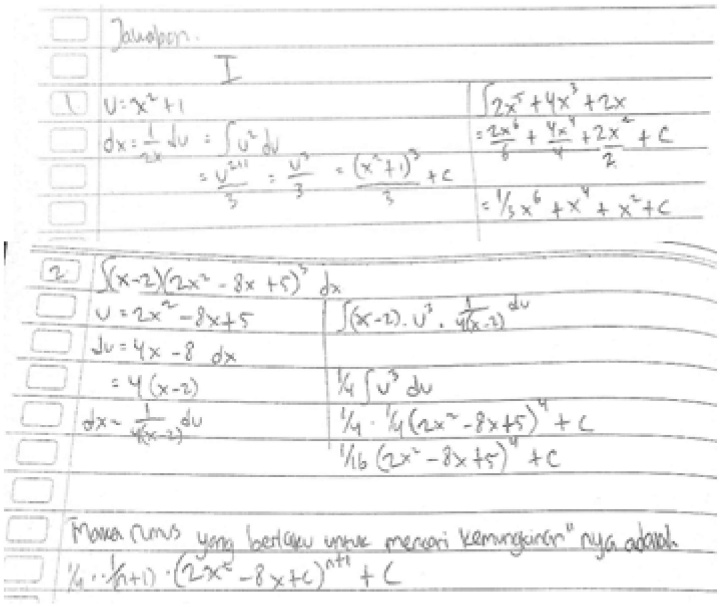

Figure 7. Posttest response results of MCTS with low MR

Figure 7 above shows the results of students working with code 064LD with the low resilience category being able to solve 2 questions. It can be seen in the results of the responses. Students in the control class have completed with more than one solution, but the answer is still not correct. This indicates that the fluency and flexibility indicators for students have not met. In addition, students have not been able to meet the originality and elaboration indicators, because students do not seem to be working on questions with originality and elaboration indicators. This is in line with students with low mathematical resilience categories having difficulty understanding a problem because they cannot understand the concept well so they cannot make the right strategy in solving the given math problem ('Athiyah et al., 2020; Sari & Untarti, 2021).

■ CONCLUSIONS

Learning mathematics using the AR-based flipped classroom learning model has a significant effect on students' mathematical creative thinking skills, showing an influence in large categories and having a good relationship. Meanwhile, students in this class are dominated by high category mathematical resilience. Therefore, students with learning mathematics using the AR-based flipped classroom learning model have better mathematical creative thinking skills than students with conventional mathematics learning. Based on Wright Maps, the high category of mathematical resilience is dominated by students who learn using the AR-based flipped classroom learning model. While the low category resilience is dominated by students with conventional learning. This shows that students with learning using the AR-based flipped classroom learning model are more active and enthusiastic in learning compared to students with conventional learning.

Based on the results of research that has been done, teachers can apply learning using the AR-based flipped classroom learning model and other supporting media that can help the learning process. In the future, researchers can explore the media used in learning with more contrasting variables and subjects.

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