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Effect of Learning Using Geogebra Software on Mathematical Critical Thinking Ability Based on Adversity Quotient

Fitri Alyani[1]*, Natalia Dinda Sartika Putri[2] (iD)

[1,2] Department of Mathematics Education, University of Muhammadiyah Prof.DR.Hamka, Jakarta, Indonesia
*Corresponding author: fitrialyani@uhamka.ac.id

Abstrak

Penelitian ini ialah penelitian kuantitatif eksperimen dengan tujuan mengetahui pengaruh pembelajaran menggunakan *software GeoGebra* terhadap kemampuan berpikir kritis matematis berdasarkan *adversity quotient*. Populasi penelitian ini yaitu siswa SMA kelas XII di Jakarta dan sampel yaitu 40 siswa yang berasal dari kelas eksperimen dan 40 siswa berasal dari kelas kontrol dengan pembelajaran konvensional dan dipilih secara purposive. Instrumen tes didasarkan pada penilaian kemampuan kritis matematis dan non-tes berupa angket *adversity quotient*. Hasil yang diperoleh dari pembelajaran matematika menggunakan *software GeoGebra* memiliki kemampuan berpikir kritis lebih baik dari siswa dengan pembelajaran matematika konvensional. Berdasarkan *Wright Maps, adversity quotient* siswa tipe *climber* didominasi oleh siswa dengan pembelajaran menggunakan *GeoGebra*. Sementara tipe *quitter* didominasi oleh siswa dengan pembelajaran konvensional.

Kata kunci: *Adversity Quotient*; Kemampuan Berpikir Kritis Matematis; *Geogebra Sofware*

Abstract

This research is experimental quantitative research with the aim of knowing the effect of learning mathematics using GeoGebra software on mathematical critical thinking skills based on the adversity quotient. The population of this research is high school students of class XII in Jakarta and the sample is 40 students from the experimental class and 40 students from the control class with conventional learning and selected purposively. The test instrument is based on an assessment of critical mathematical abilities and a non-test in the form of an adversity quotient questionnaire. The results obtained from learning mathematics using GeoGebra software have better critical thinking skills than students with conventional mathematics learning. Based on the Wright Maps adversity quotient climber-type students are dominated by students who study using GeoGebra. While the quitter type is dominated by students with conventional learning.

Keywords: Adversity Quotient; Mathematical Critical Thinking Ability; Geogebra Software

1. INTRODUCTION

Mathematical critical thinking is the foundation of the thinking process in generating ideas, analyzing arguments, and developing a logical mindset (Dhayanti et al., 2018; Wahyu Hidayat & Sari, 2019; Wechsler et al., 2018). The thought process in question is carried out, so that in learning not only remember and know the concept but to the stage of developing a mindset and applying it in a structured manner. For this, Batubara (2019) states that critical thinking is not only able to remember or know the concepts that have been studied but, in the process, can express again with other easy-to-understand concepts, interpret data and apply concepts based on structured logical thinking patterns.

Referring to the content standards contained in primary and secondary education units in mathematics subjects by teachers, among others, there are analytical, logical, creative, systematic, and critical thinking skills, that can work together (Asmar & Delyana, 2020). The re-application of mathematical critical thinking skills in the 2013 curriculum has the aim that, in learning, students will be able to start thinking critically (Wulandari, 2020). Because they need critical thinking skills to overcome their problems in life (Delina et al., 2018). Paul and Elder (2019) developed indicators of critical thinking skills which include the identification

process, analysis of the results of identification, then evaluation, and finally the conclusion process. Based on this, critical thinking skills are important for students to have because they can develop a logical mindset, can think rationally, and apply them in dealing with problems in the learning process.

However, the importance of critical thinking skills is not accompanied by an optimal learning approach and one's initial abilities, so it influences studies related to the results of skills in mathematical critical thinking. This is based on the findings (W. Hidayat & Aripin, 2019) which state that the learning approach and initial abilities cannot meet the achievement of mathematical critical thinking skills. Not only initial abilities and approaches to learning mathematics are the determinants of success, but there is also an attitude factor in it. Mathematical critical thinking according to Rahayu and Alyani (2020) is an ability that demands being able to solve all the problems it is facing. To be able to fight through this challenge, the Adversity Quotient plays an important role in solving the problems in it.

Adversity Quotient (AQ) is a concept that was first put forward by Paul Stolz in measuring how hard a person's struggles and ability to solve problems is also one of the attitude factors that influence mathematical critical thinking skills in mathematics subjects (Rahayu & Alyani, 2020). This can be seen in Quitter's difficulty in solving existing problems and is classified as weak in critical thinking achievement, namely at an average score of 4.27 (Sari & Hidayat, 2019). Adversity quotient is divided into three types: Climber, Camper, and Quitter. In this initial type (Climber), whatever pressure a person faces will tend to be able to persist in solving the problems at hand. The second type (Campers) tend to be satisfied with what they get and don't want to take high risks. Then, in the third type (Quitters) a person tends not to want to try to be able to solve the problem, and gives up easily. So that the three types can also be used as indicators of a person facing difficulties(Wahyu Hidayat et al., 2018; Wulandari, 2020). Wahyu Hidayat & Sari (2019) stated that the adversity quotient plays a role in influencing the achievement of mathematical critical thinking skills. This is supported by research that reveals the effect of Adversity Quotient on mathematical critical thinking skills by 75%, especially for the camper type (Rahayu & Alyani, 2020). Through the ability to solve a challenge, one can train one's mathematical critical thinking skills (Supandi & Senam, 2020). So mathematical critical thinking skills are very important because they influence the Adversity Quotient aspect.

There have been several studies in recent years related to the adversity quotient, namely, Rahayu & Alyani (2020), Wahyu Hidayat & Sari (2019), Wahyu Hidayat et al. (2018), Yanti et al. (2018). Rahayu & Alyani (2020) discuss that the largest distribution of AQ type is in the camper type by 69.23%, and 75% of AQ has an influence on mathematical critical thinking ability while the rest comes from external factors. Wahyu Hidayat and Sari (2019) stated that the lowest achievement when solving questions was seen in the quitter type students and the highest in the camper type. Thus, the influence given by AQ on the achievement of critical thinking is good. Wahyu Hidayat et al. (2018) in their research found that AQ had a large effect on the argumentation ability of prospective teachers by 60.2% and other factors 39.8%. Then Yanti et al. (2018) show that climber 1 students can fulfill all wallas indicators with moderate completeness, climber 2 students have difficulty on several indicators so climber 2 students have creative abilities in the medium category.

Developments and changing times require humans to be able to think critically, logically, creatively, take initiative and be adaptive to change (Yanti et al., 2018). This requires rapid technological developments with both positive and negative impacts on life, including in the world of education through learning media. Batubara (2019) stated that mathematical critical thinking skills increased with the help of learning media in the form of GeoGebra software compared to without GeoGebra software. Geogebra is an open-source mathematical software program that can be accessed by anyone with an internet network. Not

only that, this software is easy to use because it combines the features of calculus, algebra, and geometry, which supports the construction of lines, points, and all conic sections, so this geometry software is dynamic (Birgin & Acar, 2020; Ishartono et al., 2022). Geogebra has a menu that is presented complete with icons that are easy to understand to make learning more interactive (Rohaeti & Bernard, 2018). Alkhateeb and Al-Duwairi (2019), also said Geogebra Software with features that make it easier for teachers and teachers to interact to solve math problems, has a positive influence and can deepen mathematical critical thinking.

Therefore, this study aims to elaborate mathematical critical thinking skills using GeoGebra software based on students' AQ. In this study, it will be seen whether there is an effect of learning mathematics using GeoGebra software on critical thinking skills in terms of AQ.

2. METHOD

In achieving the objectives of this study, the method used was experimental with posttest only control group design (Table 1) and a quantitative approach. To find out how the effect of mathematics learning treatment using Geogebra software in the experimental group and conventional mathematics learning treatment in the control group on mathematical critical thinking ability (MCTA) based on the adversity quotient (AQ).

Table 1. Post-test only control group design

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

Table 2 presents the post-test-only control group design where X1 and X2 are the treatments given, X1 is the treatment in the experimental group by applying Mathematics learning using Geogebra and X2 is the treatment in the control group by applying conventional Mathematics learning. While O1 and O2 represent the experimental and control groups respectively. The population in this study were students who were at the high school level in the city of Jakarta. Meanwhile, as many as 80 samples of class XI students were selected purposively from four parallel classes where each class consisted of 40 students.

The approach in this research is quantitative in the form of the results of student learning abilities, therefore the instrument used is in the form of tests and non-tests that have been validated. The test instrument is based on students' MCTA (Mathematical Critical Thinking Ability), while the non-test instrument is in the form of an AQ (Adversity Quotient) questionnaire containing positive and negative statements and adapted from (Alyani & Zahra, 2020). 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 can measure from a logit scale, display wright maps, see student distributions, and predict bias in missing data and dates (Ölmez & Ölmez, 2019).

Table 2. Fit indices

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

The validation process is carried out by two expert validators and then tested on students to see validity and reliability. The results show that the average of all items on the

test and non-test questions are valid and reliable with Cronbach's Alpha of 0.93 for the AQ instrument and 0.86 for the MCTA test questions in 208 students are 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. For example, non-test and test instruments can be seen in Figures 1 and 2 below.

Seorang pedagang kaki lima sedang mengamati salah satu pengunjung taman yang sedang berlari pagi mengitari taman berbentuk lingkaran dengan jarak lintasan pengunjung tersebut terhadap pusat taman 6 m, sedangkan jarak pedagang terhadap pusat taman 12 m. Misalkan posisi tempat pedagang melihat sebagai titik koordinat dalam meter dan pusat lingkaran terdapat pada sumbu$-x$, tentukan persamaan lintasan pengunjung dan buatlah grafik persamaan lingkaran.

Figure 1. Test instrument on adversity quotient

Saya berpartisipasi mengikuti lomba olimpiade.
a. Penyebab saya berpartisipasi mengikuti lomba olimpiade adalah sesuatu yang :
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b. Penyebab saya berpartisipasi mengikuti lomba olimpiade dikarenakan:
Saya   1   2   3   4   5   orang lain atau
sendiri   faktor lain
                                                       $O_r +$

Figure 2. Test instrument on mathematical critical thinking ability

The data generated will go through an analysis process using the Cohen's d Effect Size Test and Spearman Correlation to answer the research question, namely knowing the effect given by the GeoGebra-based Mathematics learning treatment in the experimental class with conventional learning in the control class. The decision-making criteria in the Effect Size Test use the interpretation presented in table 3 (Sawilowsky, 2009). Before the Cohen's d Effect Size test, Mann Whitney was first tested. The Mann Whitney test was conducted to determine whether or not there were differences in the data groups. The analysis of this hypothesis test was carried out through IBM SPSS 25.

Table 3. Estimated values of effect size

Estimated Values	Size of Effect
0 - 0.01	Very Small
0.01 - 0.2	Small
0.2 - 0.5	Medium
0.5 - 0.8	Large
0.8 - 1.2	Very Large
1.2 - 2.0	Huge

3. RESULT AND DISCUSSION

Result

Mann Whitney statistical test in the control and experimental groups using the logit value of the test results with the Rasch Model obtained on both AQ variables and mathematical critical thinking skills are presented in Table 4.

Table 4. Mann whitney test of mathematical critical thinking ability and AQ

	MCTA		AQ	
	Eksperiment	Control	Eksperiment	Control

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N	Valid	40	40	40	40
	Missing	0	0	0	0
Median		0.99	0.01	0.56	-0.12
Mann-Whitney U		94.00		93.50	
Asymp. Sig. (2-tailed)		.000		.000	

Table 4 shows that the MCTA of students in the control class with a median = 0.01 is significantly lower than the experimental class student's median = 0.99. Then it is known that the value of Asymp.Sig. (2-tailed) = 0.001 which is below = 0.05 which indicates H1 is accepted. On the other hand, the adversity quotient of students in the control class with a median = -0.12 was significantly lower than that of the experimental class, median = 0.56. Then it is known that the value of Asymp.Sig. (2-tailed) = 0.001 which is below = 0.05 which indicates H1 is accepted. So that it shows that there is a significant difference between the control and experimental groups on students' MCTA and AQ.

Table 5. Effect size cohen's d test of experiment and control group toward MCTA and AQ

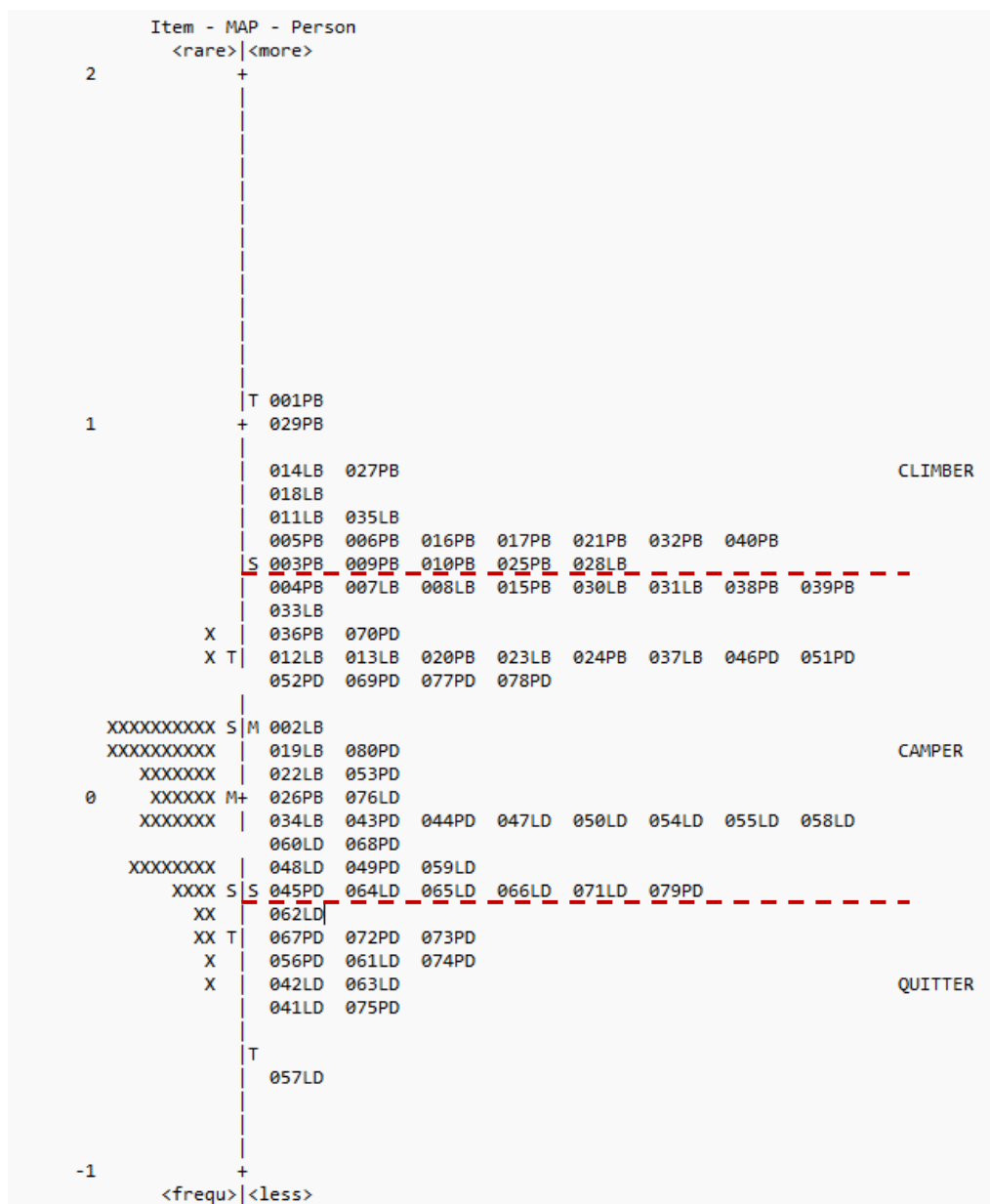| Aspect	Control Group		Experimental Group		
	Mean	SD	Mean	SD	d
MCTA	0.057	0.441	1.211	0.719	1.934
AQ	-0.125	0.275	0.533	0.256	2.519

Table 5 shows the Cohen's d Effect Size test value based on the logit value on Winstep. The results obtained that the experimental group on the adversity quotient aspect has the most significant effect size with a large effect of 2,519 and is in a large category. Furthermore, in the experimental group, the aspect of mathematical critical thinking ability (KBKM) has a d value of 1,934 which is also categorized as a large category.

Table 6. Spearman correlation test of MCTA and AQ

		KBKM	Adversity
MCTA (Mathematical Critical Thinking Ability)	Correlation Coefficient	1.000	0.918**
	Sig. (2-tailed)	.	0.001
	N	80	80
AQ (Adversity Quotient)	Correlation Coefficient	0.918**	1.000
	Sig. (2-tailed)	.001	.
	N	80	80

**Correlation is significant at the 0.01 level

Table 6 shows the results of the Spearman correlation test with the Logit value obtained between MCTA and AQ in the experimental class using Geogebra-based learning of 0.001 < 0.05. The correlation coefficient value of 0.918 with a percentage of 91.8% shows a very strong correlation between mathematical critical thinking skills and the adversity quotient. So it shows a significant influence and correlation between MCTA and AQ.

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Figure 3. The wright maps on adversity quotient

Figure 3 shows the WinSteps data based on the Wright Maps table. Data came from 80 respondents who filled out the adversity quotient questionnaire and analyzed using WinSteps. Characteristics of respondents based on the type of camper, climber, and quitter shown in the right column are given a numerical code indicating the respondent's number and a letter code indicating gender and class. Meanwhile, the distribution of items (questionnaire items) is shown in the left column. The highest distribution of types is seen in the camper type with a respondent frequency of 49 respondents and the quitter type has the lowest distribution with a respondent frequency of 12 respondents. Camper-type students tend to be easily satisfied with what they receive even though they can produce more (Anggraini & Mahmudi, 2021). In fact, they prefer to be in a zone that they think is safe (Hastuti et al., 2018).

Table 7. Student's quantity based on wright maps AQ

Types of Adversity Quotient	Quantity
Climber	19
Camper	49

Quitter	12

Table 7 shows that from 80 students as respondents, there are 12 students who easily give up on facing challenges, in contrast to 19 students who really like challenges. The highest type distribution is in the camper type with 49 students. According to the percentage, there are 15% for quitter type students, 24% for climber type students, and 61% for camper type students.

Discussion

The results of the different tests in Table 4 between the control and experimental groups on Mathematical Critical Thinking Ability and AQ showed a significant difference, the control class was lower than the experimental class. Based on the research results that have been obtained, show that learning mathematics using GeoGebra software influences students' mathematical critical thinking skills. This can be seen through the average logit value score on the achievement of mathematical critical thinking skills of control group students with conventional learning treatment less than experimental group students with mathematics learning treatment using GeoGebra software (0.057 < 1.211). This is supported by the value of the Cohen's d Effect Size test which shows the effect in the large category (1.934). In line with the findings that state that learning with the help of GeoGebra software improves students' critical thinking skills compared to learning without the aid of GeoGebra software (Batubara, 2019).

Based on the results of the Spearman correlation test, it was obtained that the mathematical critical thinking ability (KBKM) and the adversity quotient (AQ) in the experimental class using Geogebra-based learning showed a significant effect and correlation between the two (r = 0.918, p < 0.05) and the percentage was 91.8 %. This is based on the findings that result between AQ and critical thinking skills have a very strong relationship and influence (Rahayu & Alyani, 2020). The relationship between critical thinking skills and adversity quotient can be seen through the type of AQ categorized (Stoltz, 2000). In line with research that states that the achievement of thinking processes is influenced by the three levels in the adversity quotient, namely Climber, Camper, and Quitter (Yanti et al., 2018).

The findings of Asmar and Delyana (2020) state that learning by utilizing GeoGebra software shows the strength of the correlation between critical thinking and independent learning. The use of Geogebra software is also able to improve student learning achievement (Alkhateeb & Al-Duwairi, 2019). This is supported by the finding that GeoGebra supports the construction of lines, points, or all conic sections, therefore this geometry software is dynamic (Birgin & Acar, 2020). Then Supriadi (2015) in his research said that those who used the Geogebra interactive software had higher learning outcomes than those who did not use the Geogebra software.

Based on the results of the Wright Maps AQ of students in the group treated with GeoGebra-assisted learning with students with conventional learning in Figure 3, it can be seen that the distribution of the highest student adversity quotient type is in the camper type with a percentage of 61%. Meanwhile, climber and quitter type students have a percentage of 24% and 15%, respectively. Through Wright Maps, it can also be seen that the adversity quotient of climber type students is dominated by students with learning using GeoGebra and the quitter type is dominated by students with conventional learning.

Rahayu and Alyani (2020) stated that in their research the effect of Adversity Quotient on mathematical critical thinking skills was 75%, especially for the camper type. Wahyu Hidayat and Sari (2019) found that quitter students tend to find it difficult to solve existing problems and are classified as weak in critical thinking achievements. In several studies of the climber type, it was found that students with this type were able to persist in solving

mathematical problems by fulfilling mathematical critical thinking indicators (Rahayu & Alyani, 2020). To find out the distribution of students' mathematical critical thinking skills with learning treatment using GeoGebra and conventional learning treatments, researchers divided the results of mathematical critical thinking skills that can be seen through three types of AQ taken from Table 6.

Figure 4. The response of students with AQ quitter

Identification : Given the equation of the circle $1 = x^2 + y^2 - 12x - 12y + 36 = 0$ and
Equation of circle $2 = x^2 + y^2 + 8x - 12y + 36 = 0$.
Asked, the position and the point of tangency of the two circles?

Analysis : $P_1 = \left(-\frac{1}{2}(-12), -\frac{1}{2}(-12)\right) = (6,6)$

$L_2 = \left(-\frac{1}{2}(8), -\frac{1}{2}(-12)\right) = (-4,6)$

$r_2 = \sqrt{\ldots}$

Figure 5. The process of MCTA of students with AQ quitter

Figures 4 and 5 show the results of students working with code 042LD with the quitter type who have difficulty completing the analysis stage. Students who are in the control class with conventional learning are only able to fulfill the identification and analysis indicators, however, the analysis indicators cannot complete completely. This indicates that students with the quitter type AQ are weak and give up easily in analyzing a problem which affects mathematical critical thinking skills (Brown et al., 2010; Wahyu Hidayat & Sari, 2019; Pangma et al., 2009; Rahayu & Alyani, 2020).

Figure 6. The response of students with AQ camper

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Identification $\quad: L_1 = x^2 + y^2 - 12x - 12y + 36 = 0$

$\qquad\qquad L_2 = x^2 + y^2 + 8x - 12y + 36 = 0.$

Analysis $\qquad: L_1 = (x-6)^2 + (y-6)^2 - 36 - 36 + 36 = 0$

$\qquad\qquad L_1 = (x-6)^2 + (y-6)^2 = 36$

$\qquad\qquad P(6,6)$

$\qquad\qquad r = 6$

$\qquad\qquad L_2 = (x-4)^2 + (y-6)^2 - 16 - 36 + 36 = 0$

$\qquad\qquad L_1 = (x-6)^2 + (y-6)^2 = 16$

$\qquad\qquad P(-4,6)$

$\qquad\qquad r = 4$

Evaluation $\qquad$: *Equation of tangent* $(0+4)(x+4) + (6-6)(y-6) = 16$

$\qquad\qquad 4(x+4) = 16$

$\qquad\qquad x + 4 = 4$

$\qquad\qquad x = 0 \; or$

$\qquad\qquad (0-6)(x-6) + (6-6)(y-6) = 36$

$\qquad\qquad -6(x-6) = 36$

$\qquad\qquad x - 6 = -6$

$\qquad\qquad x = 0$

The equation of the tangent to the two circles through the point (0,6).

Figure 7. The process of MCTA of students with AQ camper

Figures 6 and 7 above show the results of students working with code 038PB with a camper type that can complete up to the evaluation stage. Students who are given a learning approach using Geogebra software can meet the identification, analysis, and evaluation indicators, but not on the inferential indicators. In this evaluation indicator, students can determine the position of the two circles but it is not written down. This indicates that students with camper type AQ belong to the medium category (Wahyu Hidayat et al., 2018). This type is easily satisfied with what is being done and sometimes does not see the possibilities (Alyani & Zahra, 2020; Rahayu & Alyani, 2020).

Figure 8. The response of students with AQ climber

Identification : *We know that $L_1 = x^2 + y^2 - 12x - 12y + 36 = 0$ dan $L_2 = x^2 + y^2 +$*
$8x - 12y + 36 = 0$. (Intersect at a point)
Asked, position of the two lines.

Analysis : $L_1 = x^2 + y^2 - 12x - 12y + 36 = 0$

$$P_1 = \left(-\frac{1}{2}(-12), -\frac{1}{2}(-12)\right) = (6,6)$$

$$r_1 = \sqrt{x^2 + y^2 - C}$$

$$r_1 = \sqrt{6^2 + 6^2 - 36} = \sqrt{36 + 36 - 36} = \sqrt{36} = 6$$

$$L_2 = x^2 + y^2 + 8x - 12y + 36 = 0$$

$$P_2 = \left(-\frac{1}{2}(8), -\frac{1}{2}(-12)\right) = (-4,6)$$

$$r_2 = \sqrt{x^2 + y^2 - C}$$

$$r_2 = \sqrt{(-4)^2 + 6^2 - 36} = \sqrt{16 + 36 - 36} = \sqrt{16} = 4$$

Evaluation : *Determine position :*

$$P_1 P_2 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$= \sqrt{(-4 - 6)^2 + (6 - 6)^2} = \sqrt{(-10)^2 + (10)^2} = \sqrt{100} = 10$$

Inference : *It is concluded that $P_1 P_2 = r_1 r_2 = 6 + 4 = 10$. So, the position of the two*
lines is an external tangent.

Figure 9. The process of MCTA of students with AQ climber

Figures 8 and 9 above show the results of students working with code 001PB with a climber type that can solve problems easily. Students who are given a learning approach using GeoGebra software can meet all indicators of identification, analysis, evaluation, and inference. In indicators of identification and analysis, students can understand the concept of the equation of a circle in determining the radius and center of the provided equation. So, on the evaluation indicators, the results obtained and the conclusions on the inference indicators can be written correctly. This indicates that students with climber type AQ can survive to find that the solution they get is right (Wahyu Hidayat & Sari, 2019; Oliveros, 2014; Phoolka & Kaur, 2012). This type is easily satisfied with what he can and does and sometimes ignores the possibilities obtained and belongs to the good AQ category (Alyani & Zahra, 2020). This is in line with the characteristics of the climber type AQ, which can use various solutions and has a persistent and courageous nature (Hidayah et al., 2016).

4. CONCLUSION

Learning mathematics using GeoGebra software has a significant effect on students' mathematical critical thinking skills, showing an influence in large categories and having a good relationship. Meanwhile, students are dominated by camper type AQ. Therefore, students with learn mathematics using GeoGebra software have better mathematical critical thinking skills than students with conventional mathematics learning. Based on the Wright Maps adversity quotient, climber-type students are dominated by students who study using GeoGebra. While the quitter type is dominated by students with conventional learning. This is supported by the results of field findings which show that students with learning using Geogebra software are more active and enthusiastic in learning compared to students with conventional learning.

Based on the results of the research that has been done, teachers can apply learning using the GeoGebra application or other applications that can support learning. In the future, researchers can explore the media used in learning with more contrasting variables and subjects.

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