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Developing the Geometry Teaching Module by Using a Metacognitive Approach in *Kurikulum Merdeka* to Improve the Students' Critical Thinking Skills

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ABSTRACT: This research aims to solve the problem of students' critical thinking skills to follow instructions in solving mathematical problems. Students are often unaware of what they do, why they do it, and do not even know what they are supposed to do with the assignment. Meanwhile, to be a good problem solver, someone must develop good metacognition skills. By having metacognitive awareness, students are trained to solve mathematical problems through the stages of planning, monitoring, controlling and evaluating. The method used in the research is Research and Development with the model developed by Thiagarajan, Semmel & Semmel (4-D). The data collection was based on the pre-test and post-test scores in the experimental and control groups to measure the students' critical thinking skills. The result of the post-test in the students' critical thinking skills by using ANOVA test with significance level in 0.016 (< 0.05) shows that there was significant difference of teaching module with metacognitive approach in the material about circle within *Kurikulum Merdeka* to the students' critical thinking skills.

KEYWORDS: Circle, Critical thinking, Geometry, Metacognition, Teaching module.

INTRODUCTION

The education after the COVID-19 pandemic requires schools to prepare stakeholders, especially teachers and students to master information technology skills (Syahputra, 2018). This is in line with the demand of skills in the 21st century, including creative thinking, critical thinking and problem solving, communication and collaboration, while the prominent content to be taught to reach the 21st century skills is mathematics education (Gravemeijer et al., 2017). Mathematics has been introduced from primary to higher education. According to Baykul (in Unlu et al., 2017), mathematics is an important tool to learn by students as it is used to solve scientific and daily life problems.

Mathematics education is undeniably one of the most reliable sciences in civilization, so mastering mathematical skills is important to compete and progress in the modern world. However, most students have difficulty learning mathematics although the problems are meant to train and make students get used to critical and problem-solving activities (Hendrayana, 2015).

Difficulties in learning and mastering mathematics is reasonable as it requires students to think logically, systematically and reflectively in the most disciplined, detailed and earnest manner (NRC, 2002; Rey, etc., 2009 in Hendrayana, 2015). Therefore, to master mathematics, it requires five components, including conceptual comprehension, strategic competence, fluency in work process, adaptive logics and productive disposition (Hendrayana, 2015).

One of the aspects in mathematics education is geometry. The purpose of geometry according to Soemadi (Bada, 2016: 4) is to develop logical thinking skills, teach reading and interpret mathematical arguments, introduce concepts (including geometry) required for further study and develop spatial skills. To apply geometry skills, like visual, verbal, drawing, logics and applied skills, students need thorough understanding of concepts. However, in fact, students still find difficulties to understand geometry concepts (Bada, 2016: 4).

In the learning process, some students have uncomfortable, inevitable experiences. When finding mathematical difficulty with relevant understanding in metacognition, they will be able to evaluate their own understanding and predict the time and effective strategy to learn and solve problems. The strategy is related to how they are able to control or evaluate the thinking process once they are faced with problems, or, in other words, they have skills in controlling and managing cognitive processes in their mind (Richardo & Cahdriyana, 2021; Richardo et al., 2021). Otherwise, less awareness in controlling and evaluating the cognitive process or low metacognition can lead the students to difficulty in solving mathematical problems (Chairani, 2016).

Metacognition is a person's knowledge about the thinking process and all about it during the activity of its occurrence controlled by himself (Hidayanti et al., 2019). Along with the view, O'Neil & Brown also state that metacognition is a process where a person thinks about thinking for the sake of building strategy to solve problems (Weni et al., 2019). Besides, as mentioned in the content standard for primary and secondary education units in mathematics (Kemdikbud, 2019), mathematics education is required to be given to all students from primary level to introduce them to logical, analytical, systematical, critical and creative thinking as well as collaboration. The students are expected to demonstrate the critical skill, especially in critical mathematical skills through mathematics education.

Critical mathematical thinking is a fundamental process to analyze arguments and derive ideas to each meaning to develop a way of thinking logically. The process of critical thinking involves the use of logic to identify ideas or interesting issues. Question is another word of mathematics, usually including irregular questions which challenge the students' ability to use their critical and inventive thinking to solve problems (Cahyo & Murtiyasa, 2023). Students with critical thinking ability are urged to solve problems and evaluate their solutions (Riyanto & Ishartono, 2022).

Theoretically, the indicator of critical thinking developed to analyze and evaluate arguments and evidence, clarify, make consideration, make explanation and identify assumptions (Rahayu & Alyani, 2020). Richard Paul and Linda Elder define critical thinking as an art to boost the thinking ability in analyzing and evaluating certain problem solving processes (Widana, 2018). The indicators of critical thinking used in this research (cognitive skill) include the activities of interpretation, analysis, evaluation, inference, explanation and self-regulation. The indicator of interpreting activity is to be able to write problems clearly and accurately. Analyzing activity is to be able to write what to do to solve problems, while evaluating activity is to be able to write solutions to the problems. Inferencing activity is to be able to draw conclusions from the problems logically. Explaining activity is to be able to write the final answer and give reason over the drawn conclusions, while self-regulating activity is to be able to review the given answer (Hayudiyani, 2017).

According to some research conducted by Isabella (2015), Reza (2022) and Ningsih, etc. (2021), it is shown that in solving mathematical problems, it requires metacognition activity. The result of more research conducted by Zaswita, etc. (2023), Fasha (2018) and Rafia (2014), it is proven that learning by using metacognition leads to the raising critical mathematical thinking skills taught metacognitively and the higher metacognition skills a person has, the higher possibility he can solve problems. Thus, metacognition shares a positive effect on the mathematical problem solving process.

According to the mentioned background above, the problem in this research focuses on the effect of developing a geometry teaching module by using metacognition to improve the students' critical thinking skills in the materials about circle, tangent and circle bowstring. The subjects of the research include the students in SMKN 8 Jember, Semboro, Jember. The cognitive condition of the students is that they have already had prior understanding in basic materials based on *Kurikulum Merdeka* for SMA/SMK level, so this research aims to develop teaching modules to improve the students' critical thinking skills.

RESEARCH METHODS

This research is conducted by Research and Development (R&D) method. According to Sugiyono (2017), the Research and Development (R&D) method is a research method used to produce certain products and test their effectiveness. The research design used is based on the model developed by Thiagarajan, Semmel & Semmel (4-D). The developed model includes four stages known as the 4-D model (Four D Model). The model includes the stages to define, design, develop and disseminate (Hobri, 2010).

The researcher chooses the 4-D model with several considerations, including: (1) the stages are detailed, systematic and clear, so it is easier for the researcher to develop teaching module; (2) it involves the judgment of experts to control the quality of learning module before try-out; (3) it includes try-out, revision and more try-out to conduct in several cycles to gain the quality of practicality and effectiveness of the teaching module; (4) the model is relevant to develop the teaching module by using metacognition approach to improve the critical thinking skills.

The area determination of this research uses the purpose sampling area method by purposely determining the research area based on particular consideration (Arikunto, 2006). The learning module try-out is conducted in grade XI of SMKN 8 Jember. The product developed in this research is a geometry teaching module by using a valid, practical and effective metacognitive approach so the students' critical thinking skill is improved, materials about circle for grade XI discussed in the teaching module, the students' worksheets and final task. The final product of the development will be evaluated based on the quality product criteria set. The

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instrument of data collection process to measure the final task includes pre-test and post-test for students in the experimental groups of XI TKJ 1 and XI TKJ 2 as well as the control group of XI DKV-1 at SMKN 8 Jember in metacognitive and conventional approaches respectively to measure the students' critical thinking.

The data collected in the developmental research include: (1) the validity assessment sheet and instrument to the teaching module, (2) the observation sheet to the teaching module implementation, (3) the observation sheet to the students' activity, (4) the students' response questionnaire, and (5) the final task. The research data analysis is explained as follows: 1) validity analysis. The instrument validity level is categorized into several types served in Table 1. The teaching modules fulfills the validity criteria if at least reaching the valid category.

Table 1. Interval of Teaching Module Validity

Interval	Category
$1 \leq V_r < 2$	Invalid
$2 \leq V_r < 3$	Less Valid
$3 \leq V_r < 4$	Enough Valid
$4 \leq V_r < 5$	Valid
$V_r = 5$	Very Valid

2) Practicality analysis of the teaching module. The practicality level interval of the observation analysis result to the teacher's activity is served in Table 2. The instrument fulfills the practicality criteria if at least reaching the practicality category. The teaching module fulfills the practicality criteria if at least reaching the practicality category.

Table 2. Interval of Practicality

Interval	Category
$1 \leq KP < 2$	Very low
$2 \leq KP < 3$	Low
$3 \leq KP < 4$	Fair
$4 \leq KP < 5$	High
$KP = 5$	Very high

3) Effectiveness analysis of the teaching module. There are three indicators as reference to assess the effectiveness of a learning instrument, including the final score, the students' active participation and the students' response. The teaching module is effective if the final score fulfills 80% of total students. Meanwhile, the students' active participation in the learning process at least falls into the Enough Active category. The interval of students' active participation is shown in Table 3.

Table 3. Interval of the Students' Active Participation

Interval	Category
$1 \leq IO < 2$	Not Active
$2 \leq IO < 3$	Less Active
$3 \leq IO < 4$	Enough Active
$4 \leq IO < 5$	Active
$IO = 5$	Very Active

4) Data analysis of critical thinking skills. The assessment of the students' critical thinking skills can be obtained by analyzing the students' answers in the final task. The interval of students' critical thinking skills is served in Table 4.

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Table 4. Interval of Critical Thinking Skills

Interval	Category
32 – 48	High
16 – 31	Fair
0 – 15	Low

The analysis prerequisite test after all assumption tests are fulfilled, the next step is to analyze the research data. The assumption tests used are normality test and homogeneity test. The result of the normality test is based on the statistics values of *Kolmogorov-Smirnov* with a significance level of 5%. The result of the variance homogeneity test is based on *Levene*'s test with a significance level of 5%. The hypothetical test aims to test the previous hypothesis. The tested data is critical thinking skills from the results of pre-test and post-test. The decision making is based on ANOVA test as follows:

1. If the significance level is < 0.05, Ho is rejected and H_1 is accepted which means the instrument of teaching module by using metacognitive approach significantly affects the students' critical thinking skills.
2. If the significance level is > 0.05, Ho is accepted and H_1 is accepted which means the instrument of teaching module by using metacognitive approach does not significantly affect the students' critical thinking skills.
3. The research hypothesis is shown below.
   Ho: There is no significant effect on the students' critical thinking skills after applying learning with the teaching module by using a metacognitive approach.
   H_1: There is a significant effect on the students' critical thinking skills after applying learning with the teaching module by using a metacognitive approach.

RESULT AND DISCUSSION

Result

The developing process of the teaching module with the Four D Models (Thiagarajan) has been successfully developed through the teaching module by using a metacognitive approach. The teaching module has been designed through the following phases.

Define Phase

The Define Phase is the early stage which includes the analyzing activity. The objective of the phase is to determine and define the need of the learning process by analyzing the purpose and material limitation. This phase includes five basic stages which are: 1) front-end analysis; 2) learners' analysis; 3) concept analysis; 4) task analysis; and 5) specifying instructional objectives.

Design Phase

The Design Phase of the teaching module includes four stages; (a) test-making process. The plot of learning objectives becomes the foundation of the test making process. The test is conducted to assess the behavioral change after learning in comprehension and application skills as well as to measure the students' critical thinking skills. The test is a final task in the form of four essay questions about circles; (b) media determination based on the task analysis, the character analysis of students and tools, media used including CP, ATP, the students' worksheet and the final task; (c) format determination including shape and content formats of *Kurikulum Merdeka* teaching module, including identity, core components and attachment; (d) early design-making process including prototype of teaching module of learning process, the students' worksheet and the final task. The design aspect observed is the teaching process and the students' active participation.

The next stage is designing the teaching module focusing on the learning approach, the critical questions, the students' worksheet and the final task. In the section of critical questions, the test question brings up critical thinking skills. In the teaching module, the critical questions are: *(*1) "Wheels are ideally circular. Did you ask why? What would happen if a bicycle's wheel was not circular?" (2) "Sewer holes are normally circular. How would its circular shape relate to the safety of the worker inside it? What could happen if it was in another shape? What if it was square? What if it was a rectangle?" See Figure 1.

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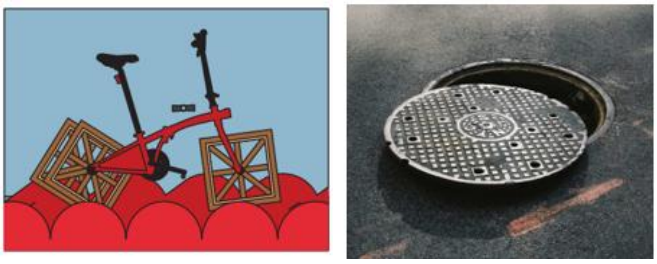

Figure 1. Teaching Module of Critical Thinking

The core component of the teaching module in the learning design is problem-based learning (PBL) by using a metacognitive approach. The implementation of learning activity by using a metacognitive approach in the experimental groups include: (1) Planning stage. The stage includes introduction and phase 1 involving introducing problems to the students. The teacher shows daily issues related to the circle application. The students are also asked to observe problems in the students' worksheet. Meanwhile, the indicator of critical thinking skills observed is interpreting skills; (2) Monitoring stage. The stage includes phases 2 to 4, like organizing, guiding and serving the result of the students' discussion. The indicators of critical thinking skills are analyzing, evaluating and inference; (3) Evaluation stage. Phase 5 and closure include the reflection of the students and the teacher. The indicator of critical thinking skills is self-regulation.

In the final task, a question model is designed to measure the critical thinking skill in the pre-test and post-test conducted before and after the learning process as in Figure 2 below.

The people of Riam Muntik Village, Kayan Hulu, Sintang, West Kalimantan build a water wheel used for power energy and irrigation. The circular wheel is 10 meters in diameter and is placed on the river, so the lowest point of the wheel is one meter. Find the angle between the water surface and the axle around the wheel and find the distance of two points in the wheel positioned on the water.

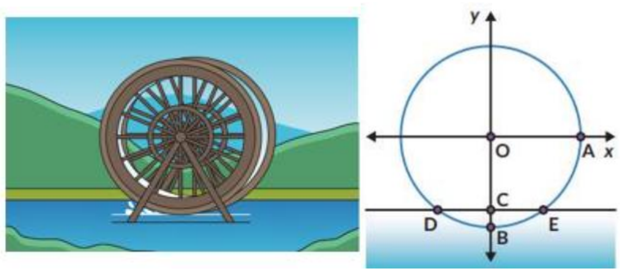

Figure 2. A Question in the Final Task of Critical Thinking Skills

Develop Phase

In the development stage of the teaching module, the students' worksheet, the final task is validated by the experts of mathematics education, including two lecturers and a teacher at SMKN 8 Jember. The validity result of experts to the three instruments is subsequently analyzed. The validity analysis result is shown in Table 5 below.

Table 5. Recapitulation of Instrument Validity

Instrument	Average Score	Criteria
Teaching module	4.60	Valid
Students' worksheet	4.70	Valid
Final task	4.60	Valid

Meanwhile, the average result of research instrument validity is 4.33 which means it is valid. The observation of teaching module application is in 4.74 within high criteria, so it shows the practicality of the teaching module. Based on the result of observation in the students' active participation during teaching and learning process in average from three meetings shows 4.01 which means the students' participation is active, so the teaching module is effective.

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Disseminate Phase

The Disseminate Phase of the teaching module is conducted after the module is considered valid, practical and effective. The teaching module is disseminated through a small group of mathematics teacher, try-out in other classes, other schools and the *Merdeka Mengajar* platform on https://guru.kemdikbud.go.id/pelatihan-mandiri/aksi-nyata/2573375?_topik_name=_Kurikulum%20_Merdeka&topik_id=6, where the effect test of the teaching module by using a metacognitive approach is also conducted to measure the students' critical thinking skills in the final task answers. The indicator of the students' critical thinking skills can be seen in Figure 3 below.

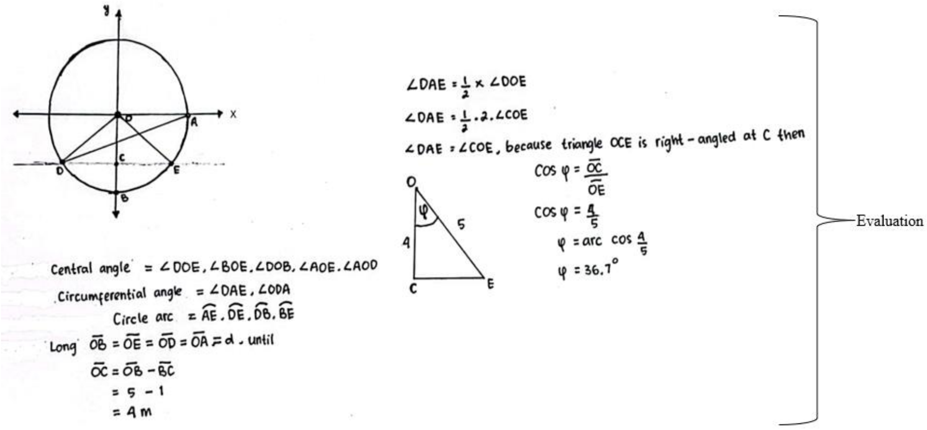

Figure 3. Indicator Evaluation of Critical Thinking

Meanwhile, to identify the effect of the teaching module by using a metacognitive approach to the critical thinking skills, there are experimental and control groups. Grade 2 of the experimental group is the students of XI TKJ-1 and XI TKJ-2, while the control group is in XI DKV-1. In the experimental group, the teaching module occupies a metacognitive approach, while the control group works on conventional learning which centers on the teacher and includes discussion. The students' critical thinking skills are analyzed based on the pre-test and post-test scores. According to the recapitulation of the evaluated score in the pre-test, the students' critical thinking skills in the experimental and control groups can be seen in Table 6.

Table 6. The Students' Critical Thinking Skills Based on the Pre-test

Groups	Number of Students	Lowest Score	Highest Score	Average	Std. Deviation
Experimental 1	30	13	43	29.53	6.095
Experimental 2	30	13	42	28.87	5.935
Control	30	10	41	25.17	7.940

Based on the category and result in Table 6, the result of the pre-test of the Experimental Group 1 ranges from the maximum score in 43 (high category) to the minimum score in 13 (low category) with 29.53 on average (medium category). The Experimental Group 2 results from the maximum score in 42 (high category) to the minimum score in 13 (low category) with 28.87 on average (medium category). Meanwhile, the Control Group results from the maximum score in 41 (high category) to the minimum score in 10 (low category) with 25.17 (medium category). The number of students with critical thinking skills in the pre-test from low, medium to high categories in the experimental and control groups is shown in Table 7.

Table 7. Recapitulation of the Number of Students Based on Critical Thinking Skills Category in the Pre-test

Groups	Low Category		Medium Category		High Category	
	Number of Students	Percentage	Number of Students	Percentage	Number of Students	Percentage
Experimental 1	2	6.7%	19	63.3%	9	30%
Experimental 2	3	10%	22	73.3%	5	16.7%
Control	6	20%	20	66.7%	4	13.3%

The post-test is conducted after the learning process in the last meeting to measure the students' critical thinking skills. The result of post-test in the Experimental Group 1, the Experimental Group 2 and the Control Group is shown in Table 8 below.

Table 8. The Students' Critical Thinking Skills Based on the Post-test

Groups	Number of Students	Lowest Score	Highest Score	Average	Std. Deviation
Experimental 1	30	15	46	35.13	6.377
Experimental 2	30	15	44	32.33	6.343
Control	30	14	43	27.53	7.696

According to Table 8, the Experimental Group 1 in post-test results from the maximum score in 46 (high category) to the minimum score in 15 (low category) with 35.13 on average (high category). The result in the Experimental Group 2 in the post-test ranges from the maximum score 44 (high category) to the minimum score in 1 (low category) with 32.33 on average (high category). Meanwhile, the Control Group results from the maximum score in 43 (high category) to the minimum score in 14 (low category) with 27.53 on average (medium category). The number of students with critical thinking skills in low, medium to high categories in the experimental and control groups is shown in Table 9 below.

Table 9. Recapitulation of the Number of Students Based Critical Thinking Skills Category in the Post-test

Groups	Low Category		Medium Category		High Category	
	Number of Students	Percentage	Number of Students	Percentage	Number of Students	Percentage
Experimental 1	1	3.3%	9	30%	20	66.7%
Experimental 2	1	3.3%	14	46.7%	15	50%
Control	4	13.3%	20	66.7%	6	20%

In the next stage, a hypothetical test is used to identify the effect of learning by using a metacognition approach to the critical thinking skills. The prerequisite test is for normality and homogeneity. The normality test used is the data test by *Kolmogorov-Smirnov*. As the score of the pretest in the Experimental Group 1 with sig.= 0.194, in the Experimental Group 2 with sig.= 0.147 and the Control Group with sig.= 0.150 bigger than 0.05, both scores in the pre-test distribute normally. In the homogeneity test, the Based on Mean score (sig.= 0.996) is bigger than 0.05, so the data are homogenous. After the normality test shows that the data are distributed normally, the hypothetical test is conducted to identify the effect of the students' critical thinking skills with the teaching module by using a metacognitive approach by using Analysis of Varian (ANOVA). The result of the ANOVA test shows that the sig. value 0.459 > 0.05. Therefore, there is no significant effect on the students' critical thinking skills.

After the learning process, the hypothesis is managed in the post-test to identify the effect of learning by using a metacognition approach to the critical thinking skills. The prerequisite test is for normality and homogeneity. The normality test used is the data test by *Kolmogorov-Smirnov* shown in Table 10 below.

Table 10. Normality Test in the Post-test for Experimental and Control Groups

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Post-test	Statistic	df	Sig.	Statistic	df	Sig.
Learning Outcome	Experimental 1	.107	30	.200*	.943	30	.111
	Experimental 2	.090	30	.200*	.976	30	.713
	Control	.126	30	.200*	.952	30	.188

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 11. Homogeneity Test in the Post-test

		Levene Statistic	df1	df2	Sig.
Learning Outcome	Based on Mean	.501	2	87	.608
	Based on Median	.370	2	87	.692
	Based on Median and with adjusted df	.370	2	81.882	.692
	Based on trimmed mean	.515	2	87	.599

According to Table 10, the scores in the Experimental 1 Group with sig.= 0.200, the Experimental Group 2 with sig.= 0.200 and the Control Group with sig.= 0.200 are bigger than 0.05, so both scores in the pre-test are distributed normally. Meanwhile, the homogeneity test shows the Based on Mean score significance 0.608 (Sig > 0.05), so the data are homogenous. The ANOVA test analysis in the post-test is conducted to identify the effect of the teaching module applied. The ANOVA test result is shown in Table 12.

Table 12. The ANOVA Test Result

Learning Outcome	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	886.400	2	443.200	9.489	.016
Within Groups	4063.600	87	46.708		
Total	4950.000	89			

The criteria of the hypothetical test, in the ANOVA test, if the significance or probability value > 0.05, H_0 is accepted and H_1 is rejected. Meanwhile, if the significance or probability value < 0.05, H_0 is rejected and H_1 is accepted.

Hypothesis:

H_0 : There is no significant effect on the students' critical thinking skills after applying a learning instrument by using a metacognitive approach.

H_1 : There is a significant effect on the students' critical thinking skills after applying a learning instrument by using a metacognitive approach.

According to Table 12, it is shown that sig.= 0.016 < 0.05, so H_0 is rejected and H_1 is accepted which means there is a significant effect to the students' critical thinking skills in the experimental class after applying the teaching module by using a metacognitive approach.

DISCUSSION

Developing the teaching module is based on *Kurikulum Merdeka* by using a metacognitive approach with Thiagarajan model (Four-D Model). The Define Phase, there are five basic stages, including front-end analysis, learner analysis, concept analysis, task analysis and specifying instructional objectives. In the Define Phase, it is known that the geometry teaching module can improve the students' critical thinking skills of Grade XI at SMKN 8 Jember. One of the approaches relevant to instrument development is the metacognitive approach. The next phase is the Design Phase. During the phase, the researcher organizes a

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learning instrument to develop which is a geometry teaching module by using a metacognitive approach along with the supporting research instrument.

The teaching module developed is the teaching module, the students' worksheet, and the final task about circles completed with essay problems to train the students' critical thinking skills. Meanwhile, the research instrument is organized from the observation sheet of the teaching module application, the observation sheet of the students' active participation and the students' response questionnaire. The Develop Phase is conducted after Define and Design Phases. During this phase, the teaching module validity is assessed by experts, including two lecturers of mathematics education at FKIP University of Jember and a mathematics teacher at SMKN 8 Jember. The validity test to the learning instrument developed results in the validity value of the teaching module in 4.33, the students' worksheet in 4.70 and the final task in 4.60. Meanwhile, the average validity result of the learning instrument is 4.33. Therefore, the teaching module and research instrument are valid under the value of $4 \leq V_r < 5$. The try-out stage is conducted after the learning instrument is considered valid. The stage aims to identify the practicality and effectiveness of the teaching module. The observation result of the teaching module application shows value in 4.74 in high criteria. According to the observation result of the students' activity during the learning process, the three meetings show value in 4.01 on average which means the students' participation is considered active, so the teaching module is considered effective as during the learning process, the students show active participation, think systematically and evaluate what they have done. Related to this, Zaswita, etc. (2023) mention that there is an effect of applying learning by using a metacognitive approach to the students' critical thinking skills. Furthermore, a research by Rafia (2014) states that the learning by using a metacognitive approach shows effectiveness to the students' critical mathematical thinking skills taught metacognitively. The strategy is significantly higher than those taught conventionally. Besides, another research also shows the learning effectiveness by using a metacognitive approach as shown by Fasha (2018) which underlines that the learning by using a metacognitive approach can improve the students in mathematical problem-solving and critical thinking skills, the students show better performance than those with conventional learning and there is an improvement of interaction among the students during the learning process.

The teaching module considered valid, practical and effective is subsequently assessed through a hypothetical test to identify the effect of the teaching module to the students' critical thinking skills by involving sample students of two experimental groups (XI TKJ 1 and XI TKJ 2) and a control group (XI DKV 1). In the experimental group, the teaching uses a metacognitive approach while in the control group the teaching is conventional. According to the ANOVA test, the metacognitive skills difference between the students in the experimental and control groups shows value of sig. in 0.016. The significance value is less than 0.05, so Ho is rejected and Hi is accepted. Therefore, it can be concluded that there is a significant effect to the students' critical thinking skills after applying the learning by using a metacognitive approach. The teaching module by using the approach shares several advantages. They are: 1) The teaching module by using a metacognitive approach can help students think critically to learn and keep information quickly. The condition can occur because the students understand the method to use for self-learning and problem-solving. 2) The students' worksheet developed can guide and train students to think systematically, observe and evaluate the students' works as well as discuss in groups. 3) Learning by using a metacognitive approach can invite caring and controlling attitude among students during group work. 4) The given problems challenge the students' critical thinking skills. However, the teaching module developed also has weaknesses, like prior preparation needed by the students before the teaching process and long allocated time to fill in the students' worksheet. Therefore, it needs preparation management and effective time for successful application of the teaching module.

CONCLUSION

The research and development processes from the early analysis to the end have been conducted and reached a conclusion that developing the geometry teaching module is considered valid, practical and effective in terms of circle material. Besides, the students' critical thinking skills are improved by the teaching module by using a metacognitive approach, especially for vocational high school students. This research is expected to be a reference for more innovative learning processes at school under Kurikulum Merdeka. Further recommendation is for other researchers developing different learning materials to wider research subjects in many schools to improve mathematical communication skills and more.

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