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Ethnomathematics Based Geometry Module Development with a Scientific Approach to Improve Students' Metacognition Ability

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ABSTRACT

This study aims to develop a geometry module based on ethnomathematics with a scientific approach, test the module's validity and feasibility, and determine the effect of using modules in learning on students' metacognitive abilities. This study uses a research and development (R&D) approach with a 4D model (define, design, develop, and disseminate). The research subjects were students of 8rd Junior High School in Malang. Data analysis of the effect of the use of modules on metacognition abilities using the paired sample t-test. The research results showed the ethnomathematics based geomery module with a scientific approach is valid, developed by with a 4D model. The module is also categorized as effective for use in learning activities. The ethnomathematics based geometry modules with a scientific approach has an effect on metacognition abilities.
Keywords: ethnomathematics, geometry module, metacognition, scientific

ABSTRAK

Penelitian ini bertujuan untuk mengembangkan modul geometri berbasis etnomatematika dengan pendekatan saintifik, menguji kevalidan dan kelayakan modul, serta mengetahui pengaruh penggunaan modul dalam pembelajaran terhadap kemampuan metakognisi siswa. Penelitian ini menggunakan pendekatan penelitian research and development dengan model 4D (define, design, develop dan desseminate). Subyek penelitian ini adalah siswa kelas VIII SMP di Malang. Analisis data pengaruh penggunaan modul terhadap kemampuan metakognisi menggunakan uji paired sample t-test. Hasil penelitian menunjukkan bahwa modul geometri berbasis etnomatematika dengan pendekatan saintifik valid, dikembangkan dengan model 4D. Modul juga efektif uji kevalidan modul diperoleh nilai validitas 3.65 dengan kategori sangat valid. Modul geometri berbasis etnomatematika dengan pendekatan saintifik berkategori efektif digunakan dalam pembelajaran dan berpengaruh terhadap kemampuan metakognisi siswa.
Kata kunci: etnomatematika, metakognisi, modul geometri, saintifik

INTRODUCTION

Mathematics is a subject studied at all levels of formal education (Surya & Syahputra, 2017). Learning mathematics motivates students to be critical and innovative and fosters good reasoning in solving problems (Ibrahim & Widodo, 2020; Yuanita et al., 2018). Students' motivation to be critical, innovative, and have good reasoning can be supported by utilizing media in learning (Arigiyati et al., 2019; Tok, 2013). The module is one of the learning media used in the learning process (Stols, 2012).

The module helps students learn independently because the module contains complete learning, has its explanatory power and is arranged according to student characteristics (Surya & Syahputra, 2017). Modules are also systematically arranged according to the curriculum that allows students to learn independently (Schwarz, 2017). Learning by using the module, students are required to be independent and innovate in solving problems according to the materials in the module (Taufiq, Arcana, Sumiyati, Sucahyani, & Mas'ad, 2020). Learning with modules allows the students to directly construct their knowledge and learning experiences (Prendergast, et al, 2017). Learning with modules can encourage students to participate actively and open their horizons (Pedrotty et al., 2020). The module's materials are designed independently to meet the existing material specifications (Thatthong et al., 2012); for instance, a geometry module is designed accordingly to achieve the specifications of geometry materials.

Geometry is an important topic to learn in mathematics (Putra et al., 2020; Tyas et al., 2017). Therefore, geometry is studied at all education levels, from elementary to university level (In'am & Hajar, 2017). Geometry is a challenging learning topic for most students (Fitriyani et al., 2018; Siregar et al., 2019) and is one of the challenging subjects for students to comprehend (Taufiq et al., 2020). The causative factors of students' difficulties in comprehending geometry topics are less innovative learning methods and dull teaching materials (Risnawati et al., 2019). A geometry module is teaching materials designed with the specifications of mathematical materials related to geometric objects (Sudirman,Yaniawati, Melawaty, & Indrawan, 2020). The geometry module allows students to have experiences that will hone students' skills in solving geometry problems (Aysen, 2012). The primary function of such a module in learning geometry is as an independent learning mediator for students to learn according to their abilities (Suastika & Wahyuningtyas, 2020). The geometry module is also believed to foster a planned, independent, complete, and transparent output, especially in geometry (Mahazir & Arif, 2015).

According to Prastowo (2014), to produce a useful module, the technique preparation must be following the criteria in the module preparation, which are: (1) Self-instructional; (2) Self-contained, (3) stand-alone, (4) adaptive, and (5) user-friendly. First, the self-instructional criterion refers to the idea that the teaching materials can make students learn by themselves. Second, the self-contained criterion indicates that all subject matters from one unit of competence or sub-competence are covered in one single teaching material as a whole. Third, the stand-alone criterion means that the teaching materials do not depend on other teaching materials or do not have to be used together with other teaching materials. Fourth, the adaptive criterion shows that the teaching materials should have a significant adaptive influence on science and technology development. Fifth, through the significance of geometry materials, educators must have a better comprehension of the materials and keep the learning design innovation alive (Aklimawati, 2015). Therefore, the need for improvement in learning geometry, such as a geometry teaching module with ethnomathematical concepts, is imperative. The application of ethnomathematics in learning geometry can provide more knowledge about geometric objects integrated with cultural things (Tarigan et al., 2020). The ethnomathematics-based geometry module provides a better learning experience for geometry and culture materials than other modules in general (Ambarawati & Agustin, 2019). The ethnomathematics-based geometry module is developed to provide more knowledge about geometry and cultural objects themselves (Fouze, & Amit, 2018). Ethnomathematics represents real cultural objects in mathematical concepts (Sudirman et al., 2020). The idea of mathematics is also perceived as a lens to perceive and understand that mathematics is a cultural product (Ambarawati & Agustin, 2019). Ethnomathematics learning has an impact on improving mathematical thinking skills (Widada et al., 2020). The purpose of ethnomathematics-based geometry learning is to enhance skills related to geometric concepts and cultural knowledge (Mauluah & Marsigit, 2019); therefore, a scientific learning approach is necessary (Setiyadi, 2017).

A Scientific approach is relevant to the nature of science, namely observing, classifying, communicating, measuring, predicting, and concluding (Case et al., 2018; Said, et al, 2016; Daniela, 2015). The learning process with the scientific approach is designed in such a way, so that students can actively construct their concepts and knowledge (Morelent, 2015). According to Ayuningtyas (2019), the scientific approach contains learning objectives to form high intellectual ability. The scientific approach's application aims to improve the quality of learning to increase the students' cognitive ability (Fadhilaturrahmi, 2017). In the implementation of the 2013 curriculum with the scientific approach, students develop metacognition competency based on their curiosity about science and technology (Ministry of Education and Culture, 2013).

Metacognition is an experience that refers to students' awareness and understanding of competency or materials (Artelt, 2010). Metacognition ability itself is a description of the process and ability to solve problems (Thomas, 1998). Metacognition is an experience that refers to students' awareness and understanding of competency or materials (Artelt, 2010). Learning with a metacognitive approach focuses on students' learning activities, guides students, and helps students develop what they do when learning (Iskandar, 2014). Based on the above discussion, this study aims to develop a module, test the module's validity and feasibility, and examine the effect of using the module on the improvement of students' metacognitive ability.

METHOD

This study used the Research and Development (R&D) approach referred to the 4-D Thiagarajan, which consisted of four stages: defining, designing, developing, and disseminating. The module development model is shown in Figure 1.

The define stage in this study consist of five stages, namely: initial analysis, student analysis, concept analysis, task analysis and formulation of learning objectives. This initial analysis was carried out by analyzing the curriculum. The things analyzed include the standard competency (SK) and Basic Competence (KD) of the material to be developed. Student analysis was conducted to determine student characteristics, level of student cognitive development, and student motivation. This analysis is carried out by means of observation, observation during learning in class, conducting interviews with teachers and students. Concept analysis aims to determine the content of the material in the module to be developed. This concept analysis is carried out by detailing, identifying and systematically arranging the material, the relevant concepts to be taught based on the initial analysis.

Task analysis is carried out by identifying the task or question exercise and the main skills performed by students during learning. Then analyze it into a more specific sub-skill framework.

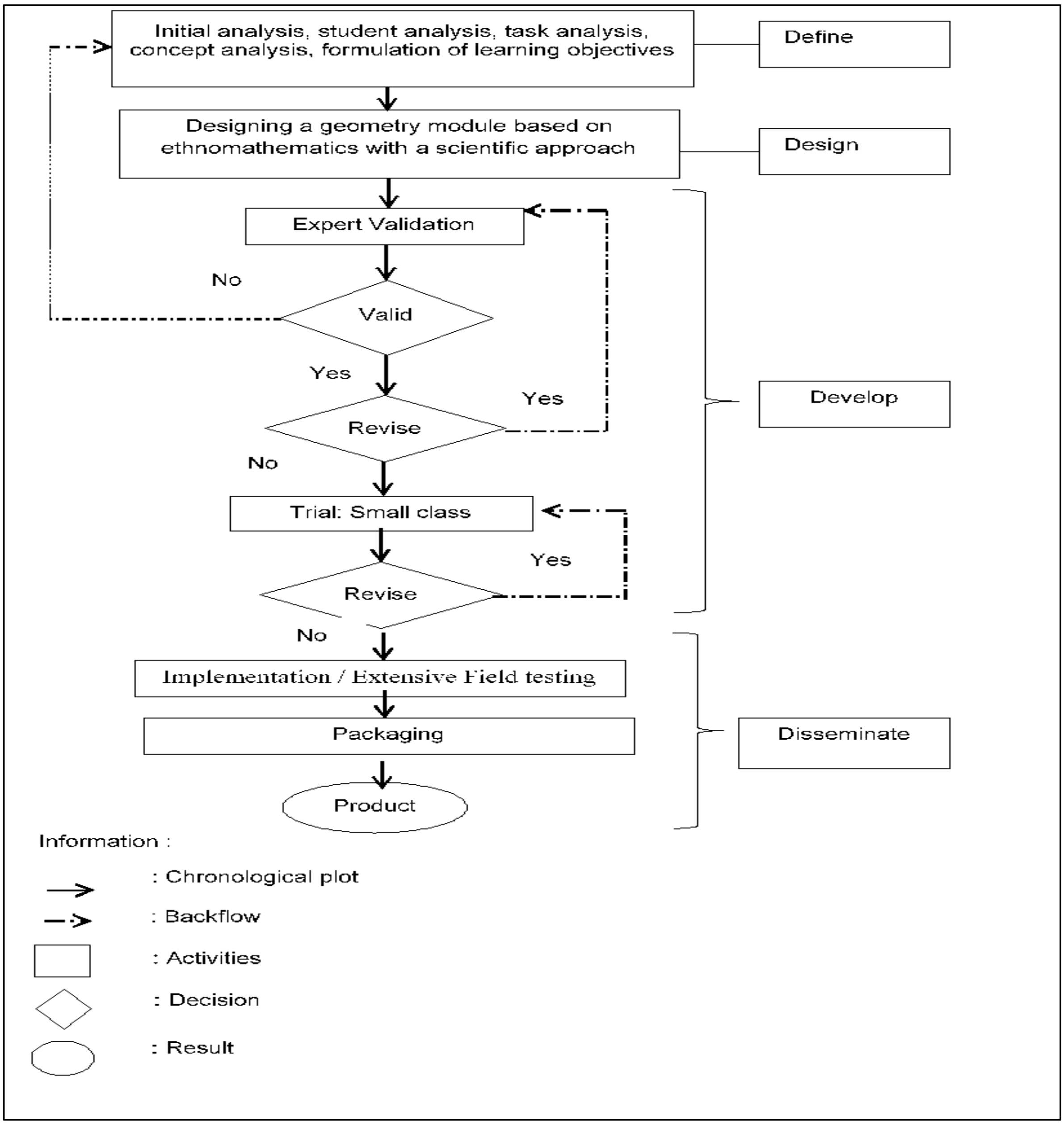


Figure 1. Module Development Chart

The second step after defining is the design stage. The design stage in this development consists of three stages, namely the preparation of tests, media selection, and format selection. Preparation of tests as an initial measure to measure the level of students' initial metacognition skills. Media selection is used to select learning media in accordance with the material and student characteristics. Format selection is a step in presenting learning with learning media that is in accordance with the student's condition. After these three stages are carried out, a draft or product design is produced, namely a learning module that is in accordance with the content framework of the results of the curriculum and material analysis. The next stage is Develop, This stage is carried out with two activities, namely Expert appraisal and developmental testing. Expert appraisal aims to validate or assess the appropriateness of modules developed by experts in their fields. This expert validation stage was carried out by involving four expert validators which included content validation, presentation validation, language validation and design component validation.

Expert appraisal is used to validate the module or assess the feasibility of the module being developed. The instrument used for validation was a feasibility assessment questionnaire, namely the components of content, presentation, grammar and design. The expert appraisal results obtained suggestions for the improvement of the module to be developed and then used as a basis for revision. This assessment is expected to make the developed module more precise, effective, in accordance with the concept, tested and of high value. Table 1 is the value of the module validity criteria used in this study.

Table 1. The range of values for each validation criterion

Value Range	Validation Criteria	Information
3.26 - 4.00	Very Valid	No Revision Needed
2.51 - 3.25	Valid	No Revision
1.76 - 2.50	Less Valid	Partial Revision
1.00 - 1.75	Invalid	Total Revisions

The third stage of development is developmental testing, which is an activity to test the draft on the actual target subject. The resulting module is then tested in a small class before being distributed or tested in a large class. The trial results are used to improve the product until it gets effective results. The small class trial, observations were made to obtain response data, reactions, or comments from the target users of the module. The instruments in the small class scale trial were non-test instruments, namely observation sheets, validation sheets and student questionnaires.

The disseminate stage aims to disseminate the developed module. This stage consists of the implementation stage or large scale trial and the packaging stage. At the large scale trial stage, the achievement of objectives and the effectiveness of the module being developed are carried out. The validation testing stage, the revised module is implemented in large-scale classes. At this stage, the measurement of goal attainment is carried out, namely the effect of using modules on students' metacognitive abilities. The instrument used was a test instrument, which consisted of five essay questions. The last development stage is packaging, this stage is carried out so that the product or module is packaged attractively and can be utilized, and this stage is done by printing the module. The module developed is compiled with learning that uses a scientific approach, in which there are learning stages that are packaged in 5M activities, they are come on watch, come on task, let's associate, come on reason, and let's communicate (Setyawati, 2016). The description for each of these activities can be seen in Table 2.

Table 2. Scientific learning activities

Learning Activities	Activity Description
Come on Watch	- Students observe examples, illustrations, cases or problems presented
Come on Ask	- Students are given the opportunity to ask questions to the teacher regarding problems that are observed or things that are not understood regarding the material to be studied

Learning Activities	Activity Description
Let's Associate	- Students collect information by reading the examples presented in the module
Come on Reason	- Students try to understand the concepts/material being studied by working on the questions provided - Students process the information that has been collected to make conclusions related to the concept/material being studied
Let's Communicate	- Students are given the opportunity to convey concepts / materials to friends in both small groups and large groups

The research design data analysis used was true-experimental design with pre-test post-test control group design, namely by testing the results of the pretest and posttest in learning using modules that were developed on students' metacognition abilities. Data collection techniques used in this study were expert validation tests, documentation studies, observations, and student learning outcomes tests (pre-test and post-test) using the developed module. The questionnaire instrument was used for expert validation, to obtain a valid module based on expert experts. Observation is used to collect data about activities during learning activities with modules. Finally, the test questions were used to obtain data about the module's potential effects on students' metacognition abilities.

The effect of using modules on metacognition abilities is measured by analyzing the answer scores given by students in the pre-test and post-test. The instrument used to assess metacognitive abilities was in the form of pre-test and post-test questions consisting of 5 essay questions. The effect of using the module on metacognition ability was carried out by means of the paired sample T test, which is used to compare the results of the pre-test and post-test, with the help of the SPSS 17.00 for windows computer program. Paired sample T test, the data used must be normally distributed, so that the data obtained can be analyzed. This value then determines the decisions taken in the study. Table 3 is some of the indicators used in determining the metacognitive level (Mahromah, 2013).

Table 3. Criteria for Metacognition Level in Solving Mathematics Problems

Level	Indicator
Tacit use	Planning - Students are less able to understand the problem - Students are less able to plan problem-solving strategies Monitoring - Students are less able to realize the concepts and calculation methods used Evaluation - Students are less able to carry out evaluations
Aware use	Planning - Students are quite capable of understanding the problem - Students are quite capable of planning problem solving strategies Monitoring - Students are quite capable of realizing the concepts and calculation methods used Evaluation - Students are quite capable of evaluating

Level	Indicator
Strategic use	Planning - Learners are able to understand problems - Students are able to plan problem solving strategies Monitoring - Students are able to realize the concepts and calculation methods used Evaluation - Students are able to do evaluation
Reflective use	Planning - Students are very capable of understanding problems - Students are very capable of planning problem solving strategies Monitoring - Students are very capable of realizing the concepts and methods of calculation used Evaluation - Students are very capable of evaluating

The subjects in this study were students of class VIII of Junior High School, namely SMP Islam Karangploso. Data from the pretest and posttest were analyzed by categorizing the level of students' metacognition abilities.

RESULT

Module Development

This research was conducted with a research and development (R&D) approach with 4-D development stages, namely define, design, develop, and disseminate. At the 'define' stage, the researchers analyzed the target school curriculum, which implemented the 2013 curriculum. The analysis found the Standard Competency and Basic Competence in the to-be-developed material, Solid Geometry on Flat Side. The Basic Competence includes the knowledge aspects (3.9), namely distinguishing and determining the surface area and volumes of flat-side spaces (cubes, blocks, prisms, and pyramids), and the skill aspects (4.9), that is solving problems related to the surface area and volumes of flat-side spaces (cubes and blocks) as well as their combinations. At the design stage, the researchers compiled the draft of the module. In this stage, the learning structure is divided into learning units, as in table 4.

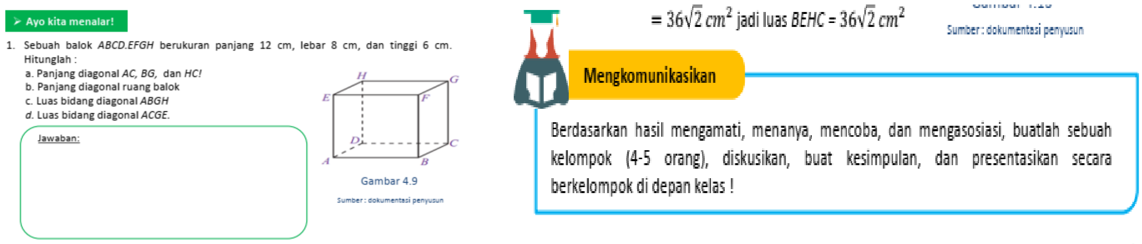
Table. 4 Division of Material Units in Cubes and Blocks

Learning Unit	Material Content
Unit 1	Introduction to cubes and blocks
Unit 2	Nets and surface area of cubes and blocks
Unit 3	Volumes of cubes and blocks
Evaluation	Exercises
Unit 4	Introduction to Prisms and Pyramids
Unit 5	Nets and surface area of prisms and pyramids
Unit 6	Volumes of prisms and pyramids
Evaluation	Exercises

(a) (b) (c)

Figure 2. Student Activities in observe (a), associate (b), and ask (c)

In this stage, the researchers arranged the learning activities using the scientific learning approach, which consists of observing, questioning, associating, reasoning, and communicating. Some pictures of the designed module can be seen in Figures 2 and 3. While the cover, odule can be seen in Figure 4.



(a) (b)

Figure 2. Student Activities in give reasons (a), and communicate (b)

Next, in the 'develop' stage, the module's revised draft was developed based on the inputs from the experts and the data obtained by small-scale trials. The activities at this stage comprised expert validation and some limited trials. Two lecturers and two mathematics teachers carried out expert validation. Table 5 shows the result of expert validation.

Table 5. Results of Expert and Teacher Assessment

No.	Validator	Score	Validation Criteria	Information
1	X-1	3.59	Very Valid	No Revision
2	X-2	3.54	Very Valid	No Revision
3	X-3	3.78	Very Valid	No Revision

No.	Validator	Score	Validation Criteria	Information
4	X-4	3.71	Very Valid	No Revision
Average		3.65	Very Valid	No Revision

Based on the table 5, the average score of the module validation was 3.65 with very valid criteria. It indicates that the module developed was feasible for use without needing any major revision.

The 'disseminate' stage aimed at publicizing the developed module. This stage consists of implementation, packaging, and trial in a big class. The implementation was carried out online. The researchers also looked for important data used for the analysis related to the dependent variables in this study.

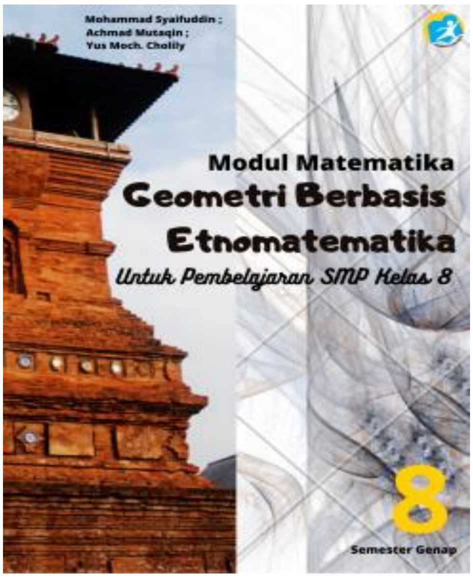


Figure 4. Module Cover

In the 'disseminate' stage, assessing the module's effectiveness on learning activities was also conducted. This effectiveness test was carried out by measuring the achievement level of the students' scores that meet the Minimum Completeness Criteria (KKM) is ≥ 75. The following diagram shows the results of the students' achievement score in learning using the developed module.

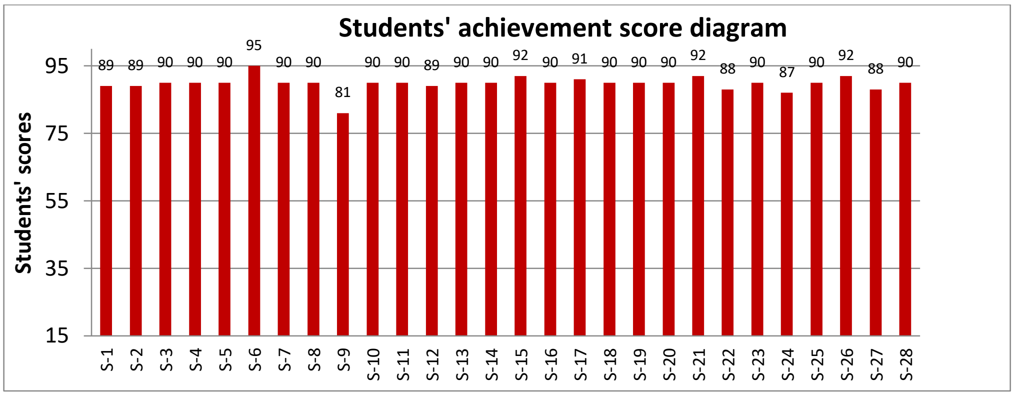


Figure 5. Diagram of Students' Achievement Score

Based on the diagram, an increase in the students' scores is indicated as their scores meet the Minimum Completeness Criteria, with the scores ≥ 75. All students' scores are above the Minimum Completeness Criteria, with the average score above 80, ranging from 81 to 95. From the result, it can be concluded that the developed module has a high level of effectiveness perceived from the students' achievement that is above the Minimum Completeness Criteria.

Metacognition Ability

The Table 6 shows the students' metacognition level data in solving problems at the pre-test and post-test.

Table 6. Results of the Students' Metacognition Level at the Pre-Test and Post-Test

Metacognition Level	Pre-test		Post-test	
	Number of students	%	Number of students	%
Tacit Use	10	35.71	0	0.00
Aware Use	9	32.14	3	10.71
Strategic Use	6	21.43	12	42.86
Reflective Use	3	10.71	13	46.43
Number	28	100.00	28	100.00

The effect of using the developed module on the improvement of the students' metacognition level was investigated using SPSS version 17. The results are shown in Table 7.

Table 7. Values of the Students' Metacognition Level at the Pre-test and Post-test

Statistics	Scores of VIII B	
	Pre-test	Post-test
Number of samples	28	28
Lowest score	50.00	80.00
Highest score	78.00	94.00
Average score	65.00	87.89
Standard deviation	6,377	3,614

Before implementing learning with the developed module, the lowest score at the pre-test was 50.00, and the highest score was 78.00. The students' average score at the pre-test was 65.00, with a standard deviation of 6.377. It means that most of the data distribution is in a plus-minus group of 6.377 from the average. Meanwhile, the students' average score in the post-test was 87.89, with a standard deviation of 3.614. It shows that most data distribution is in a group within a plus-minus of 3,614 from the average. After implementing learning with the developed module, the lowest score found in the post-test was 80.00, and the highest score was 94.00.

Testing the students' metacognition ability improvement was applied to both students' pre-test and post-test scores. This paired test was conducted to determine the relationship between the module's use and the increase in the students' metacognition ability. However, before testing the paired sample t-test, it is also imperative to conduct a normality test to determine whether the data is normally distributed or not.

Based on the Table 8, the Kolmogorov-Smirnov normality test obtained a significance (Sig.) from the pre-test score with 0.150 and the post-test score with 0.11. It can be concluded that the analyzed data are normally distributed as the Sig.> 0.05. Thus, the paired-sample t test can be done. This test was conducted to assess the module's use with regards to the students' metacognition ability. The test was carried out by taking the students' scores from both the pre-test and post-test. The results are indicated in the following Table 9.

Table 8. Normality Test Results

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig
Pre-test score	.143	28	.150	.963	28	.406
Post-test score	.190	28	.11	.901	28	0.12

The findings are shown in the descriptive statistical results of the pre-test and post-test scores on the Table 9. From the total respondents of 28 students, the pre-test mean score is 65.00, and the mean score of the post-test is 87.89. From the results, the difference between the learning outcomes in the pre-test and post-test is implied.

Table 9. Average Results of Pre-test and Post-test Values

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 Pre-test score	65.000	28	6.37704	1.20515
Post-test score	87.8929	28	3.61416	.68301

Based on the Table 10, the significance value (Sig. 2-tailed) is 0.00 < 0.05. Then, null hypothesis is rejected, and alternative hypothesis is accepted. Therefore, it can be assumed that the average difference of the learning outcomes between the pre-test and post-test occurs; it means that there is an effect of using the ethnomathematics based geometry module with a scientific approach on the students' metacognition ability.

Table 10. Paired Sample Test Results

	t	df	Sig. (2-tailed)
Par 1 Pre-test score-Post-test score	-17.943	27	.000

DISCUSSION

The results of the research on the development of an ethnomathematics based geometry module with a scientific approach obtained an average validation value of 3.65. This is relevant to research conducted by Hartono & Noto, 2017; Setiyadi, 2017; Haryanti & Saputro, 2016 that the average validation value is categorized as very valid or very good. The effectiveness of the modules developed in learning has a good impact, this is obtained from the value of student learning outcomes that meet the Minimum Completeness Criteria for Mathematics, namely ≥75. Based on the above analysis, it shows that the ethnomathematics-based geometry module with a scientific approach is effective in learning mathematics. These results are in line with research conducted by Febriana, Haryono, & Yusri (2017) dan Suryani, Anwar, Hajidin, & Rofiki (2020). Likewise, ethno-mathematics-based geometry modules can improve student achievement, such as the results of research by Tyas, Pangesti, & Retnowati (2017) that the geometry module plays a role in developing intellectual abilities, skills, and student learning achievement.

The use of developed modules influences on students 'metacognition abilities, the research data shows an increase in the percentage of students' metacognition ability categories before and after learning with modules. The module testing developed also has a significant effect on metacognition abilities. The data on metacognition ability were obtained from the results of the pretest and posttest scores of students with the normality of 0.150 at pretest and 0.011 at posttest, meaning that the data obtained from the study were normally distributed with a Sig. > 0.005. This is in line with the results of research conducted by Ruyadi, 2010; Helmiati dkk., 2013; Sumartini, 2018 obtained the Sig. > 0.005 categorized as normally distributed. Because the data is normally distributed, the paired sample t-test can be do it. (Sumartini, 2018).

The results of the paired sample t-test between the use of the developed module with the effect of increasing metacognition ability obtained a Sig. (2-tailed) value of 0.00 <0.05, then H0 is rejected and H1 is accepted. The test results are in line with Lastuti, 2018; Montolalu & Langi, 2018; Kelanang & Zakaria, 2012, that the Sig. (2-tailed) 0.00 <0.05 then H1 is accepted. So it can be concluded that there is an effect of using a geometry module based on ethnomathematics with a scientific approach on students' metacognition abilities. Based on the results of t count and t table, it is obtained that t arithmetic from the output above the t value is 17.943. Furthermore, the t value table df value 27 and the significance value $\alpha/2 = 0.05/2 = 0.025$, then the t table value is 2.0518. Thus, the value of t count > t table, it is concluded that there is an effect of using the developed module with metacognition abilities. Based on the analysis and description above, it shows that the use of ethno-mathematics-based geometry modules with a scientific approach has an effect on metacognition abilities. These results are in line with research by Novalia & Noer (2019), Kapustina et. al. (2014), and Novriani & Surya (2017) which were state that there is an effect of using modules on metacognition abilities. Based on the 2013 curriculum, the implementation of a scientific approach to learning mathematics will encourage students to have metacognitive competencies based on their curiosity about science and technology (Kemdikbud, 2013). Thus, the use of ethnomathematics based geometry modules with a scientific approach affects metacognition abilities.

CONCLUSION

Based on the results and discussion above, the research conclusions are (1) the module development is carried out with the 4D model (define, design, development, and disseminate), resulting in the geometry module based on ethnomathematics with a scientific learning approach; the materials focus on cubes, blocks, prisms, and pyramids. (2) The ethnomathematics based geometry module with a scientific approach is valid with very good categories. The module is also categorized as effective for use in learning activities. (3) Ethnomathematics based geometry modules with a scientific approach has an effect on metacognition abilities.

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