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DEVELOPMENT OF GEOGEBRA ASSISTED LEARNING MODULES TO IMPROVE MATHEMATICAL REPRESENTATION ABILITIES AND SELF REGULATED LEARNING OF SENIOR HIGH SCHOOL

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ABSTRACT

This research aims to analyze: 1) Validity of the geogebra-assisted learning module developed; 2) Practicality of the geogebra-assisted learning module developed; 3) Effectiveness of the geogebra-assisted learning module developed; 4) Increasing mathematical representation abilities by using the geogebra-assisted learning modules that were developed; 5) Increasing self regulated learning by using the geogebra-assisted learning modules that were developed. This research is development research using the ADDIE development model. This development model consists of 5 development stages, namely analysis, design, development, implementation and evaluation. From the results of trial I and trial II it was obtained: 1) The geogebra-assisted learning module developed meets the valid criteria; 2) The geogebra-assisted learning module developed meets the practical criteria; 3) The geogebra-assisted learning module developed meets the effective criteria; 4) The mathematical representation ability using the geogebra-assisted learning module that has been developed has increased as seen from the N-gain value of 0,45, meaning it is in the "medium" category; and 5) Self regulated learning using the geogebra-assisted learning module that has been developed has increased as seen from the N-gain value of 0,42, meaning it is in the "medium" category.

Keywords: Module, Geogebra, ADDIE, Mathematical Representation Ability, Self Regulated Learning

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PRELIMINARY

Mathematics is important for humans because it cannot be separated from everyday life problems. The existence of mathematical methods provides inspiration to thinkers in the social and economic fields. Mathematical calculations form the basis of engineering disciplines. In addition, mathematical thinkers gave color to the activities of painting, architecture and music. In the world of banking and economics, mathematics supports the progress and decline of a country, because in the current free market era, everything must be calculated and carried out mathematically. With mathematics, we can develop everything according to our mindset. So it can be said that the role of mathematics is in almost all aspects of life and supports efforts to advance human life.

But in actuality, Indonesia's issue is that its kids continue to do poorly in mathematics at both the national and international levels. The 2018 Program for International Student Assessment survey findings demonstrate that Indonesian students' proficiency in mathematics is still lacking. Indonesia itself is ranked 75th out of 81 countries with a score of 379. Comparatively, with scores of 591 and 569, respectively, China and Singapore hold the top spots.

This is certainly a big challenge for mathematics teachers to create interesting learning so that students like mathematics lessons that have been considered scary and ultimately this is in line with increasing mathematics learning achievement. There are certain mathematical skills that pupils need to possess in order to increase their math learning achievement. The capacity for mathematical representation is one of the most crucial mathematical skills that pupils should possess. Mathematical representation ability is an ability that includes aspects of the ability to use ictures/diagrams/tables/mathematical symbols/mathematical equations to express a mathematical idea so that it is useful in solving mathematical problems, explaining them and communicating them (Minarni, et al, 2020). Mathematical representation also has an important role in solving mathematical problems. If students already have good mathematical representation skills, then it is certain that students will be greatly helped in solving mathematical problems.

When students construct, compare, and apply different mathematical representations, they can deepen their understanding of mathematical topics and their relationships. This is why mathematical representations are crucial to the mathematics learning process. Students can also convey their ideas more effectively by using representational tools including physical objects, images, graphs, diagrams, and symbols (NCTM, 2000). The mathematical representation indicators employed in this study are as follows: 1) using visuals to help solve problems and make them more understandable; 2) using the problem to construct a mathematical expression or model; and 3) using computations to solve problems requiring mathematical expressions.

Empirical data indicates that pupils' proficiency in mathematical representation is still lacking. This is consistent with what the researcher learned from speaking with a math study teacher at SMA Negeri 14 Medan. The researcher first inquired about the content that students found challenging and the difficulty of explaining it to them. Distance matter in flat-sided space is one of these materials, he said. “Students are not able to translate the questions I give into mathematical language. They found it very difficult to convert my problems or questions into mathematical symbols mathematically, and many were unable to express them in the form of pictures. This of course becomes an obstacle for students to solve the problems presented. In short, the representation abilities of these children are still very low," he added. In fact, as we know, mathematical representation ability is one of the standard mathematical skills that students must have. Next, the researchers categorized the results of students' work into 5 categories, namely students with mathematical representation abilities in the categories very high, high, medium, low and very low. The categorization uses Table 1 (Ratumanan, et al.,2022).

Table 1. Category of mathematical representation ability

Score	Category
$85 \leq x$	Very High
$70 \leq x < 85$	High
$55 \leq x < 70$	Medium
$40 \leq x < 55$	Low
$x < 40$	Very Low

On September 23, 2022, 36 students in grade XII at SMA Negeri 14 Medan were given mathematical representation questions. The results showed that 52.8% of the students who met the indications drew the issue to help explain it and make it easier to solve (19 persons). Furthermore, the indicator for making mathematical expressions or models from the problems given was 43.2% (17 people). Meanwhile, the indicator for carrying out calculations to solve problems involving mathematical expressions was 38.9% (14 people). The test results also indicated that 2 individuals were in the very high category, 5 individuals were in the high category, 8 individuals were in the medium category, 14 individuals were in the low category, and 7 individuals were in the low category based on the classification of students' mathematical representation abilities. Meanwhile, if viewed in terms of completeness for the competency to be achieved in this material, only 16 people achieved the minimum completeness criteria, namely 70. This means that only 44.4% achieved a score of 70, while the percentage of classical completeness should be 85% (Trianto, 2011). These data demonstrate how poor studentss' mathematical representation ability remain.

Apart from students' mathematical representation abilities as a cognitive aspect, affective aspects are also needed as soft skills in mathematics. According to Afrilianto & Rosyana (2014), the emotive behavior exhibited by an individual when applying mathematical hard skills is what defines mathematical soft skills as a part of the mathematical thinking process in the affective domain. One of the affective behaviors that is important for students to have in learning mathematics is self regulated learning. Self regulated learning simply means learning independently or not being told/ordered/commanded to study. Self regulated learning is a form of learning that provides opportunities for learners to determine learning goals, resources and activities according to their own needs. In the learning process, students can participate actively in determining what to learn and how to learn it (Kozma, et. al., 1998). According to Brookfield (2000), Self regulated learning is self-awareness, self-driven, the ability to learn to achieve goals. According to Butler & Winne (1995), self regulated learning is characterized by learning that is driven by motivation to learn, metacognition—the ability to think critically about one's own ideas—and strategic action—the ability to plan, monitor, and assess one's own progress in relation to a standard. In Minarni (2020), Wenne and Omrod define self-regulated learning as the process of managing and assessing one's own behavior and learning.

Minarni (2020) summarizes aspects of self regulated learning into several phases, namely motivation, planning (planning activities), action (action on one's own initiative in accordance with planning), and monitoring and checking the implementation of actions/activities. Meanwhile, Sufyarma (2006: 50-51) stated that independent people can be seen using indicators including: (1) progressive and tenacious; (2) take the initiative; (3) controlling from within; (4) self-stability, (5) gaining satisfaction from one's own efforts. Self-regulated learners have a repertoire of tactics they use correctly to manage the day-to-day problems of academic work. They are also aware of their academic strengths and shortcomings. Independent learners ascribe their success or failure to their own performance (e.g., amount of effort put into activities, application of effective tactics, and self-control) and hold extra views about intelligence (Dweck & Legget, 1998). Students who having independence in learning will not blame those outside himself for the failures he achieves, for example, he will not call teachers favoritism in setting grades. In addition, the goal of national education is to mold future students into people who believe in and are committed to God Almighty, have noble character, are knowledgeable, capable, creative, independent, and responsible, as stated in Law Number 20 of 2003 concerning the National Education System. Based on the objectives of the national education system, pupils should possess the independent element as one of their key competences. If students Having high levels of independence, it is hoped that he will be able to face the challenges of a competitive era without depending on other people.

However, the problem that exists in the field to date is that classroom learning is less than optimal in supporting students' self regulated learning. Existing learning still focuses on teachers as the only source of learning so that it does not give rise to high learning motivation for students. Students rely too much on explanations of material from teachers and very few students try to find other learning sources to support their academic assignments. This kind of learning causes students to tend to be passive in learning, accepting whatever the teacher teaches so that students do not learn to construct their own knowledge.

This is consistent with observations reported by researchers who discovered that teacher-centered learning is still prevalent in education. Learning is still merely transferring information using conventional learning models that use lecture methods, questions and answers and giving assignments. Students only listen to explanations given by the teacher, follow instructions and example questions from the teacher which shows low student initiative and curiosity which is an indicator of student self regulated learning. In addition to the responses from the previously provided mathematical representation test, there are additional student responses that demonstrate the lack of responsibility, reliance on others, and confidence in oneself. The findings of the observations also revealed that students' use of instructional resources was restricted to textbooks and did not involve the use of applications.

Looking at the facts explained above and also the existing learning conditions, it is necessary to make changes in the process of learning activities to increase students' Self regulated learning and mathematical representation abilities. It is hoped that the learning carried out will no longer be teacher-centered, but rather student-centered, thereby giving students the opportunity to be active in learning. In addition, students no longer rely on teachers as the only source of learning, but must be able to learn independently so that they can support successful learning in mathematics. Therefore, researchers consider that it is necessary to strive for activities and mathematics teaching materials that can support students' mathematical representation abilities and self regulated learning. In this research, the teaching materials in question are modules and the media used is the Geogebra application. The module was chosen because, up until this point, pupils had only used printed materials provided by the school. No module had been individually designed by the mathematics teacher at SMA Negeri 14 Medan. Apart from that, the module is self-instructional so that students can learn independently, as stated by Prastowo (2015), modules are printed instructional resources that are methodically arranged according to students' age and knowledge levels in easily understood language. This allows students to learn independently with little assistance or direction from teachers.

The aforementioned claim is consistent with that made by the Pusdiklat Perpurnas (2021), which states that a module is a piece of learning content that students can study on their own. It has simple parts and directions so that kids can follow along step-by-step without assistance from teachers. This is different from those which are accompanying learning provisions which involve teachers and students directly, both face to face and online. Using textbooks usually requires assistance from the teacher.

The module that will be used in the research later is a module assisted by the GeoGebra application, namely a module whose contents are integrated with problem solving steps using the GeoGebra application. Geogebra is dynamic mathematics software that integrates geometry, algebra, and calculus, according to Hohenwarter et al. (2008). Geogebra is a user-friendly mathematics program that can be used for geometry, algebra, and calculus, according to Wulandari (2015). Based on the several definitions provided above, it can be said that GeoGebra is a kind of mathematical software that is used to teach geometry, algebra, and calculus. Students can learn mathematics more effectively by using Geogebra as a visual aid for abstract concepts. In addition, teachers can utilize Geogebra as a mathematics teaching tool to build interactive lessons that let students investigate a range of abstract mathematical ideas. The reason researchers chose GeoGebra was because teachers in the field of study had never used applications in learning and GeoGebra also had the advantage of being free software, which could be used on various operating systems. supported by more than 40 languages, supports 3D, .ggb files on Geogebra can be published as web. This makes it easier for students to use, because they only need to use a browser to interact. In other words, students do not need to have GeoGebra installed on their computer, but must ensure that the latest version of Java is installed. Another advantage is easy to use. On Geogebra, every button and syntax has accompanying usage instructions and support.

From all the explanation above, it can be concluded that students' representational abilities and self regulated learning are very important in learning mathematics. However, the information obtained shows that the majority of students do not have these two things, so it can be stated that there is a problem that needs to be resolved. So to solve this problem the researcher developed a teaching material that would meet the criteria of being valid, practical and effective. The research that will be done in this instance is the development of geogebra-assisted learning modules to improve high school students' mathematical representation abilities and self regulated learning because these teaching materials are related to the learning process goals, particularly in improving students' mathematical representation abilities and self regulated learning. So, in this research, we will analyze validity of the geogebra-assisted learning module developed, practicality of the geogebra-assisted learning module developed, effectiveness of the geogebra-assisted learning module developed, increasing mathematical representation abilities by using the geogebra-assisted learning modules that were developed, and increasing self regulated learning by using the geogebra-assisted learning modules that were developed.

METHODS

This study use development research as its methodology (Research and Development). Using this research methodology, specific goods are created and their viability is evaluated. The ADDIE model is the development model that was applied in this study. The goal of this project is to create a math learning module on distance in flat space using geogebra assistance. SMA Negeri 14 Medan, situated on Jalan Siswa Ujung Gg. Darmo, Binjai Village, Medan Denai District, Medan Municipality, North Sumatra Province, is the location where the research was carried out. During the odd semester of the 2023–2024 academic year, this research was conducted. Students in class XII at SMA Negeri 14 Medan for the academic year 2023–2024 served as the research subjects. A learning module with assistance from Geogebra is the subject of this study. The present study employs the ADDIE development paradigm for the production of learning modules. This approach comprises five development steps or phases, namely Analysis, Design, Development, Implementation, and Evaluations.

Analysis Stage

At this stage, researchers analyze the need for developing learning modules and the feasibility and requirements for development. According to Rusmayana (2021), the first step in the ADDIE development research model is to assess the demand for creating new goods (models, techniques, media, and instructional materials) as well as the prerequisites and viability of doing so. A fault with an already-existing or implemented product may serve as the impetus for a new product's development. Current or existing products may no longer be relevant to target needs, learning environments, technology, student characteristics, and other factors, which can lead to problems. Thus, the researcher conducted an analysis in this study that encompassed elements of curriculum analysis, learning objectives analysis, student character analysis, and student needs analysis.

Design Stage

According to Winaryati, et al., (2021), design activities include: a) taking all information from the analysis stage and starting the creative process of designing the product; b) identify materials and resources that will be needed, design activities, determine how to assess; c) the final result of the design stage is a blueprint or storyboard. Adopting the activities at the design stage according to Winaryati, et al., (2021), the researcher carried out three steps at this stage, namely: (1) setting up and assessing the tool; (2) choosing media that aligns with the content and learning goals; and (3) choosing the format, which involves looking at the forms of teaching materials that are currently in use and figuring out what structure the new materials will take. At this point, a preliminary draft of the learning implementation plan (RPP) is created for three meetings, as well as learning modules, activity sheets, student-regulated learning questionnaires, alternative solutions, and scoring criteria. Students' tests of mathematical representation ability are also developed. At this design stage, all outcomes are referred to as draft I.

Development Stage

A learning module's draft I design is the result of the analysis and design phases. The initial step in the development stage is to conduct field testing after having draft I validated by specialists. The format, content, graphics, and language of the created learning modules and tools were the main areas of expert validation. Draft I is revised and improved based on expert validation results, including validation AI scores, changes, criticism, and suggestions. The revision produced learning modules with geogebra assistance that satisfy the necessary requirements; these are referred to as draft II from now on. Modules and tools are revised and improved based on the findings of expert validation.

Implementation Stage

The learning tools in draft II are tested at the study site, which is SMA Negeri 14 Medan; this is known as trial I, once the generated learning tools have satisfied the validity criteria. According to the RPP, which was created with the intention of gauging the applicability and efficacy of the learning modules being developed, Trial I was conducted in three meetings in Class XII IPA 1.

Evaluation Stage

Based on the results of the first trial, an evaluation was carried out as to whether the learning module met the practical and effective criteria. If it is not met then improvements are made to obtain results in accordance with the research objectives, namely producing valid, practical and effective learning modules. The results of the revisions to draft II produced draft III which was then tested again. Trial II was carried out to measure draft III as a geogebra-assisted learning module that met all the practical and effective criteria set.

Additionally, the One-Group Pretest-Posttest Design trial design utilized in this study is shown in Table 2 (Sugiyono, 2013).

Table 2. One-Group Pretest-Posttest Design

Pretest	***Treatment***	***Posttest***
O_1	***X***	***O_2***

Validation sheets, assessments of students' mathematical representation skills, student self-regulated learning questionnaires, teacher response questionnaires, and student response questionnaires were the instruments used in this study. In order to draw research conclusions, the data is also processed using descriptive statistical analysis based on the average score of the modules that have been validated by experts in the field of mathematics education and revised based on their corrections and suggestions. Based on this validation, it will be possible to conclude whether the learning modules and research instruments are suitable for use or need to be revised. The values that were acquired after processing are then recorded in the relevant table column. Additionally, as shown in Table 3, this cumulative average value is mentioned in the interval for figuring out the degree of module validity.

Table 3. Validity Level Criteria

Number	**V_a**	**Criteria**
1	$1 \leq Va < 2$	Invalid
2	$2 \leq Va < 3$	Less Valid
3	$3 \leq Va < 4$	Quite Valid
4	$4 \leq Va < 5$	Valid
5	$Va = 5$	Very Valid

If the minimum level of validity attained is the valid level, then geogebra-assisted modules and research instruments have a fair degree of validity, according to the criteria. Revision is required if the degree of validity attained is below valid. After then, the validation tasks are completed once more. And so forth, until the validity measure yields the perfect module.

Additionally, students must provide a minimum of a good response, the average score on the learning tool implementation sheet in class must be at least good, and the expert/practitioner assessment of the learning tools developed must state that they are usable with little to no revision for the Geogebra-assisted learning module to be considered practical.

Geogebra-assisted learning modules are said to be effective if the minimum test score for students' mathematical representation ability is 70 and classically at least 85% of students fulfill the learning mastery, the minimum student self regulated learning questionnaire score is in the "medium" category (55<SKBS≤70), and implementation time as planned.

The N-Gain formula is used to compute the gain in students' mathematical representation skills and self-regulated learning following use of the Geogebra-assisted learning module. According to Hake (1999), the N-Gain formula is a test that can give an overall impression of the rise in learning outcome scores prior to and following the application of a treatment. In Hake's (1999) formula, the N-gain is:

$$N - gain = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}}$$

Keterangan:

$N - Gain$ = N-gain score

$Spost$ = posttest score

$Spre$ = pretest score

$Smax$ = maximum score

With gain index criteria as in the following table *(Hake, 1999)*:

Table 4. N-Gain Score Criteria

Gain Score	Interpretation
$g > 0.7$	High
$0,3 < g \leq 0.7$	Medium
$g \leq 0.3$	Low

RESULT AND DISCUSSION

At the analysis stage, researchers analyzed the need for developing learning modules and the feasibility and development requirements. Rusmayana (2020) stated that in the ADDIE development research model the first stage is to analyze the need for developing new products (models, methods, media, teaching materials) and analyze the feasibility and requirements for product development. The development of a product can be initiated by a problem in an existing/implemented product. Problems can arise and occur because current or available products are no longer relevant to target needs, learning environments, technology, student characteristics and so on. So in this research, the researcher carried out an analysis that covered aspects of the analysis of student needs, which involved examining the learning environment as the primary source of information and researching the challenges teachers faced in coming up with potentially more effective and efficient alternative learning activities; examining student behavior to ascertain students' attitudes toward learning mathematics; examining the curriculum while paying attention to the features of the curriculum utilized in the school in question, specifically the revised 2013 curriculum; and formulating learning objectives that are helpful in describing indicators of achievement of learning outcomes into more specific indicators.

Analysis of student needs is carried out by analyzing the learning conditions as the main information and studying the problems faced by teachers in determining possible alternative learning activities that are more effective and efficient. This analysis was carried out by interviews and classroom observation to find out basic problems. At this stage, facts and alternative solutions are presented, making it easier to determine the initial steps in developing solutions that suit students' needs. The results of observations made by researchers found that learning still tends to be teacher-centred. Learning is still merely transferring information using a conventional learning model that uses lecture, question and answer methods and giving assignments (attached observation sheet). Students only listen to explanations given by the teacher, follow instructions and example questions from the teacher which shows the low level of student learning independence. When several students were asked to solve problems, these students were unable to translate the questions into pictures or write mathematical expressions. From the results of the observations carried out, it was also discovered that the teaching materials used by students were limited to textbooks and from the results of interviews teachers had never developed modules independently. The results of interviews with students also showed that students rarely read books either at home or before lessons start because students were less interested. When researchers asked what the cause was, some students said the contents of the book were less interesting regarding the pictures and several other students said that sometimes the instructions or steps in the material were not clear. Apart from that, there is a lot of material that must be studied accompanied by the teacher/waiting for an explanation from the teacher.

The results of the student analysis start from an analysis of the academic abilities of students at SMA Negeri 14 Medan which are classified as low. As a result of interviews conducted by researchers with study teachers, it was found that students had difficulty understanding distance material in flat space. Students often don't even understand the meaning of the questions given. “Students are not able to translate the questions I give into mathematical language. "They find it very difficult to convert problems or questions from me into mathematical symbols mathematically, and many are unable to express them in the form of pictures," answered Enita Napitupulu, S. Pd as a mathematics study teacher at SMA Negeri 14 Medan in an interview session. carried out by researchers.

Based on the categorization of student scores, from the results of the initial test when the researcher made observations, data was obtained that 2 people were in the very high category, 5 people were in the high category, 8 people were in the medium category, and 14 people were in the low category, and 7 people were in the very low category. Meanwhile, if viewed in terms of completeness for the competency to be achieved in this material, only 16 people achieved the minimum completeness criteria, namely 70. This means that only 44.4% achieved a score of 70, while the percentage of classical completeness should be 85% (Trianto, 2011). These facts show that students' mathematical representation abilities are still low.

Furthermore, the learning independence of students at SMA Negeri 14 Medan is also still low. This is in line with the results of observations made by researchers who found that learning still tends to be teacher-centred. Learning is still merely transferring information using conventional learning models that use lecture, question and answer methods and giving assignments. Students only listen to explanations given by the teacher, follow instructions and example questions from the teacher which shows low student initiative and curiosity which is an indicator of student learning independence. Apart from the answers from the mathematical representation test given previously, there are the same student answers which show that students do not have self-confidence, depend on other people, and do not have a sense of responsibility.

Curriculum analysis was carried out by taking into account the characteristics of the curriculum used in the school concerned, namely the revised 2013 curriculum. This is done so that the development of learning modules is in accordance with curriculum demands. After that, researchers studied Basic Competencies (KD) to formulate indicators of learning achievement. And formulating learning objectives is useful for describing indicators of achieving learning outcomes into more specific indicators. The preparation of learning objectives or indicators for achieving learning outcomes is based on basic competencies (KD) and indicators listed in the curriculum regarding a material concept.

Tabel 5. Learning Objectives: Distance in Flat Space

Number	Topic	Learning objectives	Meeting
1	Distance between points in flat space	1. Students are able to describe the distance between points in space correctly 2. Students are able to explain the procedure for determining point-to-point distances correctly 3. Students determine the distance from point to point in flat space correctly	1
2	The distance between a point and a line in flat space	1. Students are able to describe the distance from points to lines in space correctly 2. Students are able to explain the procedure for determining the distance from a point to a line correctly 3. Students determine the distance from a point to a line in flat space correctly	2
3	The distance between a point and a plane in flat space	1. Students are able to describe the distance from a point to a plane in space correctly 2. Students are able to explain the procedure for determining the distance from a point to a plane correctly 3. Students determine the distance from a point to a plane in flat space correctly	3

At the design stage, an initial draft (draft 1) was prepared to design examples (prototypes) of learning modules, lesson plans, worksheets, test instruments for students' mathematical representations, student Self regulated learning questionnaires, learning implementation observation sheets, and student response questionnaires. According to Winaryati, et al., (2021), design activities include: a) taking all information from the analysis stage and starting the creative process of designing the product; b) identify materials and resources that will be needed, design activities, determine how to assess; c) the final result of the design stage is a blueprint or storyboard. Adopting the activities at the design stage according to Winaryati, et al., (2021), the researcher carried out three steps at this stage, namely: (1) preparing the instrument and evaluating the instrument, (2) selecting media that suits the characteristics of the material and learning objectives, (3) selecting the format, namely reviewing existing teaching material formats and determining the format of teaching materials to be developed.

The preparation of the instrument consists of tests and non-tests which are prepared based on the specifications of the learning objectives and the ability indicators being measured. The test prepared is a mathematical representation ability test and the non-test prepared is a learning independence questionnaire. To design the tests and non-tests, a grid was prepared based on indicators of mathematical representation ability and learning independence. The tests developed are adjusted to the level of students' cognitive abilities. Scoring test results uses an evaluation guide that contains answer keys and scoring guidelines for each test item. Apart from that, a validation sheet is also prepared which will be used by the validator to assess the instruments that have been prepared. At this stage, an initial draft of the learning implementation plan (RPP) is produced for 3 meetings, learning modules, activity sheets, students' mathematical representation ability tests and student learning independence questionnaires, alternative solutions and scoring guidelines. All results at this design stage are called draft I.

Validating draft I with specialists and conducting field trials are the first steps in the development stage. The structure, subject matter, language, and graphics of the created learning modules and tools were the main areas of expert validation. The first draft is revised and improved based on expert validation results, which include validation AI scores, errors, criticism, and recommendations. The revision produced learning modules with geogebra assistance that satisfy the necessary requirements; these are referred to as draft II from now on. Modules and tools are revised and improved based on the findings of expert validation. A learning module received an average score of 4.15, indicating that it was in the legitimate category, based on the findings of expert validation.

Step two is the implementation stage, where learning modules and instruments in draft II form are tested at the research site, SMA Negeri 14 Medan, henceforth referred to as trial I, after the developed learning modules and instruments have satisfied the validity criteria. Trial I was conducted in the classroom. The trial I average for the total number of positive replies from students was 87.43%, falling into the "good" category. However, the trial I average for the application of learning utilizing the learning module that was built fell into the "not good" area with a score of 2.96. This score does not meet the criteria for success in the practicality of learning media in terms of learning implementation. It can be concluded that the learning module developed is not yet practical because it does not meet one of the practical criteria, namely the implementation of learning tools in the classroom has not reached the minimum good category.

Next, improvements were made to the Geogebra-assisted learning module and trial II was carried out. In trial II, the average percentage of total positive responses from students in trial II was 90.29%, namely in the good category, but the average score for implementing learning using the learning module developed in trial I was in the "executed well" category. good” with a score of 3.84. The learning module meets all practical criteria so we can say that this Geogebra-assisted learning module is practical.

In trial II, pupils' mastery of classical learning was 28.57% in the pretest and 85.71% in the posttest. The posttest results of students' mathematical representation abilities in trial II have satisfied the requirements for achieving classical completeness, which are based on the requirement that a minimum of 85% of students who participate in learning be able to achieve a score of 70 (complete). The average student's self-regulated learning score was 80.09 in the "medium" category following treatment, compared to 65.51 in the "sufficient" group prior to treatment. It is likewise in line with the scheduled learning period in terms of learning duration. Thus, we may conclude that this Geogebra-assisted learning module is effective because it satisfies all the effective criteria.

Next is data analysis on increasing students' mathematical representation abilities and Self regulated learning based on the N-Gain score. The average N-gain of mathematical representation ability obtained was 0.45 or an increase in the "medium" category ($0.30 < 0.45 \leq 0.70$). Meanwhile, the average N-Gain score for student Self regulated learning obtained was 0.42 or an increase in the "medium" category ($0.30 < 0.42 \leq 0.70$).

Based on the aforementioned explanation, it can be inferred that the proposed geogebra-assisted learning module satisfies the requirements for being useful, realistic, and efficient in addition to improving students' capacity for self-regulated learning and mathematical representation. Several elements lead to the acquisition of a valid learning module, such as: First, content validity is met by the learning module that was created. This indicates that the requirements of the current curriculum were followed in the preparation of this Geogebra-assisted learning module. These curricular requirements pertain to fundamental and core competencies that students must acquire through learning exercises that are tailored to the subject matter or lesson plan. The aforementioned is consistent with Arikunto's (2012) assertion that a learning tool has strong content validity if it can measure certain, targeted objectives that are related to the subject matter or lesson content. Curriculum validity is another term for this content validity.

Second, the learning module developed has met construct validity. This means that the development of this Geogebra-assisted learning module is in accordance with the concepts and indicators of mathematical representation ability and student Self regulated learning which are then combined with problem-based learning. The module developed is designed to complement the RPP and Worksheets which are adapted to problem-based learning to measure students' mathematical abilities and Self regulated learning. Furthermore, the discovery of weaknesses in the implementation of trial I became a reference for researchers to improve the learning module so that practical and effective criteria were met.

Furthermore, research conducted by Ratumanan, et al., (2022) entitled "Mathematical Representation Ability of Mathematics Education Study Program Students" demonstrates the findings, which point to two primary causes of inferior mathematical representation ability: (1) comparatively low prior knowledge and (2) mathematics learning. This is controlled by educators; education does not give students the chance to practice their mathematical representation skills. So by using Geogebra-assisted learning modules, learning is of course no longer dominated by teachers because by using modules students can learn independently without or accompanied by a teacher. Apart from that, in the module developed there are clear steps in using the GeoGebra application so that apart from discussing in groups, students can develop mathematical representation skills through using the GeoGebra application.

Similar things were also expressed in research conducted by Juliana (2020) where the use of learning modules could improve mathematical representation abilities and Septian's research (2022) where increasing mathematical representation abilities using geogebra was better than mathematical representation abilities using ordinary learning.

From the learning activities that took place from start to finish, researchers saw that students' self regulated learning continued to increase. The learning module itself motivates students to search for information related to learning material. In addition, the role of the teacher who is only a facilitator (not explaining like conventional learning) makes students feel that the modules given are weapons that they must master to fight in learning activities. Furthermore, the use of the GeoGebra application is interesting for students because the two classes that are the subject of the research have never used the GeoGebra application. And when they succeed in solving their own problems with the application, students feel they have their own value. This increase in student self regulated learning is evident from the N-Gain score results of the student Self regulated learning questionnaire before and after being treated in trial I. The results of the N-Gain calculation on student Self regulated learning obtained an average of 0.42, which means it is also in the "medium" category.

The above results are in line with research conducted by Ishartono, et al. (2022), entitled "Integrating Geogebra into the Flipped Learning Approach to Improve Students'

Self-Regulated Learning during the COVID-19 Pandemic" with the results that GeoGebra integrated Flipped Learning is more effective in increasing the level of student Self regulated learning. on online mathematics learning compared to the other two approaches. Leung (2018) research with the title "Development of Learning Devices Based on Discovery Learning Assisted Geogebra Models to Improve Self-regulated Learning of Students at SMP Negeri 1 Stabat" also shows the results of increasing student Self regulated learning using the Geogebra-based Discovery Learning approach. And research from Sulastri (2015) that learning using Geogebra can increase student Self regulated learning.

This research is inseparable from shortcomings and weaknesses due to various unavoidable limitations, including: 1) Teachers experience difficulties in providing guidance to students evenly. This is because students are not used to learning using the Geogebra application and group activities; and 2) The learning module in this research is used specifically for mathematical representation abilities and self regulated learning on distance material in flat plane shapes, but cannot measure other high-level thinking abilities, such as the ability to think logically, critically, creatively and others.

CONCLUSION

Several conclusions are proposed below, based on the findings of the analysis and debate in this study:

1. The geogebra-assisted learning module developed meets the valid criteria.
2. The geogebra-assisted learning module developed meets practical criteria
3. The geogebra-assisted learning module developed meets the effective criteria
4. The mathematical representation ability using the geogebra-assisted learning module that has been developed has increased as seen from the N-gain value of 0,45, meaning it is in the "medium" category
5. Self regulated learning using the geogebra-assisted learning module that has been developed has increased as seen from the N-gain value of 0,42, meaning it is in the "medium" category

In the meanwhile, the following are a few recommendations derived from the conducted research:

1. It is advised that teachers use this geogebra-assisted learning module to help students develop their mathematical representation skills and self-regulated learning, particularly in the classroom, since it satisfies the criteria of validity, practicality, and effectiveness.

2. The indicators of students' mathematical representation abilities and self-regulated learning should be given more consideration by other researchers who wish to measure these concepts in order to expand on our understanding of students' representation abilities and self-regulated learning.

It is necessary to develop Geogebra-assisted learning modules on other materials apart from the material on distances in flat space. Conclusions can also be added to the continued development of research results and further applications in subsequent research.

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