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Development of GeoGebra-Assisted Electronic Student Worksheets (E-Worksheets) to Improve Student Independent Learning

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Abstract

This study aims to produce teaching materials in the form of Electronic Student Worksheets (e-Worksheets) in the GeoGebra-assisted Basic Mathematics Study course to increase student learning independence. The method used in this study is a model 4-D which consists of four phases, namely the define, design, development, and the disseminate. But in this study only up to the stage of development. The subjects in this study were based on the level of student independence, namely high, medium, and low. Data was collected through the provision of validation questionnaires, student response questionnaires, and learning outcomes tests after using e-Worksheets. The results of the study show that: (1) The results of the validation for GeoGebra-assisted e-Worksheets are 3.08; learning outcomes test of 2.78 and learning independence questionnaire of 3.45 by experts (validators); (2) The results of the class trial were limited to the aspect of the student response questionnaire to the GeoGebra-assisted e-Worksheets obtaining a score of 78.3% while the class trial results of 76.8% met the practical criteria. (3) And the results of the class trial were limited to the aspect of the student learning outcomes test, it can be seen that the percentage of student learning completeness is 80.21% while the results of the field class trial are 78.47% which indicates that the GeoGebra-assisted e-Worksheets can be said to be effective.

Keywords: e-Worksheets, GeoGebra, Student Independent Learning

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INTRODUCTION

Mathematics is a pattern that grows and develops in life that is created from a thought process that will create regular patterns, connects between concepts, and apply organized concepts in solving everyday problems (Oktiningrum et al., 2016; Philosophy, 2008; Riyanto, 2017; Widodo & Wahyudin, 2018). Learning mathematics is an orientation towards the result and emphasizes all activities in the ongoing teaching and learning process (Grootenboer, P & Marshman, 2015). So that students are not only able to solve problems in mathematics, but also must be able to provide material explanations in mathematical language and be able to think logically, critically, creatively, systematically, and innovatively in solving problems (Planas, 2018; Ramdhani et al., 2017; Surya & Syahputra, 2017).

Mathematics trains a systematic way of thinking, through regular and certain sequences. By learning mathematics, we can unwittingly solve problems in a systematic way and can solve them more easily. Mathematics should be easier to understand. But in

fact, most students still find it difficult. Especially now that there is a Covid-19 pandemic, learning is carried out online. This is also very influential on students' understanding of the material being taught. In face-to-face learning, students still have many learning difficulties, especially online learning, there are still many who have difficulty completing mathematics (Susanti & Wulandari, 2021).

Online learning requires students to study independently. For this reason, as a lecturer, it is necessary to facilitate student learning in the form of teaching materials. Teaching materials that can be used are learning videos, books/modules, Worksheets, etc. In previous research, researchers have developed a YouTube channel vlog in Basic Mathematics courses (Susanti, V. D., Krisdiana, I., Murtafiah, W., Setyansah, R. K., & Masfingatin, 2021). The video development results are the validation results of 3 teaching material validators who obtained an average score of 77% which is declared valid. Based on the student response questionnaire at the field test stage, an average value of 75.46% was obtained, declared practical. Meanwhile, in the limited test stage, 81.94% was obtained which was also declared practical. Based on the learning outcomes test in the field test, the percentage of completeness was 81.82% which stated that the YouTube vlog channel was effective. Meanwhile, in the limited test stage, the percentage of completeness was 82% which was also declared effective. So that the YouTube vlog channel developed is suitable for use in online learning. The video explains the material and a short exercise. To strengthen student understanding, there needs to be feedback by giving some questions to students. The question can be made in the form of a Worksheets. Since it is still in the pandemic period, the worksheets will be made in electronic form.

One of the uses of e-worksheets as an additional exercise for students to better understand the material, in addition to measuring how far students can explore their potential by solving math problems while studying at home. Previous research on the development of e-Worksheets is research by Aldresti et al., (2021). In the research, Aldresti et al., (2021) developed an e-Worksheets based on Collaborative Learning for the Mathematics and Natural Sciences Education Basics course. This research was only developed to the valid stage. From this research, the results obtained are three e-Worksheets products with different topics. The validation test shows that the percentage validity of e-worksheets 1 of 92.36%, e-Worksheets 2 of 86.11%, and e-Worksheets 3 of 87.50%.

In the development of e-Worksheets, researchers develop e-Worksheets assisted by GeoGebra. GeoGebra is a dynamic program with various facilities that can be used as a medium for learning mathematics to demonstrate or visualize mathematical concepts and as a tool for constructing mathematical concepts (Arbain & Shukor, 2015; Botana et al., 2015; Kramarenko et al., 2020; Majerek, 2014).

In general, the GeoGebra-assisted E-Worksheet design contains a brief explanation before students work on the questions. In this brief explanation, e-Worksheets explains how a problem is solved mathematically using GeoGebra. With GeoGebra, students can correct which part of the solutions when they encounter different answers when working on problems mathematically. Therefore, students can be more independent when implementing online learning. From the problems above, the researcher formulates the problem of how to develop an e-Worksheets assisted by GeoGebra that can increase independent learning.

METHODS

The research method used in this study is the method Research and Development (R&D). According to Sugiyono (2012), research and development methods are research methods used to produce certain products and test the effectiveness of these products. The purpose of this research is to produce a product in the field of education, namely learning tools in the form of e-worksheets.

The model used is based upon the development of the 4-D model of S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel which consists of four phases, namely the define, design, development, and the disseminate (Thiagarajan & Semmel, 1974). However, the development of e-worksheets is limited at this stage of development. The e-Worksheets development procedure can be described as in the following chart:

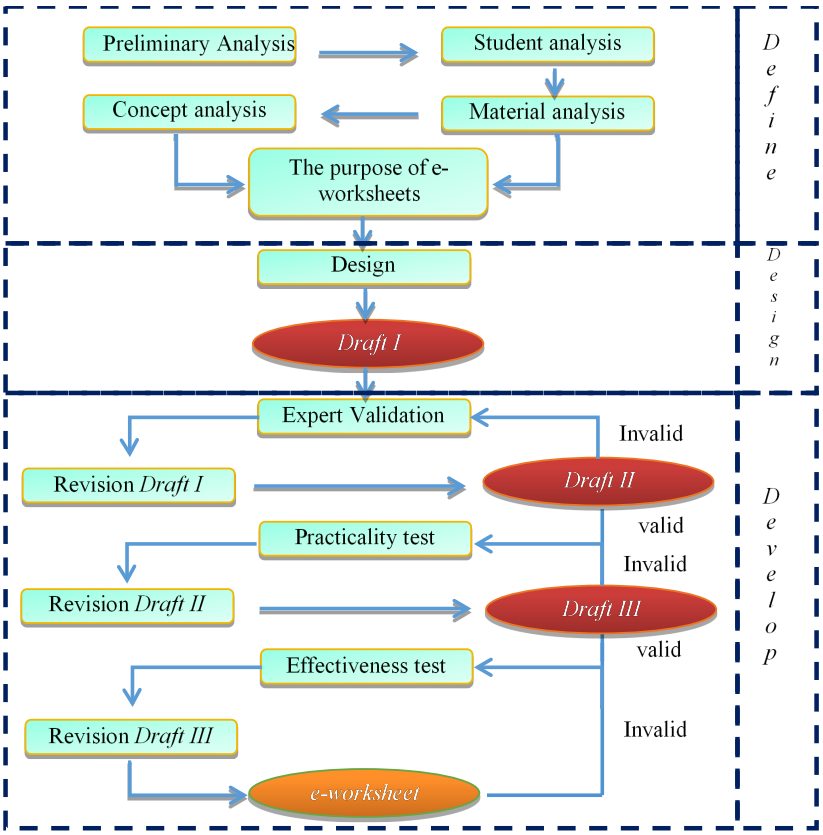

Figure 1. Modification of the 4-D Learning Device Development Model by Thiagarajan, Semmel, and Semmel

Define

The aim at this stage is to define and define learning requirements by analyzing the objectives and material limitations. Activities in this stage are:

1. Initial analysis to determine the basic problems needed for the development of mathematics teaching materials. Determination of the basic problem at this stage can be done by interviews and field observations to lecturers and students
2. Student analysis is a study of student characteristics by the design and development of GeoGebra-assisted e-worksheets, which includes student character, abilities, and experience.

3. Material analysis to identify, detail, and systematically develop e-worksheets concerning content standards.
4. Concept analysis aims to provide work direction for students so that they can overcome the problems they face in mathematics
5. The purpose of formulating the e-worksheets in the GeoGebra-assisted Basic Mathematical Study course is to formulate the achievement of student learning outcomes which then become the learning objectives. The results of the formulation of the learning objectives will be used as the basis for developing the e-worksheets design.

Design

At this stage, the designed draft of teaching materials is, namely the GeoGebra-assisted Basic Mathematical Study course. The steps in the e-worksheets design, namely: preparation of materials, selection of formats, compiling validation sheets.

Development

This stage aims to produce draft II, namely the revised e-worksheets after obtaining responses from students in the limited class test. The activity at this stage is the e-worksheets design that has been prepared at the stage design (draft I) and will be validated by experts (validators). The things that are validated by the experts include: content/material validation, validation in terms of language, limited class test, field class.

a. E-Worksheet Trial

   The e-worksheets trial is an important stage in Research and Development (R&D) research. The e-worksheets trial aims to determine the effectiveness of the developed product. The e-worksheets trial also looks at the extent to which the e-worksheets created can achieve the goals and objectives of e-worksheets development.

   1. Trial Design

      The inputs and suggestions obtained from the experts will be used as a reference for revision until the validator states that the GeoGebra-assisted e-worksheets made has good/feasible criteria. Furthermore, the product was tested in a limited class before being tested on-field class students as research subjects. In the limited class test stage, students are asked to provide responses and responses about the e-worksheets that has been made. In addition, researchers also took data in the form of student learning independence to see how far the students' achievement after using the GeoGebra-assisted e-worksheets was. The input from the limited-class test students was used as material for revising the GeoGebra-assisted e-worksheets. Furthermore, the e-worksheets are tested in the field class test. Students and lecturers are asked to respond to the e-worksheets, whether the developed e-worksheets are feasible and able to increase student learning independence.
   2. Data Type

      The type of data that will be taken in this study is the feasibility data of e-worksheets assisted by GeoGebra. Then the data is processed descriptively so that the conclusion of the product developed will be seen whether the product developed is feasible or not. Another form of data taken in this study is a student response questionnaire to the use of GeoGebra-assisted e-worksheets.
   3. Data Collection Instruments

      Data instrument is a tool used to collect data being researched. Some of the instruments used to develop the GeoGebra-assisted e-worksheets are as follows: validation sheets, tests and learning independence questionnaires.
   4. Data Analysis Techniques

      i. GeoGebra-assisted e-worksheets Validity Analysis

The scores that have been obtained are then analyzed using the formula:

$$\text{The average score of each component} = \frac{\text{TRA}}{\sum \text{V}}$$

With:
TRA = Total score of each component of all validators; $\sum$V = Number of validators
The average score for each aspect is then totaled and divided into four categories as shown in Table 1, as follows:

Table 1. Score Interpretation Criteria

Average Score	Criteria
1,00-1,75	Invalid
1,76-2,50	Quite valid
2,51-3,25	Valid
3,26-4,00	Very valid

e-worksheets assisted by GeoGebra is declared valid if the average score obtained is ≥ 2.51.

ii. GeoGebra-assisted e-worksheets Practical Analysis
The Practicality Sheet was analyzed descriptively quantitatively. First, each component is calculated, then the total average percentage is calculated using the formula:

$$\text{The average score of each component} = \frac{A}{B} x100\%$$

note:
A = the proportion of students who choose; B = number of students (respondents)
The percentage of response results is then interpreted according to the interpretation of the score in table 2:

Table 2. Interpretation of the Percentage of Student Learning Outcomes

Average Score (%)	Category
80 < X	Very good
60 < X ≤ 80	Good
40 < X ≤ 60	Sufficient
20 < X ≤ 40	Deficient
X ≤ 20	Very less

Geogebra-assisted e-worksheets is declared practical if the percentage of student response questionnaire results is > 60%.

iii. Analysis of the Effectiveness of Geogebra-assisted e-worksheets
In this study, the effectiveness of the e-worksheets is known through the results of student learning mastery after being taught using the Geogebra-assisted e-worksheets which can be calculated using the formula:

$$KB = \frac{T}{T_t} x100\%$$

b. Student Learning Independence Analysis
Analysis of student learning independence is used to determine the improvement developed through multiple-choice questionnaires in the learning media. Student

learning independence test is carried out using the following formula (Situmorang et al., 2015):

$$N - Gain = \frac{Final\ score - Starting\ score}{Max\ score - Starting\ score} \times 100\%$$

Description:
N – Gain = Result of student learning independence percentage
Final score = Total final questionnaires of the subject
Starting Score = Total subject's starting score
Max Score = Total expected score of the subjects final-start
The results of the normalized N–Gain score is divided into 3 categories, namely:

Table 3. Criteria N - Normalized Gain

Percentage	Category
N–Gain > 70	High
30 ≤ N–Gain ≤ 70	Medium
N–Gain < 30	Low

RESULTS & DISCUSSION

Results

This research produces an e-worksheets assisted by GeoGebra to increase student learning independence.

Define

a. Preliminary Analysis

Based on the results of interviews conducted by researchers, there are several problems faced by students when taking online Basic Mathematics Studies lectures, namely (1) During the COVID-19 pandemic, there are still many students who have low levels of learning independence. Students are still used to the guidance of lecturers; (2) no e-worksheets assisted by GeoGebra has yet been developed.

b. Student Analysis

The research was conducted in class III-A with a total of 30 students. For the limited class test, the researcher took 6 students as the initial sample. As for the field class test, the researchers tested all students in grades III-A. In online lectures, the character of students in one class is very diverse. The level of independence in learning is also very diverse. Some students can learn the material by watching learning videos and there is also more understanding of the material is explained directly via zoom or google meet. When the lecturer asked some questions about the material, only a few students answered. As the others just keep quiet. The way they answer questions is still adapted to the book. So that lecturers must provide clear instructions so that their thinking is formed.

c. Material Analysis

Material analysis is the stage of analyzing the Semester Implementation Plan and the content standards set by the curriculum. Material analysis is carried out by detailing the contents of the learning materials.

Content structure analysis used to develop the e-worksheets in the Basic Mathematical Studies course, especially in comparison, social arithmetic, 2D geometry, and systems of linear equations with two variables by adding a competency test at the end of the e-worksheets as an additional exercise for students. Procedural

analysis aims to determine the steps of working on comparative, social arithmetic, 2D geometry, and systems of linear equations with two variables.

d. Concept analysis

The concept used with the help of GeoGebra is to solve the problem mathematically and then the final result is adjusted to the final result of using GeoGebra. With the help of GeoGebra, students can determine whether the answers that have been solved mathematically are correct or not.

e. The purpose of e-worksheet

The purpose of developing GeoGebra-assisted e-worksheets in the Basic Mathematics Study course is to make it easier for students to understand comparative material, social arithmetic, 2D geometry, and systems of linear equations of two variables and to train students' independence in solving basic mathematical problems e-worksheet with the help of GeoGebra.

Design

The product developed by the researcher is an e-worksheets assisted by GeoGebra which aims to increase student independence. GeoGebra-assisted e-worksheets designs that have been developed are the front cover, back cover, display of e-worksheets contents. The instrument sheet made by the researcher consisted of a validation sheet, a questionnaire, and a test of learning outcomes. Validation sheets were given to three experts (validators) consisting of three mathematics education lecturers. The e-worksheets validation sheet consists of 41 statement items made using a Likert scale.

The teaching materials developed are e-worksheets assisted by GeoGebra with details; (1) Create an attractive frame; (2) Materials and practice questions that contain how to solve problems mathematically and how to solve these problems using the GeoGebra application; (3) Adding words of wisdom that can generate a sense of self-confidence; (4) Set the border and footer layout, materials, images, animations, and motivational words; (5) Making cover designs using Corel Draw. The designs that have been made are as follows:

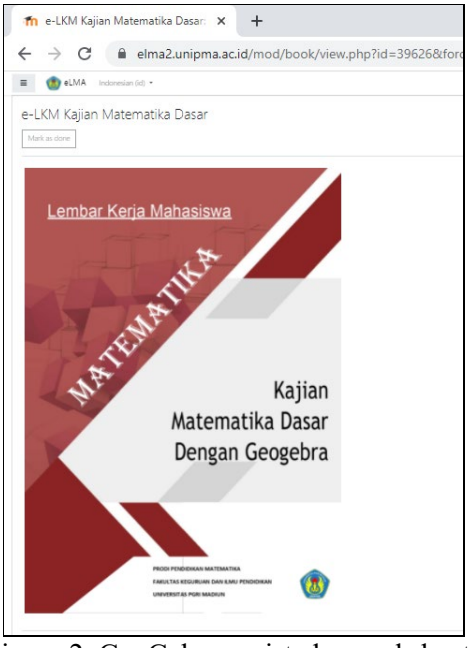

Figure 2. GeoGebra-assisted e-worksheets

Development

The final result at this stage is draft 1 which will later be validated by experts.

Expert Validation

The initial draft (draft I) of the finished e-worksheets is then validated by experts (validators) to determine the feasibility of the MFI. The inputs given by the experts (validators) are used as a reference for revising draft I so that it becomes more perfect into draft II. Based on the results of the expert assessment (validator) of the feasibility of the GeoGebra-assisted e-worksheets in the Basic Mathematical Studies course that has been developed, an average score of 3.08 is obtained from a maximum score of 4.00. According to the results of the analysis, it can be concluded that the MFI developed is in the Valid category. So that the GeoGebra-assisted e-worksheets is suitable for use as innovative teaching materials to support the learning process in the third semester of Basic Mathematics Studies.

The experts (validators) also provided some input in the form of written and verbal comments on the developed e-worksheets. The comments from experts (validators) can be seen in the following table:

Table 4 Comments of Experts (Validators) About GeoGebra Assisted e-worksheets

No.	Comment	Revision
1	Include a list of tables/figures	Add table list
2	The language on the learning indicators is not clear	Improve language on learning indicators by eliminating the word "can"

These comments are used as a reference for revising the first draft MFI (draft I). The revised e-worksheets (draft II) can then be used in a limited class test to determine student responses on a small scale to the GeoGebra-assisted e-worksheets.

The results of the validation of student learning outcomes test questions were carried out to 2 experts/validators from mathematics education lecturers. The results of the validation of student learning outcomes test questions get a score of 2.78 from a maximum score of 4.00. Based on the results of the analysis, it can be concluded that the learning outcomes test developed is in the Valid category. So that the learning outcomes test is feasible to use.

The results of the validation of the student learning independence questionnaire were carried out to 1 expert/validator from the Counseling Guidance lecturer. The results of the validation of the independence questionnaire for student learning outcomes obtained a score of 3.45. Based on this score, it was concluded that the learning independence questionnaire was said to be valid and could be used to determine the level of student learning independence before and after using the GeoGebra-assisted e-worksheets.

Limited Class Test

Students who take part in the class trial are limited to 10 people. The results of the class trial were limited to the aspect of student response questionnaires, it can be seen that the GeoGebra-assisted e-worksheets obtained an average score of 60% which is 78.3% so that the GeoGebra-assisted e-worksheets could meet the practical criteria. And the results of the class trial were limited to the aspect of student learning outcomes. It can be seen that the percentage of student learning completeness is 80.21% which indicates that the GeoGebra-assisted e-worksheets can be said to be effective because the percentage of learning completeness is 75%.

According to the results of the analysis, it can be concluded that the developed GeoGebra-assisted e-worksheets is included in the good category. From the limited class test, several students also gave written suggestions in the comments room, including:

Table 5. Student Comments on the Limited Class Test on GeoGebra-assisted e-worksheets

No.	**Student Name**	**Comment**
1	Y1	With the e-worksheets, it is easy for me to understand the Basic Mathematics Studies course
2	Y2	The e-worksheets assisted by GeoGebra; it helps practice skills in solving Basic Mathematical Studies problems by matching answers using GeoGebra.

Based on the comments given by students on the limited class test, it can be seen that students show a positive response to the GeoGebra-assisted e-worksheets. Students also suggested that the GeoGebra-assisted e-worksheets be further developed so that it can help students understand the material being taught.

Field Class Test

In the field class test, 34 students participated. The results of the field class trial on the aspect of student response questionnaires can be seen that the GeoGebra-assisted e-worksheets obtains an average score of 60%, which is 76.8% so that the GeoGebra-assisted e-worksheets can meet the practical criteria. Based on the results obtained, students gave a good response to the developed e-worksheets. Apart from being seen from the results of the student response questionnaire, the good response can also be seen from the positive comments given by the students. Some contain criticisms that are used by researchers as a reference for improving draft III.

The results of the analysis can be concluded that the e-worksheets developed is included in the good category. At the field class test stage, comments were also obtained from several students regarding the developed e-worksheets, including:

Table 6. Student Comments on the Field Class Test on e-worksheets assisted by GeoGebra

No.	Name	Comment
1	X1	e-worksheets are very important and make learning from home easier
2	X2	There should be a game in the e-worksheets to make it interesting to work on
3	X3	I enjoy learning to use e-worksheets because it makes learning easier
4	X4	Studying math e-worksheets is fun and trains me to be more independent
5	X5	I think the language in these e-worksheets is difficult to understand
6	X6	e-worksheets is very interesting
7	X7	The e-worksheets are very interesting and easy to understand
8	X8	Very neat, good, colorful, easy to understand, very complete, the language used is good

Based on the comments given by the students, most of the students really like this GeoGebra-assisted e-worksheets. Most students seem to show a positive response to the e-worksheets.

The results of the field class trial on the aspect of student learning outcomes test can be seen that the percentage of student learning completeness is 78.47% which indicates that the GeoGebra-assisted e-worksheets can be said to be effective because the percentage of learning completeness is 75%.

Student Learning Independence Analysis

Increased student learning independence is obtained from the results of questionnaire analysis by calculating N-Gain using the SPSS application. The results of the analysis of student learning independence at the large class trial stage are presented in the following figure.

Table 7. The results of the analysis of student learning independence

			Statistic	Std. Error
NGain_Score	Mean		62,3192	5, 82943
	95% confidence interval	Lower Bound	50,1181	
	For Mean	Upper Bound	74,5204	
	5% Trimmed Mean		62,2992	
	Median		57,9412	
	Variance		679,646	
	Std. Deviation		26,07002	
	Minimum		25,00	
	Maximum		100,00	
	Range		75,00	
	Interquartile Range		53,72	
	Skewness		,332	,512
	Kurtonis		-1,123	,992

Based on the results of the analysis using SPSS software in the table 7, it can be concluded that the developed GeoGebra-assisted e-worksheets has an average percentage of 62.32% in large class trials so that it can be categorized as moderate (Situmorang et al., 2015). So, it can be concluded that the use of GeoGebra-assisted e-worksheets can increase student learning independence.

Increasing mathematics independent learning by utilizing applications to distinguish academic performance and knowledge in previous learning (Cueli et al., 2017). The suitability of this study is related to increasing learning independence in learning mathematics as the basis for academic achievement. Academic achievement in this study is in accordance with achievement in improving mathematics learning achievement.

Discussion

The validity of e-worksheets assisted by GeoGebra

This study involved 3 expert reviews which included two mathematics education lecturers to validate GeoGebra-assisted e-worksheets and learning outcomes tests and one Guidance Counseling lecturer to validate student learning independence questionnaires. The validation results from the validator are used as the basis for improving the research instrument. In general, the validator states that the GeoGebra-assisted e-worksheets can be used with minor revisions. After the e-worksheets assisted by GeoGebra was revised

based on the validator's suggestions and comments, then the validator filled in the values on the validation sheet.

Based on the results of the expert assessment (validator) of the feasibility of the GeoGebra-assisted e-worksheets in the Basic Mathematical Studies course that has been developed, an average score of 3.32 was obtained. The results of the validation of student learning outcomes test questions were carried out to 2 experts/validators from mathematics education lecturers. The results of the validation of student learning outcomes test questions get a score of 2.78. The results of the questionnaire validation results of student learning outcomes obtained a score of 3.45. Based on the results of the analysis, it can be concluded that the e-worksheets, learning outcomes test, and learning independence questionnaire developed are in the valid and very valid categories. So that the three instruments are feasible to use.

In Nurdin (2019), the results of the validation score are more than 80% and the results of developing an worksheets based on a guided approach are valid and can be used at a later stage. Laka & Sutrisno (2021) and Wijayanti et al., (2021) also said that the instrument has met the theoretical validity and can be used for further analysis.

In line with the research study of Alcock et al., (2015) related to designing workbooks in the form of modules to support independent learning in proving abstract algebra through epistemological beliefs and study habits in higher education. The suitability of this research is related to e-worksheet as mentoring. At the same time, the study of Alcock et al., (2015) relates to the design of workbooks in the form of modules to support the independent research of group theory material on abstract algebra as a study habit in higher education.

The practicality of e-worksheets assisted by GeoGebra

Students who take part in the class trial are limited to 10 people. The results of the class trial were limited to the aspect of student response questionnaires, it can be seen that the GeoGebra-assisted e-worksheets obtained an average score of 60% which is 78.3% so that the GeoGebra-assisted e-worksheets could meet the practical criteria. In the field class test, 34 students participated. The results of the field class trial on the aspect of student response questionnaires can be seen that the GeoGebra-assisted e-worksheets obtains an average score of 60%, which is 76.8% so that the GeoGebra-assisted e-worksheets can meet the practical criteria.

Based on the description above, the GeoGebra-assisted e-worksheets is practical for use in learning and learning mathematics, as evidenced by the positive response from students who stated that the material described in the GeoGebra-assisted e-worksheets was quite easy to understand and interesting. Very easy to understand in terms of presenting complete material and accompanied by examples of everyday problems. In addition, it is equipped with a solution using the GeoGebra application.

This shows that the use of e-worksheets assisted by GeoGebra can facilitate students to help become independent students in learning by using modules (Aspriyani & Suzana, 2020; Harta et al., 2014; Novalia & Noer, 2019; Setyawan & Wahyuni, 2019) and can also strengthen students' cognitive learning outcomes (Candra et al., 2020).

The effectiveness of e-worksheets assisted by GeoGebra

And the results of the class trial were limited to the aspect of student learning outcomes. It can be seen that the percentage of student learning completeness is 80.21% which indicates that the GeoGebra-assisted e-worksheets can be said to be effective because the percentage of learning completeness is 75%. The results of the field class trial on the aspect of student learning outcomes test can be seen that the percentage of student learning completeness is 78.47% which indicates that the GeoGebra-assisted e-worksheets can be said to be effective because the percentage of learning completeness also reaches more than 75%.

In line with research conducted by oleh Nurwati et al., (2018) and Susanti et al., (2019, 2020), mathematics teaching materials are declared effective because the average field test results reach more than 75% so that these teaching materials are suitable for use and disseminated. The GeoGebra-assisted e-worksheets that has been developed and is ready to be distributed already contains instructions and questions that guide and guide students starting from formulating problems, collecting information, discussing, and concluding (Watika & Suliyanah, 2019).

CONCLUSION

The results of the GeoGebra-assisted e-worksheet development that have been carried out by researchers show that the results of the GeoGebra-assisted e-worksheet validation are declared valid. The results of the class trial were limited to aspects of the student response questionnaire to the GeoGebra-assisted e-worksheet that met the practicum criteria. The results of the class trial limited to the aspect of student learning outcomes showed that the GeoGebra-assisted e-worksheet could be said to be effective. Meanwhile, the average percentage of using GeoGebra-assisted e-worksheets can be concluded to increase student learning independence. With e-worksheet assisted by GeoGebra that has been developed, it is hoped that it can help students to better understand the material they are studying, so they can maximize the achievement of competencies according to the learning objectives set. For other researchers who want to develop similar research, they are expected to develop e-worksheet that is more attractive and can facilitate students to be more enthusiastic about learning and achieving.

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