Development of a GeoGebra-Assisted Calculus Worksheet to Enhance Students' Understanding

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***Abstract*—The goal of this study is to develop a GeoGebra-assisted worksheet to enhance students' understanding of calculus. Many studies report that students have difficulty understanding calculus. GeoGebra provides an alternative method to overcome the difficulties associated with calculus. The Plomp development model consists of three phases: specifically, preliminary analysis, prototype development and an assessment was used in this study. The subjects of this study were 37 students. The results of this study are valid in terms of content, presentation, linguistics and graphics and practical in terms of implementation, time, ease of use and effective in terms of its potential impact on students' mathematical understanding. The GeoGebra-assisted worksheet can help students rediscover the given concept, while the use of visualization of the calculus concept can significantly enhance students' mathematical understanding. Likewise, GeoGebra-assisted worksheets can be used to enhance students' understanding of calculus. Teachers are suggested using GeoGebra in order to build students' understanding on calculus subject.**

***Index Terms*—Calculus, GeoGebra, Plomp model, worksheet.**

I. Introduction

Calculus is a part of mathematics that is essential and needed in modern science and technology [1]. It serves as gateway to other higher mathematics lessons. Many fields of science require calculus, such as chemistry, biology, physics, economics, computer graphics, informatics engineering and others. Physical concepts that use calculus include heat, harmonics, light, electricity, motion, acoustics, astronomy, dynamics, Einstein's theory of relativity and electromagnetism. In chemistry, calculus is used to predict functions such as radioactive decay and reaction rates. In biology, it is used to formulate rates of birth and death. In economics, itis used to calculate marginal costs and marginal revenue. In the field of computer graphics, calculus is used for ray-tracing and lighting techniques. In the field of informatics engineering calculus is important for artificial intelligence which is the intelligence shown by an artificial entity [2].

However, many studies report that students have difficulty understanding Calculus [1], [3]-[5]. Derivatives and integrals are the most difficult concepts [6]. Most students do not have a deep understanding of calculus concept [7]. The acquisition of the student is only around 35% in the category above or equal to B with the remaining 65% of students in the category below B [2].

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Many causes of these difficulties, they are 1) lack of pre knowledge [5], 2) difficulties in connecting between concepts such as set theory of real, relation, number systems, limit continuity, differential functions and differential applications, 3) difficulties in performing arithmetic and algebraic operations on functions, 4) difficulties in performing verbal procedures verbal relating to the application of functions and derivatives, 5) difficulty in logic [8], and 6) difficulty in describing objects visually. Fatimah and Yerizon [2] reported that students had difficulty drawing graphs of functions and determining the domain and range of functions. They also have difficulty doing algebraic manipulation, determining tangents, parallel lines and perpendicular lines. As a result, students have difficulty understanding the concept of calculus.

Various attempts have been made to overcome the difficulties of these students' difficulties. Case and Speer [8] examined strategies that teachers could use in helping students understand abstract ideas in calculus and reason in terms of calculus theorems. Adams and Dove [4] uses Flipped learning to improve student learning outcomes and perceptions in calculus learning. Carnell *et al*. [5] examine the differences in the abilities of students who have taken calculus from those who have not taken calculus. Dawkins and Epperson [3] examined traditional calculus learning with problem-solving-oriented labs. This has not given good results because the calculus material is still abstract for students.

The effort that can be done is to use technology in learning [9], [10]. Technology is become significant in daily teaching like computers and software. Students can take benefit of alternative ways of learning from technology integration in their learning [11]. Using technology not only can contribute to mathematical problem solving but also develop creative thinking skills [12], [13]. It can foster mathematical reasoning and mathematical thinking [6]. Using technology (technology-supported environment) in calculus learning specifically the use of GeoGebra in Riemann sums [14].

GeoGebra provide an alternative method to overcome the difficulties about calculus [6]. GeoGebra has been designed for improved learning out comes. It is a dynamic, interactive, open-source, student-centered and user friendly. It has played big roles in incorporating ICT into Mathematics education [9]-[11]. GeoGebra supports constructions with points, lines and all conic sections. It gives specific features for a such as finding critical points of functions, direct input of finding derivative and integrals of the given functions. Therefore, it is a good option for varied of presentations for mathematical objects [15]. Visual representations play an important role in understanding and making sense of mathematics. Students and teachers are more likely to use a variety of colorful

figures, pictures, diagrams, and graphs. Visualizing is a crucial step in understanding and attempting in solving a mathematics problem [1], [14].

For teachers, GeoGebra provides opportunity to create interactive learning climate [16]-[18]. It is being used for learning mathematics at any level of education ranging from primary to the university level. Many Teachers and researchers have developed variety of worksheets and methods using this software. Students more understand the calculus concept when the visualization shows by this software [6].

GeoGebra is designed to help students gain a better insight of mathematics. Students are able to manipulate variables easily by dragging "free" objects around the plane or by using sliders. Students are able to generate changes using a technique of manipulating objects, and then they can learn how it affect the dependent objects. At that moment, students learned to solve problems by investigating mathematical relations dynamically. The main role of teaching is not to explain, lecture, or to transfer mathematical knowledge, but to build contexts or situations for students that foster their mental constructions [15].

Tatar and Zengin [6] found that GeoGebra is an effective tool in mathematics teaching and learning. This software is an effective tool in increasing students' attitudes towards proof and proving. [6] use this software on the secondary mathematics teachers in understanding definite integrals to elicit their opinions on using computer-assisted instruction (CAI). It can be used as a medium to help users to construct mathematical concepts [19]. GeoGebra can demonstrate or visualize mathematical concepts [20]. Umi [21] reports that the learning outcomes of students who use GeoGebra on graphs learning line equation are better than students who do not use GeoGebra . The process of students building their own knowledge assisted by GeoGebra is able to bring up new knowledge that is more meaningful. GeoGebra had a significant influence on students' mathematical abilities [22].

Because of its importance, this study aims to produce a valid, practical, and effective GeoGebra-assisted calculus worksheet. Valid in terms of content, presentation, linguistic, and graphic. Practical in terms of implementation, time, ease of use and effective in terms of its potential impact on students' mathematical understanding. In this worksheet, instructions are given using GeoGebra to assist students in constructing calculus concepts.

II. Research Methods

The type of this research is design research with the Plomp research model which consists of three stages, namely preliminary research, development or prototyping phase, and assessment phase [23]. The phases through which the product design is evaluated. The development phase shown in Table I.

In the preliminary research phase, information is collected about calculus learning difficulties and their causes. Then alternative solutions can be used to overcome these problems. The instruments used were interview and questionnaire guidelines.

In the Development / Prototyping Phase, a worksheet is designed and created based on information at the preliminary stage. It done through the stages of formative evaluation, namely, 1) expert review, 2) one-on-one, 3) small groups, and 4) field testing. An expert review is conducted to produce a valid worksheet. Expert review aims to provide an assessment of the worksheet in terms of content, material, graphics, and language [24]. The validation results are calculated by a formula.

TABLE I: Development Phase

Phase	Description	Instrument
Preliminary research	Doing need and context analysis	Interview Guidelines and Questionnaire
Development/ Prototyping Phase	Designing, developing	Development/ Prototyping Phase
Assessment Phase	Conduct field trials (Field Test)	Questionnaire, interview guide, and test

$$R = \frac{\sum_{i=1}^{i=m} \sum_{j=1}^{j=n} V_{ij}}{mn}$$

in which:

R is the average assessment results from experts.

V_{ij} is the score of the j-th expert's assessment against the i-th criterion.

n is the number of experts who judge.

m is the number of criteria.

The validity criteria are shown in Table II.

TABLE II: Validity Criteria for Worksheet

No.	The R Value	Category
1	R > 3.20	Very valid
2	2.40 < R ≤ 3.20	Valid
3	1.60 < R ≤ 2.40	Sufficiently valid
4	0.80 < R ≤ 1.60	Less Valid
5	0 ≤ R ≤ 0.80	Invalid

After that, it follows by four stages of the formative evaluation process, namely, 1) expert review, 2) one-to-one, 3) small groups, and 4) field tests. Expert review was conducted to produce a valid worksheet. One-to-one, small group, and field tests to produce practical and effective worksheets [25].

One-to-one is carried out on 3 students who have heterogeneous mathematical ability which aims to identify the clarity of the worksheet on the design aspects, grammar that is still poorly understood, clarity of directions or unclear directions, difficulty level, ease of use and student satisfaction.

Small group evaluation aims to see the practicality and effectiveness of the worksheet that include implementation, appropriateness of time allocation, ease of use of the worksheets [26]. The instruments used were questionnaires and mathematical reasoning ability tests. The practicality criteria are shown in Table III.

TABLE III: Practicality Criteria for Worksheet

No.	The P Value (%)	Category
1	$80 < P \leq 100$	Very Practical
2	$60 < P \leq 80$	Practical
3	$40 < P \leq 60$	Sufficiently Practical
4	$20 < P \leq 40$	Less Practical
5	$0 \leq P \leq 20$	Not practical

In the Assessment Phase, field trials are conducted in the actual class (37 students) to produce an effective worksheet. At this stage the lecturer and student responses were asked

for the quality of the worksheets used. The purpose of designing a worksheet is to provide an overview of students' mathematical reasoning abilities [19]. Then a test is given to see the impact of using the worksheet on students' mathematical reasoning abilities. The category of students' mathematical reasoning ability values can be seen in Table IV.

TABLE IV: CATEGORIZATION of Mathematical Reasoning Ability

Score (S)	Grade	Category
$85 < S \leq 100$	A	Excellent
$70 < S \leq 85$	B	Good
$55 < S \leq 70$	C	Enough
$40 < S \leq 55$	D	Bad
$0 \leq R \leq 40$	E	Very Bad

The worksheet is said to be effective if 60% of students get a minimum score of B.

III. RESULTS AND DISCUSSION

A. The Results of Preliminary Research

Needs analysis is done to reveal the problems that occur in calculus learning by interviewing lecturers and giving questionnaires to students. The results of the interview of researchers (RS) with lecturers (LC) who teach calculus are as follows.

RS: "What obstacles did you encounter in the learning process of differential calculus in class?"

LC: "Most students are lazy to read textbooks before class meeting. Every task given is not done optimally. Problems that are quite complicated tend to be abandoned. No effort was made to ask the lecturer before the collection time scheduled. In the last few years the student's input ability is quite low."

RS: "What did you do to resolve the issue?"

LC: "The lecture is made 2 meetings a week. Meeting 1 is to teach the essence material from differential calculus, the second meeting is called *responsi*, which is to discuss questions relating to the essence material."

RS: "What teaching material do you use in Calculus learning?"

LC: "Differential calculus textbooks."

RS: "What obstacles did you encounter with the teaching materials used?"

LC: "There are some languages that are not understood because the translation is not right. Students need to read it several times so it can be understood. Some students don't because they are bored."

RS: "Do you use worksheets when teaching and learning?"

LC: "Not yet"

RS: "Why?"

LC: "I actually planned to make a worksheet in learning differential calculus because it was requested by the department, but I did not have the opportunity to make it yet."

RS: "What do you think about using the worksheet in the learning process?"

LC: "I think the learning process will be better. Students solve problems in worksheet so they have the responsibility to complete the challenge of using the worksheet in the learning process."

RS: "There is a GeoGebra software that can be used to use via mobile phones and computers. Have you ever used the application in the learning process?"

LC: "Never."

RS: "Do you think that using the GeoGebra application in learning Calculus is able to help students understand concepts?"

LC: "Good, I think the use of worksheets with the use of the GeoGebra application will be able to help reduce student problems so far."

Based on observations of the implementation of learning activities in class, it is found that the learning process is still focused on the lecturer. The learning process has not facilitated students to construct their own knowledge of the material being studied. Students are given a formula directly and solve problems by using the formula. Students are less active in learning and do not have the courage to give opinions and ask questions. Students are lazy to read the textbooks used, because the language is difficult to understand.

Furthermore, from students' questionnaire, we obtain information about problems in calculus learning. Questionnaire results on calculus learning of 37 students as shown Table V and Table VI.

TABLE V: RESULTS OF QUESTIONNAIRES ON CALCULUS LEARNING

No.	Questions	%
1	Calculus is difficult to understand	93
3	Lecturers use cooperative learning models	4
4	The learning model used by the lecturer makes students motivated	7
5	Lecturers use mathematical software such as GeoGebra in lectures	0
6	Calculus learning resources used to help students in understanding concepts	69
7	Worksheets are needed to understand the concept of calculus	100
8	ICT is needed in understanding the concept of calculus	100

TABLE VI: QUESTIONNAIRE RESULTS FOR DIFFICULTIES IN CALCULUS MATERIAL

No.	Type of difficulty	%
1	Determine the value of limit of a point if given a graph of a function	67
2	Simplify algebraic forms in determining the limit value.	40
3	Perform algebraic manipulation in solving limit of trigonometric function	75
4	Determine derivatives of complex trigonometric function.	53
5	Determine the maximum or minimum value of the contextual problems	81
6	Graph functions using derivatives concepts	72
7	Manipulation in determining trigonometric integrals	75
8	Differentiating problem solving using integral substitution techniques and partial integral techniques.	81

Based on the results of the given questionnaire to students, Table V shows students have difficulties learning calculus. Students have difficulty in calculus in general related to graph a function. This graph is a way of guiding students in understanding the concept of a descending function and an ascending function related to the concept of maximum and minimum values. Therefore, students need a software to paint graphics and investigate aspects of the calculus. Lecturers and students agree with the activities of students constructing their knowledge assisted by the GeoGebra application. This software helps students draw graphs of functions and check answers to questions given (for several categories of

questions).

B. Prototyping Phase Results

Based on the results of preliminary research a GeoGebra-assisted calculus worksheet was designed. Worksheets are designed to guide students to investigate rediscovering a concept with the help of GeoGebra.

The outline of the worksheet being developed is as follows:

1) Instructions

1) Students are asked to draw various graphs of functions related to certain concepts using GeoGebra.
2) By observing the graph that has been described, students are asked to analyze its nature through guiding questions.
3) Students make conclusions from the results of their analysis.

2) Assignments

Students are given exercises to strengthen their understanding of the concepts that have been obtained.

The most difficulty experienced by students is determining the maximum and minimum values of the function. To determine the maximum and minimum values can be approached by using the increasing function or decreasing function. The following are examples of activities on the worksheet for the topic of the increasing function or decreasing function.

A function is said to increase at $x = c$ if $f'(c) > 0$ and to decrease if $f'(c) < 0$. Then the value of $f'(c)$ is the gradient of the tangent to the function f at $x = c$. By using the tangent gradient properties students are given scaffolding to rediscover that a function rises at $x = c$ if $f'(c) > 0$ and decreases if $f'(c) < 0$. The activity is as follows.

First, students are told to sketch the graph $y = x^2$ and the tangent line at point (2, 4) and the tangent line at point (1, 1) with the help of GeoGebra as Fig. 1 and Fig. 2. This activity aims to show students that an increase function at $x = c$ if $f'(c) > 0$.

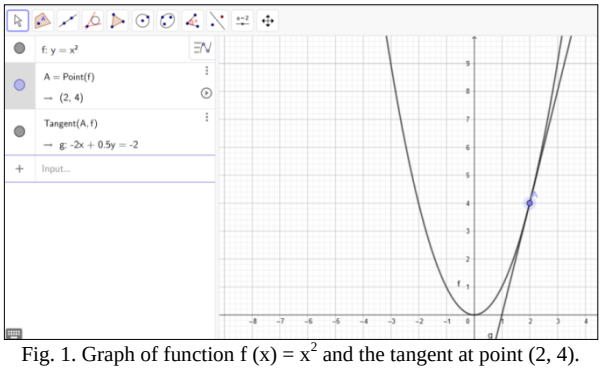

Fig. 1. Graph of function f (x) = x^2 and the tangent at point (2, 4).

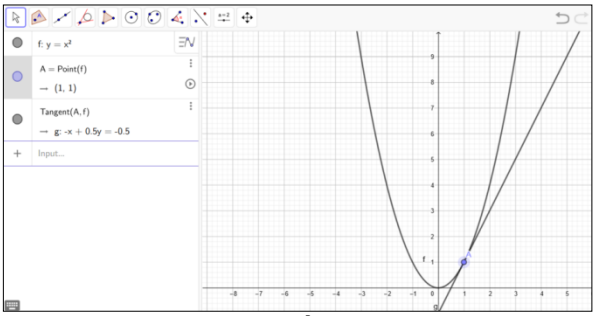

Fig. 2. Graph of function f(x) = x^2 and the tangent at point (1, 1).

Students are asked to observe that the tangent equation at point (2, 4) is $y = 4x - 4$ with a gradient of $4 > 0$ which means $f'(2) = 4 > 0$. The tangent equation at point (1, 1) is $y = 2x - 1$ with a gradient of $2 > 0$ which means $f'(1) = 1 > 0$.

Second, students are told to sketch a graph of $y = x^2$ and the tangent line at point (-1, 1) and tangent at point (-2, 4) like Fig. 3 and Fig. 4. This activity aims to show students that a function decrease at $x = c$ if $f'(c) < 0$.

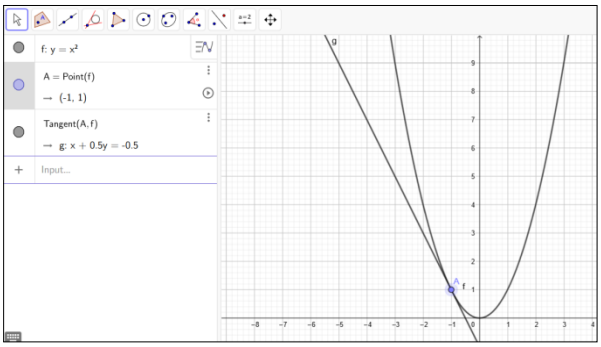

Fig. 3. Graph of function f (x) = x^2 and the tangent at the point (- 1, 1).

Students are asked to observe that the tangent equation at point (-1, 1) is $y = -2x - 1$ with a gradient $- 1 < 0$ means $f'(- 1) = - 1 < 0$. The tangent equation at point (-2, 4) is $y = - 4x - 4$ with gradient $- 4 < 0$ means $f'(- 2) = - 4 < 0$.

Based on observing the four pictures above, they concluded that a function is increase if $f'(x) > 0$ and decrease if $f'(x) > 0$. This rediscovering activity makes learning meaningful for students.

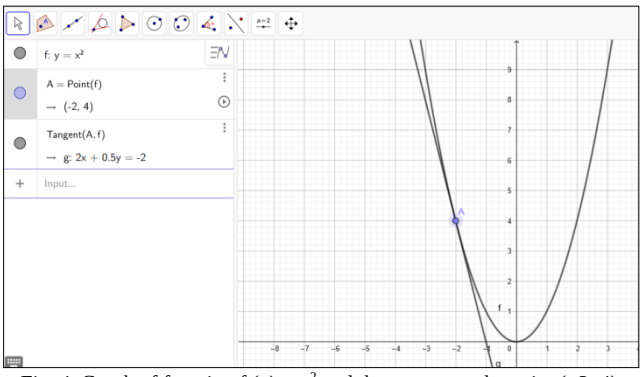

Fig. 4. Graph of function f (x) = x^2 and the tangent at the point (- 2, 4).

C. Expert Review Results

TABLE VII: WORKSHEET VALIDATION RESULTS

No.	Rated aspect	Average	Category
1	Presentation (Systematise material order, Students' scaffolding ability, Make students active and motivated)	3.61	Very valid
2	Content eligibility (Conformity of Material and Curriculum, Truth of the matter and its order, Assist students in constructing concepts)	3.38	Very valid
3	Graphic or appearance (Text, image and table layout, Size of letters and symbols, Colour combinations)	3.83	Very Valid
4	Language (Matching meaning and grammar, Legibility)	4.00	Very valid
	Average	3.70	Very valid

If Worksheets that have been examined in relation to the self-evaluation activities are consulted and discussed with experts as validators. The validated aspects relate to the

presentation features, content eligibility, in addition to graphic and language aspects. The results of the worksheet validation can be seen in Table VII and various validator suggestions in Table VIII.

Based on Table VII, it can be seen that the average validation for the worksheet is 3.70 and moreover, that it is in the extremely valid category. This means the presentation and suitability of worksheet can help students to construct knowledge and improve students' mathematical abilities.

TABLE VIII: VALIDATOR SUGGESTIONS FOR WORKSHEET DESIGN

No.	Validator suggestion
1	Improvements to grammar, clarity of writing, and layout of images
2	The activities are made more detailed
3	Directions for Using Worksheets are made clearer so they are not confusing
4	Change the dotted line with the rectangular bounded area in the worksheet
5	At the first meeting, the definition of direct derivatives given should begin with how students construct the derivative definitions of two problems one theme
6	For meetings 1 to 5, the activities on the worksheet are unclear
7	The worksheet is too messy as there are too many words

D. Results of the One-to-One Evaluation

One-to-one evaluation is undertaken to see whether this worksheet is practical. The one-to-one evaluation process is conducted by means of observation and interview. From the results of the observations, students can understand both the instructions and the instructions on the worksheet properly. However, students found typing errors, too many practice questions and limited space to answer the questions. Students highlighted that they have sufficient time to work on the worksheet. In general, the revision is only on ambiguous instructions, the correction of questions and typing errors.

The following are the results of the interviews with three students.

RS: “What do you think about the appearance of the cover and the size of the worksheet?”

Student 1: “The size is just right to carry around and the look of the cover is quite interesting”

Student 2: “I think the cover is interesting, simple and not too flashy”

Student 3: “Quite interesting because the cover is colored and the reader will not get bored”

RS: “Does the worksheet color design and appearance make you interested in reading it? Explain your reason”.

Student 1: “Interested because it is colored and different from the textbooks that I have that are colorless. So this is more interesting”

Student 2: “I am interested in reading it because the pictures relate to mathematics”

Student 3 : “Interested”

RS: “Does the worksheet have clear instructions?”

Student 1: “The instructions are very clear.”

Student 2: “Quite clear.”

Student 3: “Yes, it has clear instructions.”

RS: “Do the pictures and illustrations on the worksheet help you understand the problem being presented?”

Student 1: “Very helpful because the picture is clear enough.”

Student 2: “Quite helpful because the drawing has been made so that it’s easy to understand.”

Student 3: “Helpful and easy to understand.”

RS: “Are the instructions for the learning activities in the worksheet clear?”

Student 1: “Yes they are clear and easy.”

Student 2: “Quite clear.”

Student 3: “Clear.”

RS: “Are the sentences in the worksheet easy to understand?”

Student 1: “Understood because the words are the language used every day.”

Student 2: “Easy because it is in accordance with the Indonesian dictionary.”

Student 3: “Very easy because it uses standard language.”

RS: “Can you complete the worksheet according to the time allotted?”

Student 1: “It’s appropriate, but it depends on the topic in worksheet. If the topic is difficult then it will also take a long time.”

Student 2: “Yes because the question is not too difficult.”

Student 3: “Yes.”

E. Small Group Evaluation Results

In the small group evaluation, students learn to use a worksheet that has been designed five times. During the learning process an observation is made of the difficulties experienced by students in the learning process and furthermore, the time allocated. Moreover, small group evaluation is conducted.

Students can find, examine and determine the material independently. Furthermore, students work on exercises to apply these concepts in problem solving and use and select certain procedures or operations, so that students’ mathematical ability related to the topic will be better.

There was a slight improvement in the questions in exercise 1. Based on the results of observations and interviews in this activity, in the process of answering questions there were some students who felt confused and hesitant in finding the derivative of trigonometric functions (sine and cosine). Therefore, they still required help and explanations. After being provided with an explanation the student can work according to instructions. Likewise, students have also become accustomed to using the GeoGebra application. In the material section for determining the tangent curve, students analyze the concept assisted by the GeoGebra application.

Based on interviews with the lecturers, information was obtained that the worksheet could be used properly and could help students understand concepts. The following are the results of the interview with the lecturer.

RS: “What do you think about the clarity of the instructions on the GeoGebra-assisted worksheet?”

LC: “These instructions for using the worksheet are good because they are detailed.”

RS: “Can the appearance and colour of the worksheet motivate students to use it?”

LC: “The colour is quite good and can motivate students to learn and use worksheets. Looks interesting.”

RS: “Is the presentation of the worksheet systematic and structured?”

LC: “It is systematic and structured because it is in

accordance with existing indicators."

RS: "What do you think of learning to use GeoGebra-assisted worksheets?"

LC: "The material presented is more structured for students because it is already on the worksheet. Students are quite enthusiastic about doing it especially since they also use computers that use the GeoGebra application."

RS: "Does this worksheet make it easier for you to do the learning process in class?"

LC: "Yes, it does."

RS : "Can you use the worksheet according to the time provided?"

LC: "Yes, I can."

Furthermore, students were asked their opinions on the use of worksheets in learning. The results of the practicality questionnaire completed by students in the small group test can be seen in Table IX.

TABLE IX: PRACTICALITY RESULTS BY STUDENTS

Statement	Average	%	Category
I can clearly understand the instructions for using the worksheet	3.50	87.50	Very practical
The colours used in the worksheet made me interested in using it	3.67	91.67	Very practical
The pictures on the worksheet helped me understand the material provided	3.50	87.50	Very practical
I can understand the problems related to the material on the worksheet	3.67	91.67	Very practical
I can gain new knowledge through activities on the worksheet	3.67	91.67	Very practical
I can rediscover the concepts learned	3.50	87.50	Very Practical
I can understand the sentences used in the worksheet	3.67	91.67	Very Practical
I can complete activities in the worksheet according to the time allotted	3.50	87.50	Very Practical
Average	3.59	89.59	Very Practical

Based on Table IX, it is concluded that the GeoGebra-assisted worksheets are practical.

Based on the results of the tests related to mathematical reasoning ability, the data obtained shows that four students (66.67%) are above category B and two students (33.33%) are under category B. Based on the results of the final test analysis on small group evaluation, it can be concluded that the GeoGebra-assisted worksheets have been effective because more than 60% of the students scored above category B.

F. Results of the Assessment Phase

After being revised based on input from the evaluation of small groups, the worksheet was tested on 37 students. Students were divided into seven groups, each group consisting of five people. There were also two groups of six people. Trials were conducted in five meetings. During the field test, the researcher was assisted by one mathematics lecturer who taught in the class. Lecturers teach with worksheets that researchers have designed.

Based on the interview, it was determined that the lecturer is extremely pleased with this GeoGebra-assisted worksheet because it is easy to use, interesting and that it is easy to understand. Furthermore, it was established that the worksheet can help the lecturer present the material and the time given to complete it is sufficient. Activities and questions on the worksheet help students to build their own knowledge of the material. Students understand concepts better when they see the results in visual form [6].

To see the effectiveness of the worksheets, a mathematical reasoning ability test with six questions was given to students. Students are said to pass if they attain a B. The results of the test can be seen in Table X.

TABLE X: RESULTS OF STUDENTS' MATHEMATICAL REASONING ABILITY TESTS

Category	Complete	Not Complete	Total
Total	23	14	37
Percentage	62.16	37.84	100

Based on the results of the final test analysis in Table X, it is concluded that the use of GeoGebra-assisted worksheets has been effective for the reason that more than 60% of students have completed or scored above category B. Judging from the students' answers, it is established that students have been able to answer questions according to reasoning ability indicators. Moreover, most students are able to achieve an ideal score on each question.

Learning using this worksheet is a learning concept that encourages students to be active, creative and innovative during the learning process. Students are encouraged to build and develop their own knowledge by making connections between the knowledge they have and the material to be learned via the activities in the worksheet. This activity is part of the activity of constructing knowledge. The use of the GeoGebra application helps students construct knowledge and check correct answers to questions. Students can obtain derived concepts from several problems that are solved by students with the help of the GeoGebra application. Additionally, students can also construct their knowledge with the help of GeoGebra. This is in line with the findings of [21], specifically that learning with the support of the GeoGebra application helps students paint graphics quickly. It gives students the opportunity to explore various types of functions more broadly and enables students to create a connection between symbolic and visual representations [15].

It can be concluded that the GeoGebra-assisted worksheet that has been developed has been effective in improving mathematical reasoning ability and that GeoGebra-assisted learning gives students the ability to guess, examine, manipulate, draw up and generalize. Learning using the GeoGebra-assisted constructivism approach improves students' mathematical reasoning abilities [27]. Computers act as learning aids. A number of studies have shown that GeoGebra can drive the process of student discovery and experimentation in the classroom. Its visualization features can effectively assist students to propose various mathematical conjectures (Will You Know?) [9]. The use of GeoGebra offers students a greater understanding of algebra and geometry [17].

It should be noted that both lecturers and students agree on

the use of GeoGebra in mathematics teaching and learning. By means of GeoGebra, students can understand mathematical concepts and procedures better via visuals and graphics. Learning by using GeoGebra can make learning processes more active and increase interaction between lecturers and students. For this reason, it should be used in the pursuit of mathematics, specifically calculus GeoGebra to improve students' attainment [28]. Furthermore, GeoGebra creates an environment that is fun, interesting and facilitates students to concretize abstract concepts [6].

IV. Conclusion

Based on the results of research on development, it can be concluded that the GeoGebra-assisted worksheet is valid, practical and effective. A GeoGebra-assisted worksheet can help students rediscover the given concept, while the use of visualization of the calculus concept can significantly enhance students' mathematical understanding. Teachers are not only suggested using GeoGebra in order to build students' understanding on calculus subject but also suggested using GeoGebra-assisted worksheet using computer instead of using android phone.

Conflict of Interest

The authors declare no conflict of interest

Author Contributions

YY developed the idea of research and designed its test. SF designed worksheet and statistical analysis of data. FT prepared the theoretical base of research.

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