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THE EFFECTIVENESS OF THE GEOGEBRA-ASSISTED INTEGRAL CALCULUS MODULE

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ABSTRACT

This research was motivated by insufficient learning outcomes of students in the integral calculus course and the unavailability of the GeoGebra-assisted integral calculus module in the mathematics education program at Malikussaleh University. Therefore, this study aims to investigate the effectiveness of the GeoGebra-assisted integral calculus module. This study constitutes development research with the Plomp development model, consisting of three stages: preliminary research, prototyping phase, and assessment phase. The participants were mathematics education students at Malikussaleh University. The instruments employed in this research include observation sheets of learning activities, student response questionnaires, observer response questionnaires to modules, and tests. The findings showed that the GeoGebra-assisted integral calculus module meets the effective criteria. This recommendation is made based on the results of the learning activity observation, which is in the very good category. The student and observer responses to the module are also very good criteria. Last, student test results also performed an increase.

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INTRODUCTION

Integral calculus is classified as an important subject and a prerequisite to other courses such as differential equations, advanced calculus, mathematical statistics, numerical methods, and complex analysis. Students are required to have a comprehensive understanding of integral calculus. Students' low understanding of integral calculus will have an impact on students' difficulty in understanding and solving problems related to other subjects. The results of a previous study (Takaendengan, Asriadi, & Takaendengan, 2022) showed that students gain low scores in the calculus course. That is, the percentage of students who obtained midterm test scores less than 75 reached 77.78%. Whilst, the percentage of those who received scores less than 75 on the final test was 66.66%, and the percentage of students who did not pass both tests was around 30%.

The integral calculus course is highly important to learn since it has an important role in supporting other fields of science. In economics, integrals are used to find the original function of the marginal function, the total cost function, the total revenue function, and the capital function of the investment function. In technology, integrals play a role in using the space shuttle Endeavor's speed to determine the maximum altitude reached any given moment. Meanwhile, in physics, integrals are used in the analysis of electric circuits, the analysis of the magnetic field in the coil, the center of mass, and the moment of inertia. In the field of engineering, integrals are used to determine the area of a plane, the arc length, and the volume of a rotating object.

For students of mathematics education, this course is a compulsory subject because it consists of basic concepts as a prerequisite to other courses. In addition, this course is also important for mathematics education students as prospective teachers because it is included in the mathematics curriculum at the high school level. Therefore, students' mastery of integral calculus is crucial.

However, the learning outcomes of mathematics education students at Malikussaleh University on integral calculus remain low. Students’ test results in the integral calculus course are still insufficient, with the percentage of classical learning completeness scores of 63% (source: data on final semester exam results for students in the third semester of the 2020/2021 academic year). Based on our reflection, the researchers found problems that contribute to students' low learning outcomes in the integral calculus course. That is, students

find it difficult to represent problems in function graphs. Students also find it challenging to solve problems related to graphs, especially on integral application topics, since they cannot imagine the rotating objects in the problems. Thus, students need quite a long time to solve problems that require graphics. As a result, the time allocated for learning becomes less effective. The following figure illustrates one of the student's difficulties in drawing graphs on the final exam

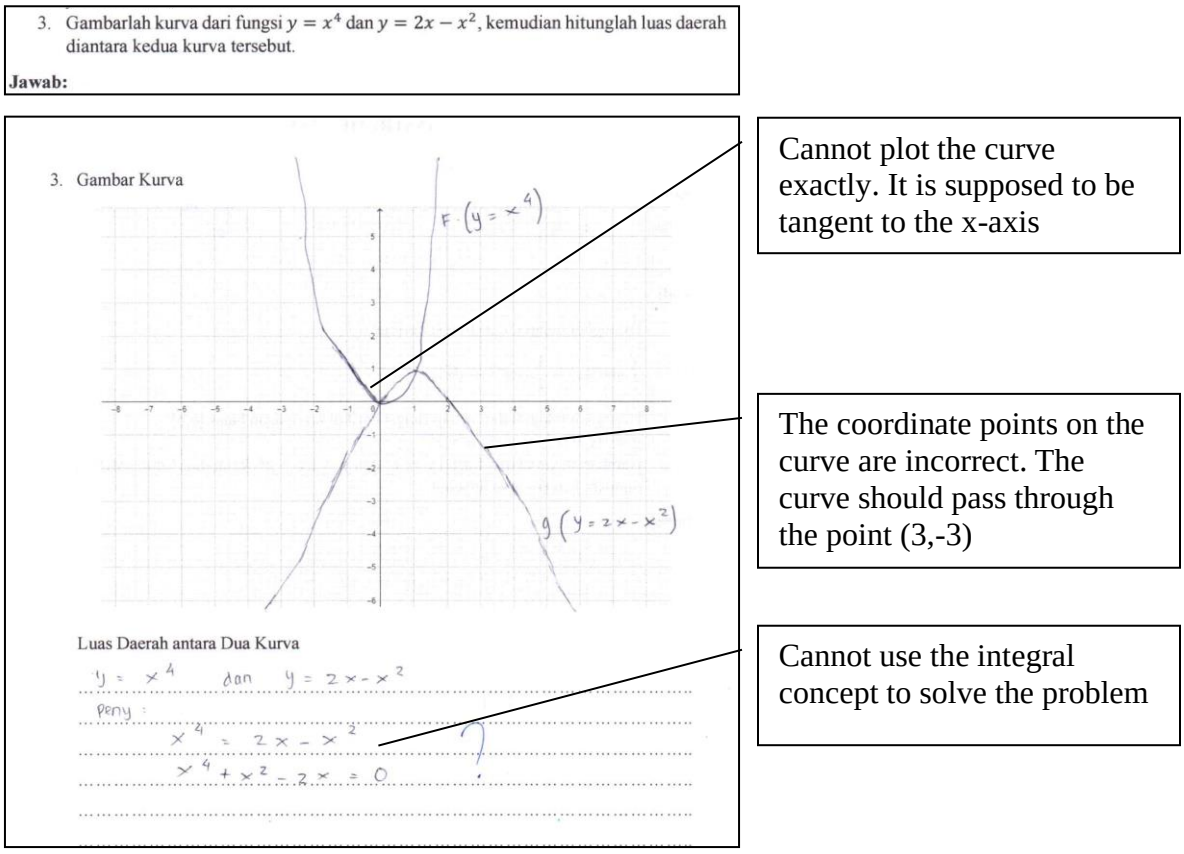

Figure 1. Student's difficulties in drawing graphs on the final exam

The effort offered to overcome this problem and to gain effective learning is developing modules assisted by computer media that can visualize questions into graphics. One of the computer-assisted mathematics learning media that can be used in the integral calculus course is GeoGebra. According to Rohman (2016), GeoGebra can be used as a medium for learning mathematics, as a tool in making mathematics teaching materials, and for solving math problems. Objects that are too abstract and difficult to imagine in integral calculus can be visualized using GeoGebra. The use of GeoGebra in learning mathematics

includes demonstrations, simulations and visualizations, as construction aids for the exploration and discovery of mathematics, as a software to develop teaching materials (authoring tools), and to solve or verify mathematical problems (Listiana, Wulandari, Aklimawati, & Isfayani, 2021).

Learning integral calculus becomes effective if it is assisted by computer media. Computers can simplify the complexities of integral calculus. Materials that are too abstract and out of experience require visualization of images and simulations of objects.

However, the integral calculus course in the mathematics education program at Malikussaleh University has not yet utilized GeoGebra. The unavailability of integral calculus books or modules that contain instructions for using GeoGebra is one of the issues. Developing teaching materials such as GeoGebra-assisted modules is also an approach to improve the quality of learning. Previous research revealed that the development of learning modules assisted by GeoGebra software supports learning outcomes and student motivation (Rahayuningsih, 2016). Others found that student activities are classified as very good, formative test results have increased, and students' and teachers' responses to the use of GeoGebra software-assisted modules are also positive (Rhilmanidar, Ramli, & Ansari, 2020). GeoGebra-assisted modules on derivative topics are considered effective, interesting, and suitable for learning media (Sari & Syazali, 2016). The GeoGebra-assisted module is also effectively used in the transformation geometry course (Isharyadi & Ario, 2018).

However, concerning the previous studies, the research on the effectiveness of the GeoGebra-assisted integral calculus module has not been widely scrutinized yet. Therefore, it leaves room for this current study to evaluate the effectiveness of the GeoGebra-assisted integral calculus module.

METHOD

This research constitutes development research with the Plomp Development model, consisting of three stages: preliminary research, prototyping phase, and assessment phase (Plomp, 2013). The development stage is designed up to the assessment of learning outcomes for the module. The research was conducted at mathematics education, Malikussaleh University. The participants were 27 third-semester mathematics education students in the 2021/2022 academic year. The basis for selecting the subjects is that they undertook the integral calculus course in the third semester.

In the preliminary research phase, problem analysis, needs analysis, and curriculum analysis were carried out. To investigate students' problems in the integral calculus course, problem analysis was carried out. Based on the researchers' reflection on the learning process, it was found that students' understanding of graphics is relatively low. Based on the problem analysis, a needs analysis was carried out as a solution to the learning problem, namely the need for modules or teaching materials integrated with computer media. The media chosen is GeoGebra software, as it can display geometry and algebra in one screen display. GeoGebra can display the integral solution and its graph at the same time. In addition to that, curriculum analysis was carried out. This analysis focuses on the learning outcomes of the course, the scope of the material, learning activities, and the form of questions and exercises.

In the prototyping phase, the researchers designed the integral calculus module, expert validation sheets, student response questionnaires and observer response questionnaires to the module, learning activity observation sheets, and tests. The modules and tests that had been designed were validated by two mathematicians and two media experts. The validation results found that the module was declared very valid, with an average score of 3.80 for material validity and an average score of 3.85 for media validity.

In the assessment phase, limited trials and field trials were carried out. Limited trials were conducted to evaluate the readability of the developed integral calculus module, whether the module needs improvement, whether the content of the material is understandable, the language and writing are effective and legible. After that, it will be assessed whether it is eligible for field trials. The limited trial involved nine students in the third semester, and the data was collected from student response questionnaires. The results of the questionnaires were considered in the very good category. Student response to the module was very positive. Field trials were conducted to determine the practicality of the integral calculus module and its effectiveness. The field trials were carried out in two meetings with a total of 27 students. Based on the results of the student response questionnaire and the observer response questionnaire to the module, the module was found to be very practical, and learning activities reached the very good category. Based on the validator statement, the module can be used for integral calculus learning, and students' test results have increased.

The discussion of the article is limited to the effectiveness of the developed integral calculus module. The criteria for the effectiveness refer to the following indicators: effective

based on expert assessment (Nieveen & Plomp, 1999); student activities reach an average percentage of 90%; having an increase in test scores; positive student responses to the use of modules during learning are more than 50%; and the observers' positive response to the learning module or the response is in a good category (Kemp, Morisson, & Ross, 1994).

The instruments for data collection include observation sheets for learning activities, student response questionnaires, questionnaires for observers' responses to the module, and tests. The learning activity observation sheet was used to observe student activities during learning. Student response questionnaires and observer response questionnaires were used to seek students' and observers' responses to the module. Last, the test was used to assess students' abilities after learning. The instruments were first validated by four experts. The result was declared valid. The percentage of the scores for the learning activity observation sheet, student response questionnaires, and observer response questionnaires were calculated using the following formula shows in (1).

$$p = \frac{the\ total\ score\ obtained}{maximum\ total\ score} \times 100\% \quad (1)$$

The percentage of the score is then converted based on Table 1 below.

Table 1. Criteria for Score Percentage

Percentage (%)	Category
86-100	Very good
76-85	Well
60-75	Enough
55-59	Not enough
<54	Not good

(Purwanto, 2013)

Comments and suggestions for the items on both student and observer response questionnaires were then analyzed qualitatively. The test consists of three open-ended questions for the two meetings. The average score of students' answers for each meeting was calculated, and then the score was converted into categories, as listed in Table 2.

Table 2. Criteria for test results

Value Range	Category
80-100	Very good
70-79	Well
60-69	Enough
50-59	Not enough
<49	Very less

(Rhilmanidar, Ramli, & Ansari, 2020)

RESULT AND DISCUSSION

The effectiveness of the GeoGebra-assisted integral calculus module is assessed based on the learning activity observation sheets, student response questionnaires, observer response questionnaires to the module, and tests. The results of field trials based on those instruments are described below.

Learning Activity Observation

Observations were made during the learning process by a lecturer in an integral calculus course. The lecturer assessed and observed student activities during learning. The analysis results of the learning activity are illustrated as follows.

Table 3. Results of Analysis on Learning Activity Observation

Meeting	Percentage
I	89,82%
II	93,52%
Mean	91,67%

Based on Table 3, the average percentage of learning activities is 91.67%, which is in the very good category.

Student Response Questionnaire

The results of the student response questionnaire to the module are described in the following table.

Table 4. The Results of the Student Response Questionnaire

Indicator	Average	Percentage (%)
INTEREST		
1. The appearance of this module is attractive	3.88	97.17
2. I am more excited to learn Integral Calculus using this module.	3.47	86.79
3. Learning the Integral Calculus course is not boring using this module	3.62	90.57
4. Mastery of Integral Calculus is strongly supported by this module	3.39	84.91
5. The motivation to study Integral Calculus is supported by the instructions for using GeoGebra and the illustrations are provided	3.72	92.93
6. With the module, I can learn by myself	3.49	87.26
Average	3.59	89.94
THEORY		
7. Using the module makes me easier to understand Integral Calculus	3.58	89.62
8. Understanding the material becomes easy	3.45	86.32
9. This module presents concepts based on calculations and results using GeoGebra	3.32	83.02
10. The material is presented in two ways: using calculations and GeoGebra to train my ability to solve problems	3.66	91.52
11. Using GeoGebra helps me get the right answer	3.66	83.49
12. The practice questions presented assess my understanding of Integral Calculus.	3.39	88.68
Average	3.48	87.11
LANGUAGE		
13. The sentences and paragraphs used are effective, precise, and easy to understand.	3.54	87.74
14. The module uses simple, communicative, and easy language.	3.64	91.04
15. The module uses letters, symbols, and terms that are clear, consistent, and easy to understand	3.69	92.45

Average	3.62	90.41
Total Average	3.56	89.15

The response questionnaire was distributed to 27 students after learning, which was at the second meeting. Table 4 shows that the total average score of the student response questionnaire to the module is 89.15%, meaning that students' response to the module is classified as very good.

Observer Response Questionnaire

The observer response questionnaire was given to an expert lecturer who taught the integral calculus course. The results of the observer's response to the module are presented below.

Table 5. Results of the Observer Response Questionnaire

Assessment Indicators	Grading Points	Score
CONTENT FEASIBILITY ASPECT		
A. Material Accuracy	1. Accurate material concept and definition	4.00
	2. The facts and data on the material are accurate	4.00
	3. The examples provided are accurate	3.50
	4. Pictures, diagrams, and illustrations displayed are accurate	4.00
	5. Notation, symbols, and icons used are accurate	4.00
B. Learning Support Materials	6. The application of the material is clear	3.50
	7. Material is interesting	3.50
	8. Motivate to seek further information	3.50
C. Material Update	9. The material is in accordance with the development of science	4.00
	10. Presenting actual drawings, diagrams, and illustrations	4.00
Average		3.80
ASPECT OF FEASIBILITY OF PRESENTATION		
A. Presentation Techniques	1. Presentation of the systematic concept	4.00
	2. Accompanied by examples of questions in each learning activity	3.50
	3. Practice questions hone thinking skills	3.50
B. Serving Support	4. There is an answer key to the practice questions	4.00
	5. Introduction	4.00
	6. Bibliography is appropriate and up-to-date	4.00
C. Presentation of Learning	7. Presentation involves students	4.00
	8. There is an introductory section	4.00
D. Presentation Equipment	9. There is a content section	4.00
	10. There is an ending section	3.50
Average		**3.85**
LANGUAGE ASSESSMENT ASPECT		
A. Business	1. Correct sentence structure	3.50
	2. The sentence used is effective	4.00
	3. Using standard terms	4.00
B. Communicative	4. The readability is high	3.50
	5. Using the correct language	3.00
C. Dialogic and Interactive	6. Ability to motivate messages or information	4.00
D. Compatibility with development level	7. Conformity with the level of the intellectual development of students.	4.00
E. Coherence and coherence of the flow of thought	8. Flow of thinking between systematic learning activities	4.00
F. Use of terms, symbols, or icons	9. The terms used are consistent	4.00
	10. The symbols or icons used are consistent	3.50
Average		**3.75**

Total Average	**3.80**
Percentage	**95%**

Table 5 describes that the total average score of the observer's response to the module is 3.80 with a percentage of 95%, meaning that the observer's response to the GeoGebra-assisted integral calculus module is very good.

Test

The test was used to investigate students' understanding of integral calculus. The results of the analysis of students' tests are illustrated in the following table.

Table 6. The Analysis Results on the Test

Student	Meeting I		Meeting II	
	Score	Score	Score	Score
S01	30	100	30	100
S02	30	100	30	100
S03	28	93	30	100
S04	28	93	30	100
S05	30	100	30	100
S06	30	100	30	100
S07	30	100	30	100
S08	30	100	30	100
S09	28	93	26	87
S10	26	87	30	100
S11	26	87	28	93
S12	26	87	30	100
S13	27	90	30	100
S14	28	93	30	100
S15	28	93	30	100
S16	28	93	28	93
S17	27	90	30	100
S18	27	90	30	100
S19	25	83	24	80
S20	25	83	25	83
S21	25	83	25	83
S22	25	83	25	83
S23	25	83	25	83
S24	25	83	25	83
S25	20	67	21	70
S26	20	67	20	67

S27	19	63	20	67
age		88.40		91.60

Based on Table 6, the average test score at the first meeting is 88.40, considered in the very good category. Meanwhile, at the second meeting, the students reached an average score of 91.60. This finding signifies that the average test score has increased.

The following figure are examples of students' answers on the test using by-hand calculations and GeoGebra.

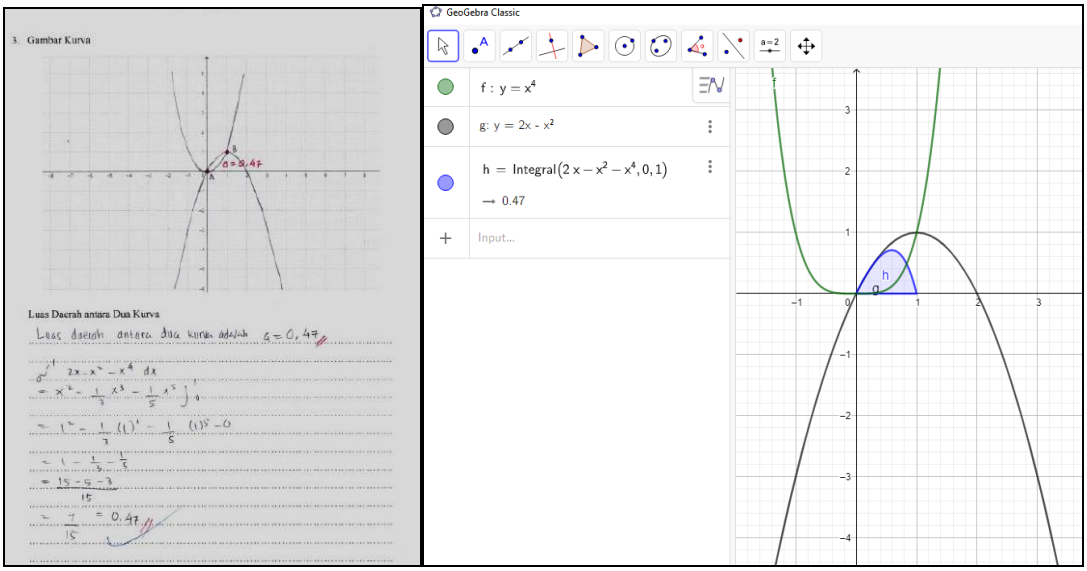

Figure 2. Examples of a student's answers using by-hand calculations and GeoGebra

Figure 2 shows that students can compare the solutions obtained by hand calculations and the solution using GeoGebra. Improvements occur because GeoGebra can display images and solutions directly. Thus, students can check whether their answers are correct, the graph is appropriate or not, and students no longer have difficulty drawing graphs.

The results of the study conclude that the GeoGebra-assisted integral calculus module is quite effective. The effectiveness gained based on the observation results of the learning activity indicates a very good category. Referring to the results of the students' and observers' responses to the module, the effectiveness of the module is in the very good category. The student test results have also increased.

Overall, the findings revealed that the GeoGebra-assisted integral calculus module had been effectively used. The results of the observer's response to the integral calculus module

indicate an average total score of 3.80 (95%). It means that the observers' response to the GeoGebra-assisted integral calculus module is very good. These results signify that observers are also interested in employing the GeoGebra-assisted integral calculus module in learning as, not only for students, it is also highly suitable for educators. This finding is aligned with the previous research, which developed calculus teaching materials assisted by Autograph software to improve students' understanding ability on the topic (Listiana, Wulandari, & Wirevenska, 2020). The finding is also similar to the study on the development of mathematics teaching materials through GeoGebra software to improve learning independence (Saputra & Fahrizal, 2019).

The analysis results of the test showed an improvement in students' learning outcomes. The average score for the first test was 88.40 (very good category) and the average score for the second test was increased, which is 91.60. These scores showed that the use of the GeoGebra-assisted integral calculus module potentially improves student learning outcomes. This finding accords with the results of research by Alkhateeb & Al-Duwairi (2019), stating that the use of GeoGebra can improve student learning outcomes. Akhini & Mahmudi (2016) contend that the use of GeoGebra in lectures has a significant effect on students' learning outcomes and motivation. Rahayuningsih (2016) has also developed a learning module assisted by GeoGebra software and found that the module can support students' scores and learning motivation.

Based on the aforementioned discussion, one may conclude that the GeoGebra-assisted integral calculus module should be used in integral calculus courses to facilitate the delivery of integral calculus concepts, thereby making students easily comprehend the concepts. This confirms the research results of Septian, A. (2017), which explains that GeoGebra can also be used by students in mathematics learning since the teaching materials using GeoGebra can be expanded independently and dynamically.

Finally, it is worth noting that this paper has several limitations. First, the results of the analysis on the limited trial are not stated. It is advisable to describe the analysis results on the limited trials when implementing small groups. This paper is also limited to the results of field trials on the effectiveness of the integral calculus module that was developed in only one class. As such, it is recommended to apply it to a wider range of respondents.

CONCLUSION

The findings of this study revealed that the GeoGebra-assisted integral calculus module meets the effective criteria to be applied in the integral calculus course. This recommendation is drawn from the observation results on the learning activities during lectures using the GeoGebra-assisted integral calculus module with an average percentage of 91.67%, which is considered the very good category. The analysis results on the test showed an increase in students' scores. The average score for the first test was 88.40 (the very good category) and for the second test was 91.60. The analysis results on the observers' response to the GeoGebra-assisted integral calculus module are classified as very good. This is based on the total average score of 3.80 with a percentage of 95%, denoting that the observers' response to the GeoGebra-assisted integral calculus module is very good.

It is recommended that further researchers develop mathematics learning modules in other courses by using GeoGebra or other applications to help students in learning.

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REFERENCES

Akhini, A., & Mahmudi, A. (2016). Pengaruh Pemanfaatan Cabri 3D dan GeoGebra pada Pembelajaran Geometri Ditinjau dari Hasil Belajar dan Motivasi. *Jurnal Pendidikan matematika dan Sains*, 3(2), 91-100. https://doi.org/10.21831/jpms.v6i2.10922.

Alkhateeb, M., & Al-Duwairi, A. (2019). The Effect of Using Mobile Applications (GeoGebra and Sketchpad) on the Students' Achievement. *International Electronic journal of Mathematics Education*, 14(3), 523-533.

Isharyadi, R., & Ario, M. (2018). Pengembangan Modul Berbantuan GeoGebra pada Perkuliahan Geometri Transformasi. *Guru Tua: Jurnal Pendidikan dan Pembelajaran*, Volume 1 Nomor 1.

Kemp, J., Morisson, G., & Ross, S. (1994). *Designing Effective Instruction.* New York: Mac Millan College Publ.Co.

Listiana, Y., Wulandari, & Wirevenska, I. (2020). Pengembangan Bahan Ajar Kalkulus Berbantuan Software Autograf untuk Meningkatkan Kemampuan Pemahaman Siswa. *Jurnal Serunai Matematika*, Vol 12(1), 32-43.

Listiana, Y., Wulandari, Aklimawati, & Isfayani, E. (2021). *Penggunaan Aplikasi GeoGebra pada Mata Kuliah Kalkulus Integral.* Yogyakarta: K-Media.

Nieveen, N., & Plomp, T. (1999). Design Approaches and Tools in Education and Training. Dordrecht: Kluwer Academic Publisher.

Plomp, T. (2013). *Educational Design Research; An Introduction to Educational Research.* Netherlands: Netherlands Institute for Curriculum Development.

Purwanto, N. (2013). *Prinsip-Prinsip dan teknik Evaluasi Pengajaran.* Bandung: Remaja Rosdakarya.

Rahayuningsih, R. (2016). *Pengembangan Modul Pembelajaran Berbantuan Software GeoGebra untuk Mendukung Hasil Belajar dan Motivasi Belajar Siswa pada Materi Segitiga di kelas VII.* Yogyakarta: Prodi Pendidikan Matematika, FKIP Universitas Sanata Dharma.

Rhilmanidar, Ramli, M., & Ansari, B. I. (2020). Efektivitas Modul Pembelajaran Berbantuan Software GeoGebra pada Materi Bangun Ruang Sisi Datar. *Jurnal Didaktik Matematika*, 7(2), 142-155.

Rohman, M. (2016). *GeoGebra Software Alat Bantu Pembelajaran matematika*. Retrieved from Mathzone: http://www.mathzone.web.id

Saputra, E., & Fahrizal, E. (2019). The Development of Mathematics Teaching Materials through Geogebra Software to Improve Learning Independence. *Malikussaleh Journal of Mathematics Learning (MJML)*, Vol 2(2), 39-44.

Sari, F. K., & Syazali, M. (2016). Pengembangan Media Pembelajaran (Modul) Berbantuan GeoGebra Pokok Bahasan Turunan. *Aljabar: Jurnal Pendidikan Matematika*, Volume 7 Nomor 2.

Septian, A. (2017). Penerapan GeoGebra untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Mahasiswa Program Studi Pendidikan Matematika Universitas Suryakancana. *Prisma,* 6(2), 180-191.

Takaendengan, B. R., Asriadi, & Takaendengan, W. (2022). Analisis Kesulitan Belajar Mahasiswa pada Mata Kuliah Kalkulus. *SEPREN: Journal of Mathematics Education and Applied*, Vol. 03, No.02, pp.67-75.