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Practicality and Effectiveness of Metacognitive-Based Flipbook E-modules Assisted by GeoGebra to Improve Mathematical Conceptual Understanding of Prospective Teacher Students

Maulani Meutia Rani[1*], Irni Latifa Irsal[2], Rahmat Hidayat[3], Annisa Ummul Khairi[4]

[1]*Pendidikan Matematika, FMIPA, Universitas Negeri Padang, Padang*
[2]*Tadris Matematika, IAIN Curup, Bengkulu*
[3] *Teknik Elektro, FT, Universitas Negeri Padang, Padang*
[4] *Mahasiswa Pendidikan Matematika, FMIPA, Universitas Negeri Padang, Padang*

*maulanimeutiar@fmipa.unp.ac.id

Abstract
Starting from the low understanding of mathematical concepts of prospective teacher students in learning and the demands of the times. Prospective teachers must first understand mathematical concepts in order to easily solve more complex mathematical problems. Preliminary studies show that prospective teachers' understanding of mathematical concepts in analytical geometry is still low. Students have difficulty describing abstract geometric objects and lack access to adequate interactive learning materials, making it difficult for them to understand geometry. Teaching materials are needed in the form of metacognitive-based electronic models to improve students' understanding of mathematical concepts. This e-module supports an independent learning process that leads students to abstract mathematical problems using the help of GeoGebra. This research was conducted with the Plomp development model, to measure the level of practicality seen from the practicality questionnaire from 9 students and a lecturer teaching the Analytical Field Geometry course, and the effectiveness of the product has been seen from the small group evaluation phase. Measurement of effectiveness is measured from the average n-gain according to Meltzer to improve students' understanding of mathematical concepts. The results showed that the GeoGebra-assisted metacognitive-based electronic flipbook module to improve students' understanding of mathematical concepts was practice and effective.

Keywords: flipbook; metacognitive; geogebra; mathematical concept understanding

Abstrak
Berawal dari rendahnya pemahaman konsep matematis mahasiswa calon guru dalam pembelajaran dan tuntutan perkembangan zaman. Mahasiswa calon guru harus paham konsep matematika terlebih dahulu agar dapat dengan mudah menyelesaikan permasalahan matematika yang lebih kompleks. Studi pendahuluan menunjukkan bahwa pemahaman konsep matematis mahasiswa calon guru pada materi Geometri Analitik Bidang masih rendah. Mahasiswa kesulitan dalam mendeskripsikan objek geometri yang abstrak dan kurangnya ketersediaan bahan pembelajaran yang interaktif yang memadai sehingga mahasiswa mahasiswa kesulitan dalam memahami materi geometri. Bahan ajar dibutuhkan berupa model elektronik berbasis metakognitif untuk meningkatkan pemahaman konsep matematis mahasiswa. E-modul ini mendukung proses pembelajaran secara mandiri yang menuntun mahasiswa terhadap

permasalahan matematika yang abstrak menggunakan bantuan geogebra. Penelitian ini dilakukan dengan model pengembangan Plomp, untuk mengukur tingkat kepraktisan yang dilihat dari angket praktikalitas dari 9 orang mahasiswa dan seorang dosen pengampu matakuliah Geometri Analitik Bidang, serta keefektifan produk sudah dilihat dari tahap small group evaluation. Pengukuran keefektifan diukur dari rata-rata n-gain menurut Meltzer untuk meningkatkan pemahaman konsep matematis mahasiswa. Hasil penelitian menunjukkan bahwa modul elektronik flipbook berbasis metakognitif berbantuan geogebra untuk meningkatkan pemahaman konsep matematis mahasiswa yang praktis dan efektif.

Kata Kunci: flipbook, metakognitif, geogebra, pemahaman konsep matematis

1. INTRODUCTION

Understanding mathematical concepts is one of the most basic aspects that must be mastered in learning mathematics. In learning mathematics, one of the things that plays an important role is student teachers (Dono & Mangila, 2021). Concept understanding is very important, especially for prospective maths teachers (Hadi et al., 2020; Hayati & Asmara, 2021; Purwaningrum & Purwoko, 2023). This is also supported by previous research as future generations of educators need a good understanding of mathematical concepts to teach mathematics effectively (Radiusman, 2020). One of the subjects that has a lot to do with school mathematics is plane analytic geometry (Pasandaran & Mufidah, 2020). It contains important concepts that are found in many schools from primary school to college (Haleem et al., 2022). Therefore, prospective teachers should have a good understanding of concepts in analytical geometry courses. However, several studies that have been conducted found that the understanding of students' mathematical concepts in analytical geometry courses is still low (Rustanuarsi, 2023). This is also supported by other studies that say students' understanding of mathematical concepts in geometry courses is still low (Meinarni et al., 2022). Students often make mistakes in identifying an equation and do not understand the concept of building space (Wilujeng & Alvarez, 2025). Some students have understood the concept but did not apply the procedure correctly (Meinarni et al., 2022). The same thing is also found in previous research which states that students' concept understanding on the material of cone slices is low. This study suggests that using props in geometry lectures because analytical geometry is one of the abstract subjects. So a medium is needed to describe the object of the building.

This is also supported by the facts found in the field that the understanding of mathematical concepts of students is still low. The low understanding of mathematical concepts is because students do not understand the concepts conveyed during learning. Mastery of the concept has not been maximized so that students do not master the concept optimally and the completeness of learning outcomes is not achieved. In addition, the unavailability of media that facilitates learning analytical geometry field is also a cause of low understanding of the concept. Students have difficulty understanding geometry concepts that are abstract. This is supported by other studies that state the unavailability of adequate media makes it difficult for students to understand abstract geometry concepts (Utami & Irawati, 2024). If the understanding of mathematical concepts in students continues to be left unchecked, it will result in low student learning outcomes in analytical geometry courses and do not understand sustainable concepts that will be taught to students in schools later. The difficulty of students who find it easier to understand or solve problems in the form of concepts or understanding by memorizing only (Ellissi & Intan, 2022). This is because students have not been systematic in preparing the steps of the solution. In helping the above problems, lecturers' skills in managing the class are needed so that learning becomes fun (Amiruddin et al., 2024). This is also closely related to the ability of metacognition about how students learn and obtain information independently so that they can choose the right strategy according to the problem and correct errors that occur in understanding the concepts applied (Fitria et al., 2020; Fuldiaratman et al., 2021). So it can be said that metacognition has an important role in organizing students in thinking, so that learning in the classroom becomes effective and efficient (Lisa & Wedyawati, 2020).

In accordance with the rapid development of technology, it is necessary to innovate teaching materials that are in accordance with the current situation (R. A. Putri, 2023). This is also supported by one of the policies issued by the Ministry of Education which expects lecturers to make creative learning innovations by utilizing technology to support student competence. E-modules that are developed can be accessed by students independently and can control the learning process to become lifelong learning so that learning is facilitated. This is also supported by previous research which found a relationship between metacognitive awareness and student academic achievement (Hassan et al., 2023). Students who are aware of metacognition have better learning outcomes. Thus, metacognition-based e-modules are teaching materials that can be accessed through computers/laptops that are interactive, because they can facilitate navigation, display images, audio, animated videos and are equipped with tests/quizzes that provide automatic reciprocal effects. Effective interactive e-modules are used to improve student learning outcomes in the learning process. The e-module developed in this study will use Flipbook software which has a function to open each page to be like a book. Reading material with flipbook is no longer monotonous and will be more interesting than an ordinary e-book. This is supported by the results of other studies which show that there is an increase in student abilities after applying metacognition-based e-modules in classroom learning (Panigrahi et al., 2025). In addition, it is necessary to develop teaching materials that can be accessed by utilising technology to support learning.

Based on this fact, GeoGebra becomes one of the solutions to facilitate students in understanding mathematics, especially geometry. By using GeoGebra more help students visualise geometry objects that are abstract to be more real. This is also supported by the results of research that shows there is an increase in understanding of mathematical concepts in geometry courses when applied to learning using Geogebra (Pamungkas et al., 2022).

So based on the previous background, this research is a development of research that has been studied previously in the field of mathematics and other fields. Research on the use of e-books in the learning process obtained a positive response to classroom learning and was able to improve student learning outcomes (Khoirunnisaa & Prajawinanti, 2023; Prasetyo, 2023). Research on metacognition-based teaching materials shows that there is a positive impact on learning outcomes. Similarly, research on using GeoGebra shows that GeoGebra can help students in learning so that learning becomes fun (Sirad & Arbain, 2021; Telaumbanua, 2020; Vinsensia et al., 2024; Wondo et al., 2020). However, there is no development research that combines metacognition-based flipbook e-modules assisted by GeoGebra to improve students' understanding of mathematical concepts in analytical geometry courses. Based on the review of previous research, this study aims to facilitate students to directly get feedback from what they learn. In addition, the e-module developed can be used as an independent learning resource, so that learning can be effective and efficient in understanding the concepts learned.

E-modules are said to be good if they can prove their practicality. Practicality is the usability of the learning media developed (Wisudariani & Wiraningsih, 2023). Practicality refers to the extent to which users, namely students and lecturers, find the developed product attractive and usable (Julian & Miaz, 2024). Practicality testing is carried out with the aim of knowing whether the products developed can be used and easily used by lecturers and students. The e-module developed is said to be practical if lecturers and student practitioners state that the e-module can be used and its implementation is in the practical category. Then to find out the practicality, the responses of lecturers and students were asked through a questionnaire.

In addition, the developed e-modules were also tested for effectiveness. Effectiveness is another word for successful, efficacious, and applicable. Product effectiveness refers to the extent to which the experience and results of the product can achieve the purpose of making a product (Julian & Miaz, 2024). Effectiveness testing is carried out with the aim of achieving the objectives in its manufacture. The effectiveness of e-modules in this study is seen from the average value of gain normality by comparing the value before learning using e-modules and after learning using e-modules.

2. METHOD

The type of research used in this study is research and development. The development model used for development in this study was adapted from the Plomp development model. The phases used in this development model consist of three phases: (1) Preliminary research; (2) Prototyping phase; (3) Assessment phase. This model was chosen because the development phases are clear and systematic, making it easy to use and suitable for developing learning modules. Based on the three phases, this research only uses the Preliminary research and Prototyping phase because the effectiveness of this e-module can already be seen in the Small Group Evaluation in practicality. Plomp's model is equipped with repeated formative evaluations, starting from the self-evaluation phase, expert review, one to one evaluation, to small group evaluation. This will produce a product with a high level of validity and at the small group evaluation phase it already represents the ability level of students at high, medium and low levels.

The instruments used in this study used two kinds of instruments, namely tests and non-tests. The test instrument is in the form of pretest-posttest questions of students' understanding of mathematical concepts. While non-test instruments in the form of observation sheets, interview lists, questionnaires, evaluation sheets. Data analysis techniques include qualitative data in the form of suggestions and input from validators as material for improvement at the revision phase. Qualitative analysis consists of analysis of learning device assessment sheets, analysis of student and lecturer response questionnaires, and N-gain analysis to measure the increase in students' understanding of mathematical concepts.

Furthermore, the research phase starts from the preliminary research phase, which is the initial phase in research that aims to apply what requirements are needed to answer problems in developing a product. At this phase, needs analysis, curriculum analysis, concept analysis, and student analysis were conducted. The needs analysis sheet was used to obtain information related to completeness in order to improve the designed module. The student analysis sheet is used to collect and analyse information related to student needs for the e-book to be developed. While the curriculum analysis sheet is used to find out the existing curriculum on campus, the demands and learning objectives studied. This analysis is used as a reference in developing e-books. Furthermore, the concept analysis sheet is used to identify, describe concepts systematically so that in developing the product it is in accordance with the needs of students.

The existing module analysis sheet is used to obtain information about the existing module. In this study, the module analysis phase was sent through an online form filled in by students who were taking analytical geometry courses. Based on the results of the analysis, it was found that learning tools are needed in the form of e-modules that contain aspects that involve technology and support and facilitate students in improving concept understanding.

In the prototyping phase is the phase of product development in the form of e-book flipbook based on GeoGebra-assisted metacognition on analytical geometry material. To see the practicality of the product is done with the steps of self evaluation, expert review, one to one evaluation and small group evaluation. Product practicality test is a measure to determine the usability of the product being made. The aspects of practicality measured in this study include the ease of users or students in using GeoGebra-assisted metacognitive-based e-modules using four aspects, namely usable, easy to use, interesting, and efficient. E-modules were tested on 9 students and a lecturer teaching analytical geometry courses. The instruments used were questionnaires and interviews. The technique of analysing the practicality of e-modules uses the descriptive statistical formula as follows:

$$P = \frac{f}{n} \times 100\ \%$$

Keterangan :

P = student score percentage

f = score obtained by students

n = total number of students

The practicality category of the developed product can be seen in Table 1. :

Table 1. Category of Product Practicality

Practicality Score	Criteria
$85\ \% - 100\ \%$	Very practical
$70\ \% - 84\ \%$	Practical
$55\ \% - 69\ \%$	Practical enough
$40\ \% - 54\ \%$	Less practical
$0\ \% - 39\ \%$	Unpractical

Source : Putri and Reinita (A. Putri & Reinita, 2023)

E-modules are said to be practical if they are in the practical and very practical criteria.

To see the effectiveness of the product seen from the test results of understanding the mathematical concepts of students already in the good or very good category. The product effectiveness test aims to determine how much influence this GeoGebra-assisted metacognitive-based e-module has on students' understanding of mathematical concepts in analytical geometry courses. Similar to the practicality test, the effectiveness test was also tested on 9 students but with different instruments. The instrument used to test the effectiveness of GeoGebra-assisted metacognitive-based e-modules in the form of mathematical concept understanding questions on point, line, and plane material in plane analytic geometry courses. In addition, the effectiveness of teaching materials on students‘ understanding of concepts is also known from the results of the gain normality test on pretest-posttest scores with the aim of seeing changes in students’ understanding of mathematical concepts before and after applying teaching materials in class. After obtaining the pretest and posttest scores, the analysis of the scores obtained was carried out with the normality gain test. This test is used to determine the effectiveness of the treatment given. The following formula is used to calculate the normality of gain according to Meltzer:

$$N - gain = \frac{posttest\ score - pretest\ schore}{maximal\ score - pretest\ score}$$

The effectiveness criteria interpreted from the normality gain value according to Meltzer can be seen in Table 2 below:

Table 2. Criteria of Product Effectiveness

Nilai Normalitas Gain	Kriteria
$0,70 \leq n \leq 1,00$	High
$0,30 \leq n \leq 0,70$	Medium
$0,00 \leq n < 0,30$	Low

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3. RESULT AND DISCUSSION

3.1 Needs Analysis Phase

At this phase, a needs analysis was carried out to collect information as a basis before designing and developing products obtained from a student needs questionnaire so that it was obtained that 67.9% said that the e-modules (teaching materials) used so far were quite easy to understand. A total of 36.7% said that what students did not like about the e-module used was that there were too many questions and assignments in the e-module, while another 28.6% said there were no pictures or the e-module video was not interesting. In addition, from the results of the questionnaire given, it is found that students feel that e-modules (interesting teaching materials) support their learning style and are colourful. As much as 60.7% of the dominant colour that students like is blue and as much as 60.7% of the writing that most students like is Times New Roman.

Based on the results obtained from the needs questionnaire, a learning tool is needed in the form of an e-module that contains aspects that use technology that supports and facilitates students in improving students' understanding of mathematical concepts. In addition, student analysis is carried out by means of direct interviews with students. From the results of interviews with students, it was found that the modules given at this time did not fully help students to understand the material and did not attract students' interest in reading and solving each problem given.

3.2 Product Development Phase

At this phase, e-module design is carried out based on the results of the previous phase. Based on the results of the previous phase, the e-module is designed as teaching material used by educators as teaching material that supports the learning process. Before carrying out product development, the e-module design phase is carried out, the e-module cover is designed by taking into account the characteristics of the analysis of student needs for analytical geometry courses in a field that depicts people writing as shown in Figure 1.

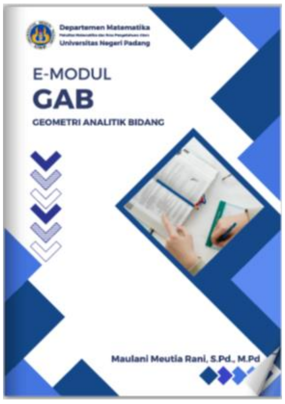

Figure 1. Analytical Geometry of the Plane E-Module Cover

The e-module component contains a cover (front page), table of contents, learning objectives for each meeting, material coverage, metacognitive-based learning activities there are several questions to emphasize students' cognitive abilities so that students are able to plan learning and evaluate their respective learning outcomes, instructions for using GeoGebra-assisted IT media to support the visualisation of geometry material, practice questions and answers that are used to hone students' understanding of concepts related to the material that has been discussed. The selection of material refers to the curriculum of the Mathematics Education study programme at Padang State University in accordance with the Semester Learning Plan (RPS) in the Analytical Geometry of the Field (GAB) course. The material included in this e-module includes: the cartesian coordinate system, straight lines in the field, vector equations and the position of two straight lines, and the distance from points to lines and line files. After the module is designed, the next phase is the self-evaluation phase. At this phase, the module that has been designed will be assessed and evaluated by itself before finally being given to experts. This evaluation is done with colleagues. Then the product revision is carried out.

After revising the product based on suggestions from validators. Then the next phase is one-to-one evaluation. At this phase, it was carried out with 3 students with different levels of academic ability, namely high, medium and low ability. The selected students have done an initial test. This one to one evaluation phase was carried out in the classroom by interviewing 3 students to find out student responses to the emodules used without being taught first. Student data at the One to One Evaluation phase can be seen in Table 3 below:

Table 3. Student Data at the One to One Evaluation Phase

No	Students	Academic Ability
1	Student 1 (L)	High
2	Student 2 (MMS)	Medium
3	Student 3 (RTP)	Low

Based on the results of interviews with the three students as a whole, it is concluded that the e-modules provided can support learning well because the problems provided are complemented by planning, monitoring, and evaluation. In addition, students can see alternative answers by checking the solution steps that we do according to what is in the e-module. With the e-module given to students, they understand and comprehend the material provided in the e-module as well as exercise and evaluation questions that can help students by doing exercises independently based on the instructions in the e-module. Thus, overall students are interested in using e-modules in learning because e-modules are designed to be more interesting and not monotonous like other ordinary learning modules. In addition, according to students, e-modules can increase their understanding of using today's technology.

The next phase is small group evaluation to see the practicality of the developed e-module. At this phase, it was conducted to 9 students who were divided into 3 different ability groups where each ability consisted of 3 students. The students selected for the small group evaluation phase can be seen in Table 4 below:

Table 4. Student Data at the Small Group Evaluation Phase

No	Students	Academic Ability
1	Student 1 (MF)	High
2	Student 2 (SW)	High
3	Student 3 (IW)	High
4	Student 4 (LHS)	Medium
5	Student 5 (KH)	Medium
6	Student 6 (RDS)	Medium
7	Student 7 (R)	Low
8	Student 8 (KH)	Low
9	Student 9 (N)	Low

From Table 4 above, the results of student practicality at the small group evaluation phase which are converted in percent units can be seen from Table 5 below:

Table 5. Student Practicality Results

No	Practicality Component	Practitioner									Average	Category
1	Usable	90	85	100	100	85	100	95	100	100	95,00	Very practical
2	Easy to use	75	85	100	100	75	100	90	95	100	91,11	Very practical
3	Appealing	93,3	90	100	100	86,7	100	93,3	100	100	95,93	Very practical
4	Cost effective	85	80	100	100	75	80	95	95	100	90,00	Very practical
	Overall Average										93,01	Very practical

In addition to students, the assessment was also given to lecturers of Analytical Field Geometry courses. The results of the lecturer's practicality can be seen in Table 6 below:

Table 6. Lecturer practicality results

No	Practicality Componen	Result (%)	Category
1	Usable	95	Very practical
2	Easy to use	95	Very practical
3	Appealing	100	Very practical
4	Cost effective	95	Very practical
	Average	**96,25**	Very practical

Based on the results of the practicality of students and lecturers, the student assessment obtained is 93.01% which is categorised as very practical. While the assessment of the Field Analytical Geometry lecturer obtained a practicality of 96.25% which is categorised as very practical. students said that the e-module developed was very interesting and helped students in understanding the learning material. In addition, the varied questions can make it easier for students to understand the material. Meanwhile, according to educators, the developed module is interesting and easy to use to help students understand the material and the developed e-module can be used independently with the instructions given in the e-module are clear.

After this small group evaluation phase, to determine the effectiveness of the e-module, a mathematical concept understanding test was conducted again to see the increase in students' mathematical concept understanding before and after learning using the e-module. At the beginning of the study, a pretest was conducted before learning using the e-module. Then learning using e-modules was given. Then, afterwards, a posttest was given to measure students' understanding of mathematical concepts after learning using the e-module. The result of the student's concept comprehension test can be seen in Table 7 below:

Table 7. Product effectiveness results

No	Prospective teachers	Pre-test	Post-test	N-Gain Score
1	LHS	40	87	0,783
2	RDS	38	87	0,79
3	SW	50	93	0,86
4	KH	24	50	0,342
5	N	21	54	0,418
6	KH	43	84	0,719
7	MF	56	95	0,886
8	R	24	65	0,513
9	IW	46	90	0,815
	Average	**38**	**80,9**	**0,717**

The results of product effectiveness based on the test of students' understanding of mathematical concepts obtained n-gain value = 0.717 so that the qualification of the average value of n-gain according to Meltzer obtained normality value is in the range of $0.7 \leq \bar{x} \leq 1.00$ with high criteria. So, from the results of the effectiveness of this e-module product, it is obtained that the e-module is effective as an additional material in learning to improve students' understanding of mathematical concepts.

E-modules are said to be practical and easy to use for students. E-modules themselves can be in printed and electronic form that can be accessed via the internet. One of the things that makes it practical is that it is easy to use because students can learn independently following the instructions in the e-module. Similarly, other studies state that the e-modules provided have learning reflections so that they are feasible and practical to use in learning mathematics (Sangka, 2021). In addition, another previous study stated that the use of electronic modules is very effective in increasing learning motivation (Murod et al., 2021). This is also closely related to the e-modules developed in this study. With an effective e-module, it can improve students' understanding of mathematical concepts. Students become not a midwife to learning because they can learn using a smartphone. In previous studies, it was revealed that e-modules were proven to be used practically and support independence in learning and affect students' ability to understand concepts so that this electronic module was effective in improving mathematics learning outcomes. (Tralisno & Alfi, 2024).

4. CONCLUSION

Based on the results of the research that has been conducted, it is concluded that 1) The practicality of the product seen from 4 aspects, namely useable, easy to use, appealing, and efficient (cost to effective) of the E-module produced has met the very practical category as shown by the practicality results of 9 students with a value of 93.01% and a lecturer teaching the Analytical Field Geometry course with a value of 96.25%. 2) The effectiveness of the product seen from the small group evaluation of the increase in students' understanding of mathematical concepts based on the qualification of the average n-gain value according to Meltzer obtained normality in the range of $0.7 \le \bar{x} \le 1.00$ with high criteria. So that this e-module can be used as additional material in learning to improve students' understanding of mathematical concepts.

Based on the research results obtained, the GeoGebra-assisted metacognitive-based e-module that has been developed can improve students' understanding of mathematical concepts. Therefore, researchers suggest that GeoGebra-assisted metacognitive-based Field Analytic Geometry e-modules can be used as teaching materials by students in improving understanding of mathematical concepts and researchers suggest that other researchers can develop e-modules on other Field Analytic Geometry materials.

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