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Development of Flip PDF-Assisted Scientific Approach E-Modules to Enhance Mathematical Understanding in Circle Topics for Grade VIII Students

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ABSTRACT

The background of this research is the limitation of e-modules that are in accordance with the abilities of students who have difficulty in learning mathematics. This causes the low mathematical understanding skills of students. The goal of this study is to create an e-module based on the scientific approach assisted by flip pdf on circle material that is able to facilitate the mathematical understanding skills of grade VIII students. The development procedure is guided by the ADDIE model. This research was only conducted until the small group trial with subjects consisting of 10 students of SMPN 35 Pekanbaru grade VIII. Data was obtained by utilising interview and questionnaire techniques. The instruments used in data collection were validation questionnaire and student response questionnaire. The findings of the research obtained that e-module have an average validity of 3.52 which is classified as very valid. Meanwhile, the practicality of e-modules is classified as very practical with an average of 3.39. Thus, the e-module produced has met the requirements of validity and practicality, so that it is worth it for use by grade VIII junior high school / MTs students.

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INTRODUCTION

Mathematics in education is a subject that has an important role and advances human thinking. Other disciplines need mathematics as a tool in solving the problems they face because mathematics is the queen and servant of science [1]. Good mastery of mathematics is a strong basis for studying other fields. In learning mathematiycs, students must understand the concepts first in order to find a solution to a problems and be able to apply the learning in the real world [2]. Higher order thinking skills are very important in mathematics education in Indonesia, especially in developing students' mathematical understanding skills.

Mathematical understanding skills is a key aspect of learning that students must have [3]. Karim and Nurrahmah [4] states that mathematical understanding skills is one of the important goals in learning mathematics because mathematical understanding skills means that the material taught to students is not just memorised, but as a concept of the material learnt. Alawiyah et al. [5] said that understanding is the level of ability that expects students to be able to understand the meaning or concepts, situations and facts they know. Understanding is very useful for training students' ability to remember something that is taught. In the context of mathematics education,

this ability helps students not only memorise formulas or procedures, but also understand the application of mathematics in real life.

The importance of mathematical understanding skills is not in line with the situation in the field. Data on students' mathematical abilities can be seen in [6] which shows that students' mathematical understanding skills in one junior high school are low. The research was conducted through student mathematical understanding skills tests on algebraic material, student questionnaire results, and documentation. Similar research was also conducted by [7] which showed that the mathematical understanding skills of students in one of the Senior High Schools was low with the results, that is only 5.26% of students who understood the indicator of restating a concept, 15.78% of students who understood when presenting concepts in various forms of mathematical representation, and there were 26.31% of students who could apply concepts to problem solving. Based on the results of the National Mathematics Examination (UN) in Indonesia for SMP / MTs in the 2018/2019 school year in mathematics subjects is 45.52. Meanwhile, at the provincial level, especially Riau Province, the average value of the National Exam (UN) in junior high school mathematics in 2019 was 46.06. This value is still below the specified minimum completeness value of 55.00 [8]. From the research results and national exam results, it can be seen that in practice students' mathematical understanding skills are still low. This is because students are less active in the learning process and tend to memorise formulas to solve mathematics problems. In other words, students are considered less able to re-explain the concepts they have learnt and cannot answer questions when given more complex problems.

Seeing the importance of mathematical understanding skills for students, a learning approach that can involve students is needed, one of which is a scientific approach. Fathurrohman [9] said that the learning approach is the way the teacher takes in implementing learning so that students can adapt to the concepts taught. Hosnan [10] mentioned that the scientific approach is a learning process that is organised in such a way that students can actively build concepts or principles through the activities of observing, formulating idea, formulating hypotheses, collecting data with a variety of techniques, such as analysing data, communicating, drawing conclusions. The principle of the scientific approach is good productive, creative, innovative and effective learner-centred learning [10][11]. The scientific approach can be implemented in mathematics learning because it provides opportunities for students to make observations and analyse learning, so that learning concepts can be understood by students who can build their matemathical understanding skills.

In order for the choses learning approach to function optimally, teaching materials are needed that also support the development of students comprehension skill. Teaching materials are external factors of students that can strengthen internal motivation to learn and provide understanding of mathematical concepts in students. Therefore, educators must innovate by creating teaching materials that are easy for students to understand, systematic, effective and efficient.

Circle is a material that is taught at the level of junior high school / MT's class VIII education. Circle material is relatively simple, but if students cannot understand then students will find it difficult to work on the questions. Based on [12] the questions on the circle material are very varied so that teachers are required to train students in answering questions in the form of stories. From the research conducted by [13] said that the difficulty experienced by students is when using mathematical formulas, especially circle material so that students seem to memorise rather than understand the formula, besides that students also have difficulty in understanding the problem. In addition, from the results of research conducted by [14] concluded that the quality of mathematical

understanding of public junior high school students in Bandung City is haven't been fully achieved, which is only about 49% of the ideal score. The process in learning that is only fixated on the material alone can affect the ability of students' understanding in solving circle material problems. Students tend to memorise formulas and students are considered to lack understanding of the concepts learned so that they cannot answer complex problems. Therefore, it is necessary to develop teaching materials (e-modules) to improve mathematical understanding skills and the right learning approach in circle topics.

This e-module supports learning where students are required to be active, creative and innovative. From research on e-modules conducted by [15] on junior high school students showed that e-module were stated to be able to improve students' mathematical concept understanding skill. According to Wijanto [16] e-module is a module that is packaged electronically on a diskette, flashdisk, CD or harddisk and can be viewed on a computer or smartphone. The software that supports the making of e-modules is Flip PDF. According to [17] among the e-module maker applications, the Flip Pdf application has more advantages, namely it is easy to use because it can be operated for beginners who don't know the HTML programming language. Besides being able to be downloaded freely or for free, Flip Pdf provides facilities that can make the learning process interesting. According to [18], Flip Pdf can be downloaded freely, can be utilised by all groups, can be opened anytime and anywhere, provides a display like a page book (reversible), can create test or quiz material, as well as varied media displays such as images, video and audio.

From the problems found and the results of previous research in facilitating students' mathematical understanding skills, the goals of this study is to develop e-modules based on the scientific approach aided by Flip Pdf on circle material that meets the valid and practical requirements. The e-module developed must be valid so that it is feasible for students to use and able to facilitate students' mathematical understanding abilities, and must be practical so that it can be utilised easily.

METHODS

The development procedure follows the stages in the ADDIE model, which includes analysis, design, development, implementation, and evaluation.

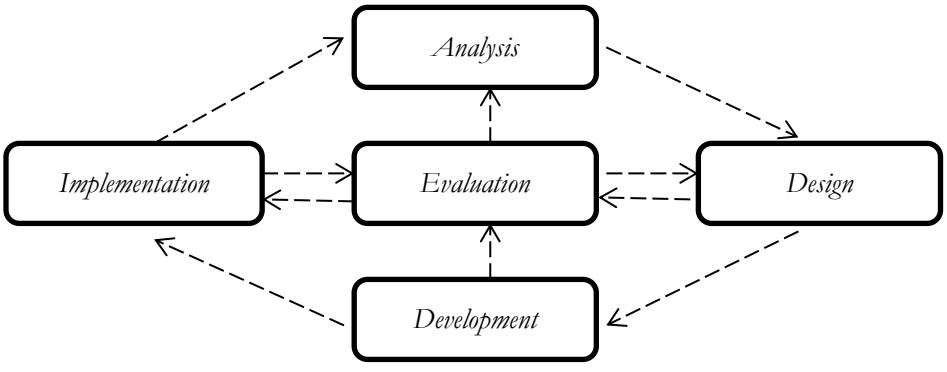

Figure 1. Stage of the Development ADDIE

The analysis stage is useful for analysing the need for developing e-module teaching materials and analysing the feasibility and requirements of development. The steps taken are needs analysis, student analysis, and curriculum analysis. At the design stage, references related to circle materials were collected, designing the systematics of making e-modules, and designing validation sheets and

student response questionnaires. At the development stage, the preliminary design of the e-module is validated by experts and criticised to improve the product. The next stage is implementation, where the valid e-modules are tested on limited students (small groups) which is useful for obtaining data related to the practicality of e-modules. The implementation of the research trial was carried out at SMPN 35 Pekanbaru involving 10 subjects of class VIII students. At the evaluation stage, researchers evaluate matters related to the development of e-modules assisted by Flip Pdf.

The data in this study are 1) quantitative data comes from the validator's score and the practicality score of using the e-module which is used as a determination of the quality of the product developed, and 2) qualitative data comes from criticism and responses from experts (validators). The instruments used to collect data are validity instruments such as validation questionnaires and practicality instruments such as student response questionnaires. The collected data were analysed using two techniques, which included validity analysis and practicality analysis. The validation score results and practicality score obtained were interpreted into the validity criteria adopted from [19], as in Table 1 and 2. E-modules are classified as valid or very valid, also practice or very practice when the score is more than or equal to 2.50.

a. Analysis of Internal Validation of E-Modul

Analyze the data from the validation sheet based on the criticism and responses from experts (validators) using the following formula and information.

$$\bar{T}_v = \frac{\sum_{i=1}^{n} \bar{V}_i}{n}$$

Description:

$\bar{T}_v$ = average total validity

$\bar{V}_i$ = average validation of the i-th validator

n = number of validator

Table 1. Internal Validity Criteria

Interval	Category of Validity
$3{,}25 \leq \bar{T}_v < 4$	Very Valid
$2{,}50 \leq \bar{T}_v < 3{,}25$	Valid
$1{,}75 \leq \bar{T}_v < 2{,}50$	Less Valid
$1{,}00 \leq \bar{T}_v < 1{,}75$	No Valid

b. Analysis of Student Response Questionnaire

The results of student responses to the questionnaire collected were thw tabulated and analyzed using the following formula.

$$\bar{T}_p = \frac{\sum_{i=1}^{n} \bar{p}_i}{n} \quad (1)$$

Description:

$\bar{T}_p$ = average total responden's

$\bar{P}_i$ = average practice of the i-th responden's

n = number of responden

Table 2. Student Response Criteria

Interval	Category of Validity
$3{,}25 \leq \bar{T}_p < 4$	Very Practical
$2{,}50 \leq \bar{T}_p < 3{,}25$	Practical
$1{,}75 \leq \bar{T}_p < 2{,}50$	Less Practical
$1{,}00 \leq \bar{T}_p < 1{,}75$	No Practical

RESULTS AND DISCUSSION

The findings of this study are e-modules based on the scientific approach aided by flip pdf of circle topic to facilitate mathematical understanding skills for class of VIII students that meet the valid and practical requirements. The e-module was developed based on the ADDIE model whose procedures are described as follows.

1. Analysis

The analysis stage aims to establish and define learning needs by collecting information obtained through interviews and documentation studies. The following is what is done during the analysis stage.

The first activity is needs analysis. Based on interviews with two mathematics teachers at SMP Negeri 35 Pekanbaru and SMP Negeri 21 Pekanbaru, it was found that the teaching materials used by teachers and students at school were textbooks and LKS. According to the teachers, the textbooks have a language that is difficult for students to understand, the context given is considered not in accordance with the experience of students, and the use of illustrative images is also sometimes inappropriate so that it must be assisted by an explanation from the teacher. To strengthen the results of the interview, observations were made with the result that students' mathematical understanding skills were still low which could be seen from the students' low mathematics learning outcomes. The low mathematical comprehension skills possessed by students can also be seen in research conducted by Rahmi [20] which states that many students have low mathematical comprehension skills so that they have difficulty working on exercises and assignments given by the teacher. According to Permendikbud No. 58 of 2014, the purpose of the subject guidelines in the 2013 curriculum is to develop, formulate, compile, and implement lesson plans, teaching materials, worksheets in an innovative, creative, effective, efficient, and contextual manner in accordance with the conditions, needs, capacities, and characteristics of students. Therefore, one solution to this problem is to provide teaching materials in the form of e-modules based on the scientific approach assisted by Flip Pdf so that students can learn independently and play an active role in the learning process so as to facilitate students' mathematical understanding abilities, especially in circle material.

Second, student analysis is useful for knowing the characteristics of students in the learning process. The results of student analysis are used as an illustration in the development of teaching materials that are in accordance with the characteristics of students. The e-module developed is intended for students of grade VIII SMP/MTs aged 12-14 years. According to Piaget [21], students who are 11-15 years old begin to enter the formal operational stage. At this stage, students already have the ability to think abstractly, think deductively and reason. Piaget also suggested that at this age is a period of change for students, so that not all stages of cognitive development of students at this age directly enter the formal operational stage. There are still students who find it difficult to accept an abstract idea if not given a concrete picture first. Therefore, in carrying out mathematics learning, it should still start with a concrete picture so that students can still build their own knowledge through the contextual problems given.

Third, curriculum analysis is useful for identifying, detailing, and systematically compiling concepts that are relevant to the material to be taught. The material chosen in this teaching material development research is circle material for junior high school / MTs grade VIII. The preparation of materials in this teaching material refers to the 2013 curriculum for grade VIII junior high school / MTs level listed in Permendikbud Number 37 of 2018 with the basic competencies of circle

material, that is KD 3.7 "Explaining the central angle, circumference angle, arc length, and circular juring area and their relationship" and KD 4.7. "Solve problems related to the central angle, circumference angle, arc length, and circular juring area, and their relationships".

The competency achievement indicators (IPK) of KD 3.7 and KD 4.7 are:

3.7.1 Identify the elements of a circle
3.7.2 Determine the circumference and area of a circle
3.7.3 Determine the centre angle and circumference angle
3.7.4 Determine arc length and juring area
4.7.1 Solve problems related to the elements of a circle
4.7.2 Solve problems related to circumference and area of a circle
4.7.3 Solve problems related to the central and perimeter angles and their relationship
4.7.4 Solve problems related to the relationship between the central angle, arc length and the area of the circumference

From the KD and IPK, the sub-materials in the e-module are arranged into 4 sections, including the elements of a circle, circumference and area of a circle, central angle and circumference angle of a circle, length of a circumference and area of a juring.

2. Design

The design stage is useful for designing teaching materials that are developed and compiling research instruments such as validation sheets and student response questionnaires. At this stage, several references related to circle material are collected from several relevant sources, that is mathematics books for Class VIII SMP / MTs Semester 2 2017 Edition from the Ministry of Education and Culture, Mathematics books for SMP / MTs Class VIII Semester 2 Curriculum 2013 Revised Edition 2016 by M. Cholik Aninawan, and Mathematics books for SMP / MTs Class VIII by Atang Supriadi. The systematic writing of the e-module is based on the adaptation of Permendikbud Year 2017 which is divided into 4 sections, as listed in Table 3.

Table 3. E-Module Writing

E-Module Section	Compounding Components
Cover	1. E-Module Title 2. Subject Name 3. Topic/Learning Material 4. Grade 5. Author
Introduction	1. Foreword 2. Table of Contents 3. Introduction to the Materials 4. Basic Competence 5. Indicators of Competence Achievement 6. Instructions for Use of E-Module 7. Concept Map
Content (Learning Materials)	1. Learning Objectives 2. Learning Activities a) Observing Activity b) Questioning Activities c) Information Gathering Activities d) Sample Questions

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E-Module Section	Compounding Components
	e) Reasoning Activities f) Communicating Activities 3. Exercise
Closing	1. Summary 2. Competency Test

At this stage, the appearance or layout of the e-module has been designed based on the systematics that have been previously determined. The use of Flip PDF begins with importing a PDF document, after which editing is done by adding text, images, video, and audio. Flip pdf allows the addition of interactive elements such as links, navigation buttons, and quizzes, which increases user engagement with the content. Once completed, the e-module is published in link website, making it accessible on various devices such as computers and smartphones. Flip PDF's advantages over other tools lie in its intuitive user interface, ability to add interactive elements, flexibility in publishing, extensive multimedia support, as well as animation and transition features that make e-modules more lively. With all these features, Flip PDF becomes an excellent choice for creating informative and interesting learning materials, increasing the effectiveness of the learning process.

In the design stage, data collection instruments were designed in the form of e-module validation sheets and student response questionnaires with a Likert scale that has four answer options, including 1, 2, 3, and 4 which state strongly disagree, disagree, agree, and strongly agree.

3. Development

In this stage, the e-module was created based on preliminary design. Some examples of development results are presented in the following figure.

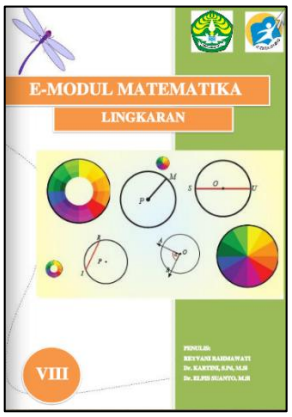

Figure 1. E-modul Cover

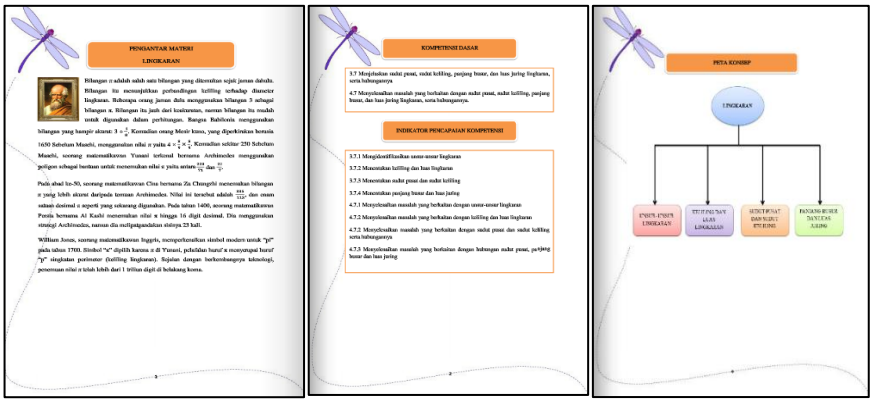

Figure 2. The Introduction Section of the E-module.

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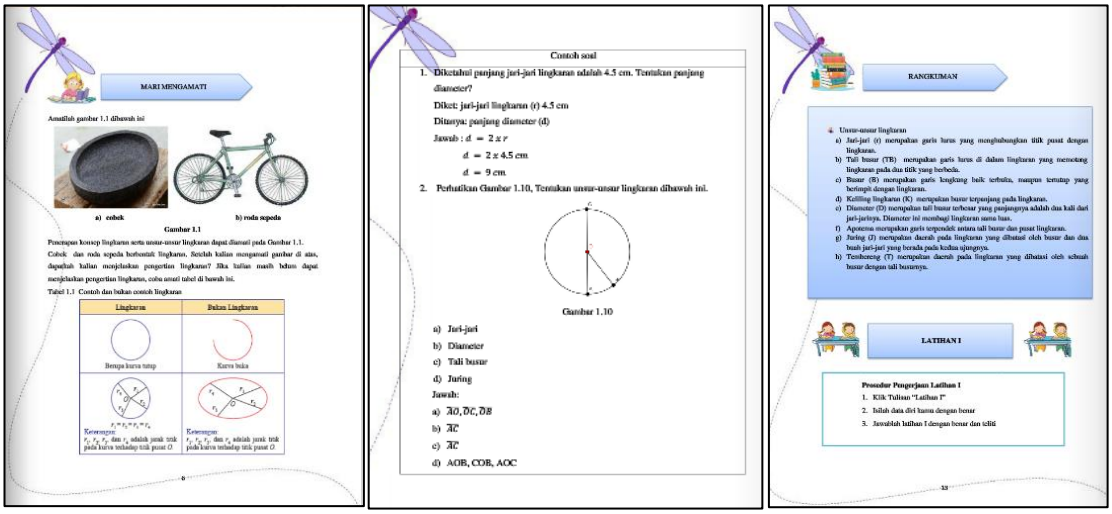

Figure 3. Content Section of the E-module

Figure 4. The closing part of the e-module

The initial e-module product was assessed by three experts (validators). to determine the level of validity of the e-module and the experts provided criticism to improve the e-module. The results of the validity analysis are shown in Table 4.

Table 4. Recap The Result of The E-module Validity Analysis

No	Aspect	Skor of validator to-			Average	Category
		1	2	3		
1	Curriculum Aspects	3,13	4	3,63	3,58	Very Valid
2	Material Aspect	3	4	3,67	3,56	Very Valid
3	Display Aspect	3	3,63	3,25	3.29	Very Valid
4	Aspect of flip pdf	3,25	4	3,5	3,58	Very Valid
5	KPM aspect	3,25	4	3,5	3,58	Very Valid
		Valid Average			3,52	Very Valid

From the table 3, the e-modules classified as very valid with an average 3,52. The interpretation is in accordance with what [19] stated that the product is very valid when the validation score is in the interval $3.25 \leq Tv < 4$. Of all the aspects assessed, the highest score was

obtained in the aspects of the curriculum, flip pdf and mathematical understanding skills, which was 3.58 with a very valid category. The material and display aspects obtained a very valid category with an average of 3.56 and 3.29 respectively. However, the validator provided suggestions for improvement of the e-module. In the cover section, the improvements include adding the sentence "to facilitate mathematical understanding skills". In the introduction section, the improvement is in the form of adding the sentence "and its relationship" in IPK 3.7.3 and IPK 3.7.4. In the material section, the improvement is in the form of changing the sentence write down your questions in the exercise book to in the notebook, clarifying the question instructions in Exercise 1, and making the material title right below the explanation so that the appearance becomes neat and efficient. In the closing section, the improvement is to add a summary of all learning activities.

4. Implementation

After the e-module has met the valid category and has been revised based on the experts' criticisms, the e-module is tested on students. However, before going to the small group test, a one to one readability test was conducted to 3 students with heterogeneous abilities to determine the validity of the e-module developed as well as to see what obstacles students faced when working on the e-module. The results of the readability test included errors in typing letters and errors in mathematical symbols in the e-module. Furthermore, the e-module was revised so that it could be implemented in the small group trial.

The e-module trial should have been conducted with small and large groups. However, due to unfavourable conditions and time, only small group trials were conducted. The subjects of the small group trial were randomly selected VIII grade students of SMP Negeri 35 Pekanbaru with heterogeneous academic abilities. The small group trial was conducted on 10 students, this is in accordance with the opinion of Mulyatiningsih [22] that small group trials consist of 6-12 students. The ten research subjects consisted of 3 students each with high and low cognitive levels, as well as 4 students who have moderate cognitive levels. In addition to working on the e-module, students were also asked to fill out a student response questionnaire to obtain practicality data.

5. Evaluation

After collecting student response questionnaire data, the data was analysed to see the practicality of the e-modules and fixed the e-module according to the criticism from the students. Table 5 shows the result of the practicality of e-modules obtained through student response questionnaires.

Table 5. Small Group Trial Results

No	Aspect	Total Statement	Persentage	Category
1	Display Aspect	3	3,47	Very practical
2	E-module Content Aspect	9	3,43	Very practical
3	Language Aspect	3	3,48	Very practical
4	Ease of Use Aspect	2	3,39	Very practical
5	KPM Aspect	4	3,19	Practical
Practicality Persentage			3,39	Very practical

From table 4, it is known that the highest percentage is obtained by the “language aspect” with a result of 3,48, while the lowest percentage is obtained by the “KPM aspect” with a result of 3,19. Thus, the average e-module practicality score is 3.39 which is classified as very practical. The

interpretation is in line with [19] that the product is declared very valid when the practicality score is in the interval $3.25 \leq Tv < 4$.

From the description of the validation and small group trials of the e-module developed, it was found that it met the valid and practical requirements for use by students in grade VIII SMP / MTs. The advantages of this e-module include 1) making it easier for teachers to deliver learning materials, because this mathematics e-module acts as a study guide for students so that they can learn independently in class and outside of school hours; 2) this e-module is developed and packaged attractively so that the student learning process will be more enjoyable and can be understood by students; 3) the process of distributing e-modules is very easy and efficient online by simply sharing a website link. In addition, there are watermark, that is that the watermark in the mathematics e-module cannot be removed because to remove it you have to upgrade the flip pdf which consists a lot of money.

The e-module in this research is integrated into the existing curriculum by aligning it with the syllabus and basic competencies for the mathematics subject of grade VIII circle. In a real classroom environment, e-modules can be applied by providing an introduction to the material by the teacher, followed by independent activities where students explore interactive elements in the module, as well as class discussions to discuss student understanding. The e-module is also equipped with evaluations such as quizzes to formatively assess students' understanding. In addition, this e-module supports the achievement of the basic competencies and indicators of competency achievement (IPK) that have been set, because it improves understanding of the circle concept, develops critical thinking skills through observation and experimentation activities, and encourages interaction and collaboration between students. Thus, the e-module not only serves as an interactive learning tool but also contributes positively to the achievement of expected competencies in mathematics education.

This research makes a significant contribution to mathematics learning by integrating the scientific approach and Flip PDF-based technology. The wider implication is the need for the adoption of educational technology that supports active, independent and innovative learning to improve the quality of education in Indonesia. This is also relevant in facing global challenges in the digital era and realising more inclusive and adaptive educational goals.

CONCLUSSION AND SUGGESTIONS

The development procedure used in this study is a ADDIE model consisting of four stages: Analysis, Design, Development, Implementation and Evaluation. At the analysis stage, conduct a needs analysis, curriculum analysis and student analysis. At the design stage is collecting references, designing systematics, designing validity sheets and study responses questionnaires. At the development stage, creating an e-modul based on scientific appoarch using a Flip PDF of circle material and validation e-modul by validator. At the implementation stage, e-modul tested on student by small group. At the evaluation stage, improvement are made at each stage of e-modul creation so that e-modul valid and practical. This study found mathematics e-module based on the scientific approach assisted by Flip PDF to facilitate mathematical understanding skills of junior high school students has reached the criteria of valid and practical. It is recommended that teachers integrate the scientific approach and contextual questions in mathematics learning, use innovative teaching materials, and participate in educational technology training to support effective implementation.

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