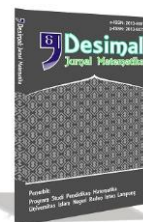




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PMRI-based e-module development on sequences and series materials

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ABSTRACT

This research aims to produce e-module products based on Indonesian Realistic Mathematics Education (PMRI) on sequences and series materials that are valid, practical, and have potential effects. This research is a type of research and development using the ADDIE model, namely analyze, design, development, implementation, evaluation. The object of research is the quality of PMRI-based e-modules on sequence and series material. Before being tested, the e-module was validated by material experts and media experts. In addition, there is also a student response questionnaire regarding the developed e-module and test questions. The validity of the e-module has an average score of 92%, which is determined based on the results of the assessment of the e-module by experts consisting of 2 lecturers and 1 mathematics teacher. The practicality of the e-module has an average score of 87%, which is determined based on the student response questionnaire to the e-module. The potential effect aspect has an average score of 87% obtained based on student learning outcomes tests. The results of expert validation, student response questionnaires, and tests show that the e-module developed is very valid, very practical, and has a very high potential effect. Overall, PMRI-based e-modules on the sequences and series material for SMA class XI are suitable for use in learning.

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INTRODUCTION

In the era of globalization, the development of information and communication technology is very rapid, and the interaction and delivery of information take place very quickly. Thus, technological advances have an impact on various fields, including education. Education is one way that aims to create a learning atmosphere where students can

be more interactive in developing their potential (Kurniawan, 2015). One of the most important scientific fields in education is mathematics.

Mathematics is an abstract and complex science. So, we need an appropriate learning method to convey the material properly and correctly. As we know, mathematics is a science that is closely related to everyday life. But, according to Shadiq (2008, as cited in

Imran et al., 2019), mathematics itself in real life is considered difficult by some students because it is only related to numbers, memorizing, and so on. According to Efrida et al. (2012), one approach that is considered good can help improve students' understanding of mathematical concepts is the Indonesian realistic mathematics education approach (PMRI).

The Indonesian Realistic Mathematics Education Approach (PMRI) or RME is a school mathematics learning method based on the application of mathematics in everyday life (Ningsih, 2014). Learning mathematics with the PMRI method is an effort to develop students' mastery of mathematical reasoning (Widayanti, 2010). Therefore, teachers need to relate the material they teach to real problems so that students can understand it easily. It is expected that by using PMRI-based learning tools, the material obtained after learning can be combined well because the problems faced are not far from real problems. One of the materials that can relate to real problems is sequences and series.

Sequences and series teaching materials are some of the materials that require many solutions so that solving a particular problem requires high problem-solving skills. However, in classroom learning, students often face difficulties in understanding sequences and series materials. In some cases, in the process of symbolizing known data, determining formulas, and problems are solved incorrectly. In addition, according to Widyatari (2017), the reason why students make mistakes in understanding the sequences and series materials are that they are not accustomed to writing down what they know about the problem and what is asked in the question, they neglect to remember the formulas in the series of materials, and lack practice in dealing with essay questions, and not rechecking the answers. This is supported

by Yulianingsih & Dwinata (2018, as cited in Septiahani et al., 2020) stating that the sequence of errors that continue to occur is due to the ability of students to understand the material for sequences and series is still not optimal.

Based on the experience of the researcher during the Field Experience Practice (PPL), the existing teaching materials are less attractive because they contain a summary of the material, and practice questions that are complex, and less contextual in nature so that students are reluctant to read them and there are still many educators who use conventional methods so that students tend to have difficulty to understand the sequences and series material, especially during a pandemic like now when students have to study independently. This is also supported by the research results of Hidayat et al. (2020) which stated that students are not quite ready to study online, the reason is due to study habits and less supportive technology.

Therefore, to minimize the problems that exist, the use of teaching materials needs to be done, in order to create more interesting and effective learning. The teaching materials developed in this research are in the form of digital teaching materials in the form of e-modules or electronic modules. According to Satriawati (2015), the use of e-modules to support learning must be done, because it can be used independently, and can solve the problem of limited school time, which can help teachers and students master teaching materials.

The e-module itself is the development of the module. According to Abidin & Walida (2017), modules are learning media that include materials, methods, learning activities, and practice questions to achieve the expected basic competencies. Meanwhile, according to Suarsana (2013), e-module is interactive technology-based content that allows you to view text, images, audio, and video. This

interactive media is defined as media that combines visual, audio, audiovisual, text, and video media. The development of e-teaching materials is intended to help and facilitate students to learn independently and can be used anywhere and anytime.

Research and development of digital teaching materials in the form of e-module has previously been carried out by Lilis et al. (2019). This research aims to develop digital module teaching materials using the Kvisoft Flipbook Maker application. This research used the 4D method, the final product of digital module teaching materials is packaged in the form of a CD (Compact Disk) and operated on a PC or Laptop. The quality of digital module teaching materials is based on the validation assessment of material experts, media experts, small group trial results, and large group trial results. However, there are some shortcomings in the digital modules that have been developed in this research, including, the process of developing digital teaching materials which further needs to be improved with more interesting animations and videos, and the final digital module product can be converted to a mobile learning application so that it can also be accessed via a smartphone and is not limited to a PC/Laptop only. Furthermore, research and development of e-module were also carried out by Wulansari et al. (2018) The result of the research is that the developed e-module is more attractive, more efficient, and more effective than the modules used previously.

Based on the description above, this research was conducted with the expectation of helping teaching and learning activities to be more effective by being able to be studied anywhere because it can be accessed via a smartphone, with the aim of producing PMRI-based e-modules on sequences and series materials that are valid, practical, and have potential effects.

METHOD

This research was conducted at SMA Negeri 11 Palembang, which used 23 students. In this research, the model used by the researchers is the ADDIE model developed by Dick and Carry in 1996. At the analysis stage, there are several things that are carried out, namely analysis of the needs of class XI students to determine the cognitive development of students in learning mathematics, software, and materials to be used. Analysis of the mathematics curriculum of SMAN 11 Palembang on sequences and series materials including KD and IPK according to the 2013 curriculum.

Design Stage: started by making the initial design at this stage in the form of compiling a product framework, planning material presentation systems, and designing instruments in accordance with predetermined KI and KD.

Development Stage: this development stage is related to product manufacture, validation, and revision so that the product developed is worthy of being tested on students.

Implementation Stage: after the product is developed, then the product is applied in learning to determine the practicality and effectiveness of using the product that has been developed by providing student response questionnaires and test questions.

Evaluation Stage: evaluation is a process carried out to provide value to the product made. Evaluation is done by formative evaluation, namely giving test questions at the end of the lesson. The results of the revision are used to provide feedback on the products produced, then revised according to the results of the evaluation.

RESULTS AND DISCUSSION

At this stage, the needs analysis of class XI students at SMA N 11 Palembang is carried out in the form of analyzing the syllabus, determining the material and

software to be used. In determining the material, the researchers obtained information that students lacked understanding of the sequences and series material seen from the low average daily test scores on the sequence and series material, and learning is still lacking in relating the material being taught with a real context. Even though as it is currently known, problems in sequences and series are often found in everyday life. This is in line with the opinion of Yulianingsih & Dwinata (2018, as cited in Septiahani et al., 2020) which stated that the sequence of errors that continue to occur is due to the ability of students to understand sequences and series material is still not optimal. Furthermore, a curriculum analyst is conducted where researchers need to know what curriculum is used at SMA Negeri 11 Palembang. The curriculum in question is the 2013 curriculum. Then the researchers determine the core competencies, basic competencies, indicators of competency achievement, and learning objectives according to the material used.

a) Core Competencies

Understanding and applying knowledge (real, conceptual, and procedural) based on their curiosity about culture related to science and technology.

b) Basic Competencies

- 1) Generalizing the pattern of numbers and sums on geometric sequences and series.
- 2) Using arithmetic or geometric sequences and series patterns to present and solve contextual problems.

c) Indicator

- 1) Find the pattern of the number sequence.
- 2) Determine the n th term and the sum of the first n terms of arithmetic & geometric sequences and series.

- 3) Solving contextual problems using the concept of sequences and series, in accordance with the PMRI approach where at the beginning of learning students are given contextual problems that are expected to be in accordance with the 2013 curriculum, namely to find and build new concepts, ideas, and values (Sari, 2017). The results of the curriculum analysis research are in accordance with the learning objectives, this is in accordance with the research results of Fajri et al. (2021) that teachers should provide questions that can train and show problem-solving skills.

d) Learning Objectives

- 1) Discover the concepts and patterns of sequences through authentic problem-solving.
- 2) Collaborate to solve actual problems with socio-cultural interaction patterns.
- 3) Higher-order thinking (critical thinking, creative) in investigating and applying concepts and patterns of sequences in solving authentic problems.

First, the researchers look for and collect several references that will be used as relevant sources for developing e-module according to the material used. Researchers also collect images from various sources such as books, research journals, and the internet, and make their own images to compose and complete the e-module. The image is used to clarify the description of the material in the e-module so that it looks interesting and makes it easier for students to understand it.

The second, making storyboards that outline the contents of e-module in general, including PMRI-based designs and materials. This storyboard is used to focus concentration and attract students' attention.

Table 1. E-Module Storyboard Display

E-Module Section	Display
Front cover	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">E-module Title</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Logo</div> </div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px; text-align: center;">Material Title</div> <div style="display: flex; justify-content: space-around; align-items: center; margin: 5px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Author Identity</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Target User</div> </div>
Introduction	<div style="display: flex; justify-content: space-around; align-items: center; margin: 5px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">E-module Identity</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Preface</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Table of Contents</div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin: 5px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Introduction</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Concept Maps</div> </div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px; text-align: center;">PMRI Characteristics</div>
Material	<div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px; text-align: center;">Knowledge</div> <div style="display: flex; justify-content: space-around; align-items: center; margin: 5px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px; text-align: center;">Sequence and Series</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px; text-align: center;">Examples of Cases in Daily Life</div> </div>
Closing	<div style="display: flex; justify-content: space-around; align-items: center; margin: 5px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Test Questions</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">References</div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin: 5px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Conclusion</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px;">Answer Key</div> </div>
Back Cover	<div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px; text-align: center;">E-module Title</div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; margin: 5px; text-align: center;">Researcher's Brief Identity</div>

The format or storyboard of the module above is in accordance with the theory of (Rahdiyanta, 2016) where the parts of the module usually consist of a cover page, a Francis page, an introduction, a table of contents, an introduction, learning, evaluation, closing.

The third, the preparation of product assessment instruments by media experts, material experts, mathematics teachers, student response questionnaires, and test questions. This

arrangement is adapted to the e-module which was developed to suit the standard needs of students.

Development

This stage is the process of making e-modules based on the storyboard that has been made and previously designed. Preparation of e-module using Microsoft Word which is then saved in PDF form. Furthermore, it was developed with the Flip Builder app. The result of this e-module is in HTML form so it will be easier

to use. From this development stage, the first product/prototype will be produced as below.



Figure 1. Front Cover Display of E-module

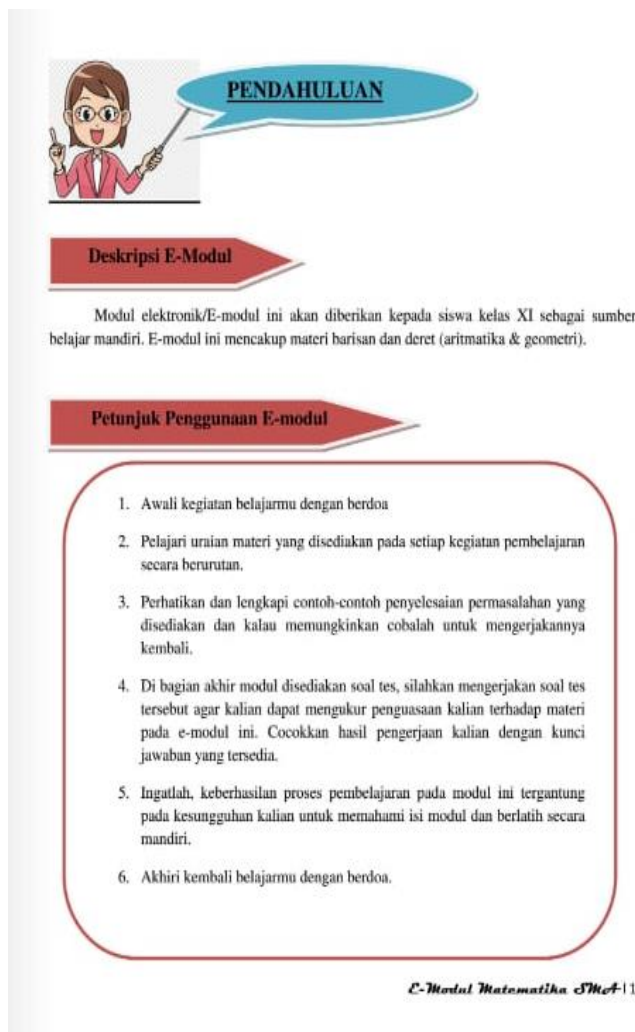


Figure 2. Introductory Display of E-module

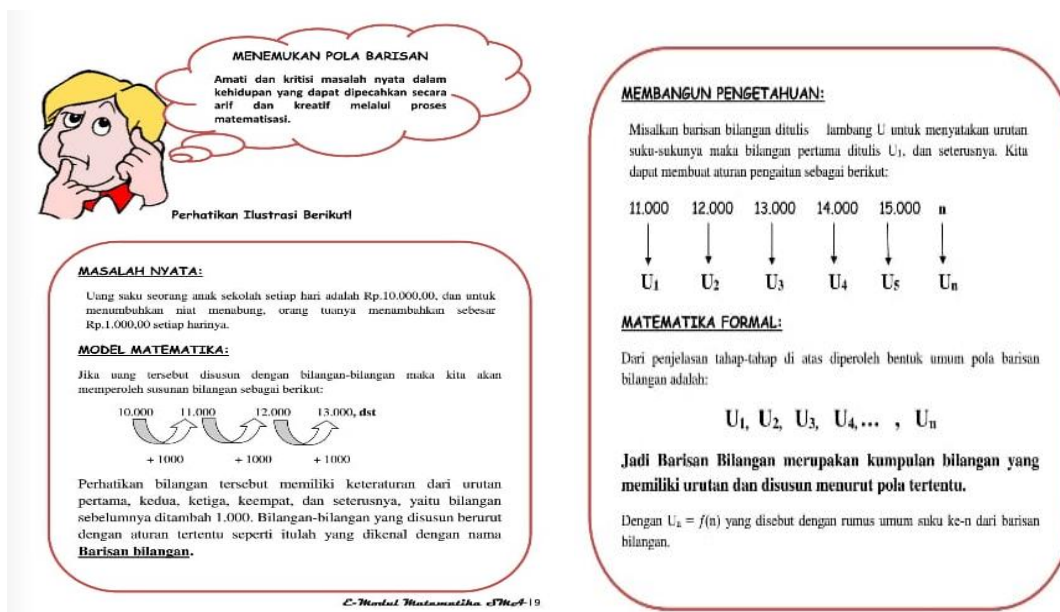
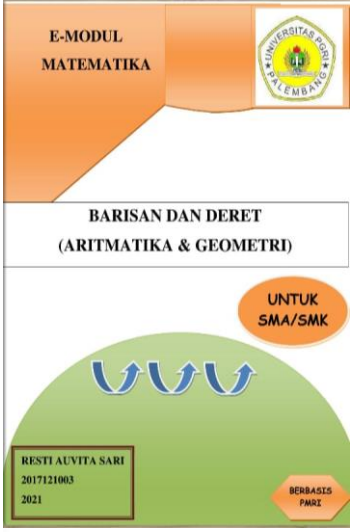



Figure 3. Display of E-module Material with PMRI Context

Table 3. Comments and Suggestions by Validator

Prototype 1	Prototype 1 Revision	Information
 <p data-bbox="277 882 628 1330"> Karakteristik PMRI Mengahami Konteks Di awal pembelajaran, guru mengajukan pertanyaan realistik dan kemudian meminta siswa untuk menyelesaikannya. Menggunakan perpektifnya sendiri Guru meminta siswa untuk menggunakan perpektifnya sendiri untuk menjelaskan atau mendeskripsikan masalah yang mereka hadapi. Membangun dan memfiksikan penyelesaian Harapannya siswa memiliki keberanian untuk mengungkapkan pendapatnya atau hasil diskusi di depan kelas. Mengaitkan penyelesaian masalah Setelah terjadi diskusi kelas, guru mengaitkan siswa untuk menarik kesimpulan tentang materi yang telah dipelajari. </p>	 <p data-bbox="671 882 1102 1330"> Untuk mengetahui lebih lanjut mengenai PMRI silahkan klik link beberapa referensi jurnal mengenai PMRI dibawah ini: https://repository.unsri.ac.id/6338/ https://jurnal.uin-antasari.ac.id/index.php/jm/article/view/97 https://jurnal.uin-antasari.ac.id/index.php/jm/article/view/97 http://repository.uinp.ac.id/72323/3/BAB%201_SUKMAWATI%20RAHAYU_POSTD%2712.pdf https://jurnal.albidayah.id/index.php/hometaricle/view/10 </p>	<p data-bbox="1134 331 1422 434">Change the cover with the sequence and series patterns symbol.</p> <p data-bbox="1134 860 1422 927">Added an explanation link about PMRI.</p>
<p data-bbox="277 1330 639 1375">No answer key</p>	<p data-bbox="671 1352 767 1397">Kunci Jawaban:</p> <ol data-bbox="687 1420 1070 1733" style="list-style-type: none"> Jadi besarnya uang Amel pada bulan ke-n adalah $U_n = 50.000n + 50.000$ Jadi jumlah jeruk yang telah dipetik selama 10 hari pertama adalah 1.875 buah Ini berarti 21 bulan kemudian terhitung dari bulan januari 2019, populasi sapi di kota A akan menjadi 3 kali populasi sapi di kota B. Jumlah populasi sapi di kota A adalah $A_{21} = 1.600 + (21 - 1) \cdot 25 = 2.100$ Jadi, telur yang ia kumpulkan pada hari terakhir sebanyak 1.250 butir. Jadi, anak ke-3 mendapat uang sebesar Rp.40.000,00. 	<p data-bbox="1134 1330 1422 1397">Added an answer key at the end of the e-module.</p>

The material in the e-module is associated with problems that exist in everyday life so that students can more easily understand the problems given, this is in line with the opinion of Misdalina et

al. (2013) which stated that one of the characteristics of PMRI is using contextual problems so that the existing problems are real and can be imagined by students. Furthermore, according to (Sari, 2017),

The PMRI approach is expected to be in accordance with the 2013 curriculum, namely to find and build concepts, ideas and discover new things. In this case, students will have the opportunity to rediscover mathematical thoughts or concepts based on their experiences in real life.

After the product has been developed, further validation of the product in the form of the first prototype is carried out by experts consisting of 2

lecturers and 1 mathematics teacher. Then improvements were made according to comments and suggestions from media experts, material experts, and teachers. The following are some suggestions and comments obtained: 1) Change the cover with the sequences and series patterns symbol. 2) Added an explanation link about PMRI. 3) Added an answer key at the end of the e-module.

The results of the expert validation assessment can be seen in Table 4.

Table 4. Expert Validation Results

No.	Indicator	Validator			Score
		1	2	3	
1	Learning materials according to the syllabus	4	4	5	13
2	The material on the e-module is in accordance with the material indicators	4	4	4	12
3	E-module contains learning objectives	5	4	4	13
4	Material truth	4	4	4	12
5	Compatibility of e-module with PMRI approach	4	4	4	12
6	Learning steps according to the PMRI approach	4	4	4	12
7	Clear working instructions	5	4	4	13
8	Practice questions according to indicators	5	4	4	13
9	Illustrations of e-modules can clarify concepts and are easy to understand	5	4	4	13
10	Presentation of e-modules can attract students' attention	5	4	4	13
11	E-module display	5	4	4	13
12	E-module cover design	4	4	4	12
13	Image in e-module	5	4	4	13
14	Video in e-module	5	4	4	13
15	Coherence of order between pages	5	4	4	13
16	Color emphasis on each page	5	4	4	13
17	The images used are interesting	4	4	4	13
18	The emphasis of writing on each page	5	4	4	13
19	Letter shape is clear	5	4	4	13
20	Language accuracy	4	4	4	12
21	The sentences used are easy to understand	4	4	5	13
22	Language compatibility with improved spelling	4	4	4	12
23	Sentences used are communicative	5	4	4	13
24	The sentence used does not cause double interpretation	5	5	4	14
25	Ease of students in understanding the language used	5	4	4	14
26	Sentence accuracy	5	5	5	15
Total		120	106	107	333
Average Score Percentage					85%

Based on the calculation of the above equation, the average value of the entire validation questionnaire is 85% and is included in the **very valid** criteria so that the developed e-module is feasible to be tested. In line with the theory put forward by Zainul Abidin (2016) that the selection of learning media needs to be carefully

planned and determined to be used and utilized properly in order to improve the quality of learning so that the use of e-modules is in line with the expected goals. This is also supported by the results of research conducted by Andriyani & Suparman (2018) which stated that teachers and students need appropriate

teaching materials to improve their ability to understand concepts in learning.

In the previous stage, validation has been carried out and shows that the e-module has been declared valid by experts and is suitable for use so that the product is ready to be implemented according to the results of prototype 2 which is the result of prototype 1 revision. The results of this trial will be used as a reference for e-module improvement. The e-module trial will be held on June 14th, 15th, 16th, 2021 at SMA Negeri 11 Palembang. This research was applied to class XI Science 4 for practical tests and class XI Science 2 to determine the potential effects of e-module accompanied by a mathematics teacher, Mrs. Linda Yuliati, S.Pd. Before continuing the e-module trial, the researcher prepared everything needed during the online learning process using the WhatsApp and Zoom applications.

1) Small-Scale Product Trial (Small Group)

After the initial product was revised, the product was then tested on a small-scale group. In the small group trial phase, 6 students of class XI Science 4 were sampled online via the Zoom applications. Furthermore, students are directed to open and study the e-module via the link shared on the WhatsApp group. The researchers invited students to conclude the material that has been studied and before the lesson ends students were directed to fill out a practical questionnaire for student responses by sharing a google form link in the WhatsApp group. The results of the e-module practicality assessment based on student response questionnaires can be seen in the Table 5.

Table 5. Student Response Questionnaire Assessment

No.	Rated aspect	Average Score	Criteria
1	Happiness	86%	Very Practical
2	Curiosity	90%	Very Practical
3	Activity	86%	Very Practical
4	Attention	88%	Very Practical
5	Interest	86%	Very Practical
Total Average Score		87%	Very Practical

From the results of the student response questionnaire, an average score of 87% is obtained, the criteria are **very practical**. So that e-modules are in line with the opinion according to Affandi et al. (2020) which stated that integrating learning media in teaching and learning activities makes students unsaturated and easier to understand the material. This is supported by the theory of Wiratmojo & Sasonohardjo (2002, as cited in Falahudin, 2014) that the use of learning media in teaching and learning activities will greatly help the effectiveness of the learning process and delivery of material. In other words, it can be concluded that the PMRI-based e-module can be used

properly as a learning medium and is suitable for use in teaching and learning activities.

2) Large-Scale Trial

Furthermore, the product was tested on a large-scale group. At this stage, large-scale group trials were conducted to measure the level of potential product effects of the student learning outcomes test. This trial was conducted in class XI Science 2 which was attended by 16 students online via Zoom application. The results of the assessment of the potential effects of e-module based on the results of student learning tests are as follows.

Table 6. Student Learning Test Results

No.	Name	Question Number					Total	Final Score	K
		1	2	3	4	5			
	Total Score	4	4	4	4	4	20		
1	AD	3	3	3	3	3	15	75	T
2	CA	4	4	3	3	3	17	85	T
3	DA	4	4	4	4	4	20	100	T
4	DZ	4	4	4	4	4	20	100	T
5	FM	4	4	4	4	4	20	100	T
6	FAW	4	4	4	4	4	20	100	T
7	FNS	3	3	4	4	4	18	90	T
8	IA	4	4	4	4	4	20	100	T
9	MEP	4	4	4	4	3	19	95	T
10	MT	2	2	2	2	0	8	40	TT
11	NM	4	3	2	2	4	11	55	TT
12	NA	4	4	4	4	4	20	100	T
13	RR	4	4	4	4	4	20	100	T
14	RM	4	3	3	3	3	16	80	T
15	SD	4	4	4	4	4	20	100	T
16	SA	4	4	4	4	4	20	100	T
17	ZA	4	4	4	4	4	20	100	T
Number of students who completed									15

Remark:

T = Completeness

TT = Incompleteness

K =

$$\frac{\text{The number of students who completed}}{\text{The number of students who took the test}} \times 100\%$$

$$= \frac{15}{17} \times 100\%$$

$$= 88\%$$

Based on the learning outcomes test, the percentage of students' completeness reached 88% so that the criteria were **very high**. Based on the data obtained, it shows that the developed e-module has a potential effect on learning. This is in accordance with the theory put forward by Laili (2019) which stated that e-modules can improve students' critical thinking skills, obtain positive responses from students and provide a high percentage of improvement. This is also in line with the research and development of e-modules previously carried out by Buchori & Rahmawati (2017) which stated that student learning outcomes using e-modules with the PMRI approach were better than those not using e-modules. That is, e-modules with the PMRI approach on sequence and series material

have a good potential effect for use in learning.

This last stage is the stage of evaluating the e-module that has been developed based on student response questionnaire sheets and student learning outcomes tests obtained from the previous stage, namely the implementation stage. The results of the evaluation are:

1) Analysis and practicality

Based on the results of the student response questionnaire, an average score of 87% is obtained based on the score guidelines in the practicality criteria table, the criteria are **very practical**.

2) Analysis and potential effects

Based on the learning outcomes test, the percentage of students' completeness reached 88%. Based on the guidelines for assessing the potential effect criteria table, the criteria obtained are **very high**.

CONCLUSIONS AND SUGGESTIONS

Based on the results of data analysis, discussion, and the results of the development of e-module media with the

ADDIE model on the sequences and series material, it can be concluded that the PMRI-based e-module product with the ADDIE model has been validated by experts, namely: (1) media expert validation obtained the percentage value of 92% and is included in the very valid criteria; (2) the validation of the material expert got a percentage value of 81% with very valid criteria; (3) the validation of the mathematics teacher got a percentage value of 82% with very valid criteria. The PMRI-based e-module product has also gone through a practicality test and received a percentage value of 87% with very practical criteria. Based on large group trials to see the potential effects of e-modules, the percentage of assessment is 88% with very high criteria.

Based on the research achievements obtained, the researchers give some suggestions as follows: For schools, it can be used as a new variation for teaching materials to improve the quality of teaching and learning; It is expected that teachers should use e-module in the learning process so that they can be used wherever and whenever they want to learn. Considering that currently learning is done online so that the use of e-module will greatly assist students in learning; For the next researcher, in order to better modify the e-module with different materials and methods, and the development of this e-module is made as modern as possible.

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