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E-Modules with Realistic Mathematics Education (PMR) Approach to Improve Students' Mathematical Problem Solving Skills

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Abstract: This study aims to develop e-modules of mathematics learning with Realistic Mathematics Education (PMR) approach to improve students' concept understanding and problem solving skills on the material of rows and series. The method used includes making a framework, preparing e-modules, and evaluating products based on suggestions from validators and students. The development results show that this e-module consists of various important components such as concept maps, instructions for use, and activity sheets designed to facilitate active learning. The evaluation shows that the use of e-modules can increase students' motivation and understanding of mathematics materials, as well as help them in applying mathematical concepts in the context of daily life. This research emphasizes the importance of innovation in mathematics learning to create a more meaningful and effective learning experience for students.

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Introduction

To survive in an ever-changing environment and compete in society, students must be able to adapt to rapid developments in technology and information. In accordance with Permendikbud No. 21 of 2016, which sets the educational content standards for primary and secondary education units, "Mathematics is a basic science that underlies the development of other sciences." In addition, each core competency and basic competency in mathematics must involve the application of mathematics using realistic problems and their interrelationships. (Widyastuti and Pujiastuti, 2014). And "Mathematics has an important role in people's lives and technological development" (NCTM, 2000). Which means that mathematics is a basic science that is very important for students to master so that in line with good mastery of mathematics it is hoped that students can also master other science specifications well.

To master math materials well, an effective process is necessary. This is one way to achieve learning objectives during the learning process. "Forming students' reasoning skills that are measurable in critical thinking, logical thinking, creativity, innovation, problem

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solving, being objective both in the field of mathematics itself or other fields in everyday life" is the general goal of learning mathematics. (Widyastuti and Pujiastuti, 2014). However, "the learning process in mathematics is still dominated by conventional learning methods and without using media. This creates a passive learning situation for students, resulting in low student understanding." (Febriyanto, *et. al*, 2018).

The objectives of learning mathematics include so that students understand mathematical concepts, explain the relationship between concepts, apply concepts flexibly, accurately, efficiently, and precisely, use reasoning in patterns and properties, perform mathematical manipulations in making generalizations, compiling evidence, or explaining mathematical ideas and statements, solve problems that include the ability to understand problems, design mathematical models, solve models and interpret the solutions obtained, and communicate ideas with symbols, tables, diagrams or other media to clarify the situation or problem. And "Given the important role of mathematics, there is an expectation that the understanding of mathematical concepts in students can be improved" (Achmad, Eka and Henry, 2018). Increasing the understanding of mathematical concepts certainly needs a strategy from stakeholders in learning activities.

The prominent feature of mathematics learning is that the concepts are interrelated, meaning that in order to master a new concept, students must understand the concepts of the previous concept, as well as the concepts learned today are related to mathematical concepts in subsequent learning. For example, in Mathematics the material of Rows and series and studied in Class X semester 2. This material is related to the previous material, namely functions. The importance of understanding concepts in this material is because the concepts in the Rows and series material are related to solving problems in other lessons, for example in physics, chemistry, or problems that arise related to contextual problems. Learning math for students is the formation of a mindset of understanding and reasoning in a problem.

The importance of problem solving skills in students, especially in mathematics, can be seen in Branca's statement in Nurfatanah et al, (2018) which states that (1) problem solving ability is a common goal of mathematics learning; (2) problem solving includes methods, procedures, and strategies which are core and main processes in the mathematics curriculum; (3) problem solving is a basic ability in learning mathematics. In addition, Russefendi in Sumartini, (2016) said that problem solving skills are very important in mathematics, not only for those who in the future will explore or study mathematics, but also for those who will apply it in other fields of study and in everyday life.

According to Apriani (2018) factors that can provide an increase in mathematical problem solving skills, including: 1) Investigating the problem, 2) Choosing a way, 3) A comprehensive view, 4) Confidence in learning, 5) effective student traits, including thoroughness, optimism, unyielding spirit, 6) Practice problems that require problem solving. Other factors that affect problem solving ability can be in the form of students' prior knowledge, students' logical intelligence (Irawan, Suharta & Suparta, 2016). According to Suherman in Nurfatanah et al, (2018) problem solving indicators include: observing, identifying, understanding, planning, guessing, analyzing, trying, interpreting, finding, generalizing and revisiting.

Based on data on the scores of class X specialization mathematics tests on the material of even semester rows and series of SMA Negeri 7 Bandar Lampung in the 2021/2022 academic year, where the test questions presented consist of 5 test questions consisting of 3, namely questions number 1, 2 and 3 questions regarding the concept of rows

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and series while 2 questions, namely numbers 4 and 5 questions regarding problem solving for the application of rows and series to everyday life.

From the results of student tests that are complete or have reached the KKM, it is known that students who have completed or scored ≥ 76 are only 11 out of 36 students in class X.4, which means that only 30.6% of students have completed the learning process. From these results it can also be seen that only student number 4 and student number 28 are really able to solve problems number 4 and number 5 about problem solving from the application of rows and series to everyday life. While students who have not reached the KKM. From the analysis of the daily test, there are 25 students who have not reached the score of 70, and it is also seen that students have not been able to solve or solve the problems presented in the problem regarding the application of rows and series to everyday life in problem number 4 and number 5. The low problem solving ability of students is suspected because students have not obtained many examples of contextual problems of everyday life in the material of Rows and series.

One of the efforts to overcome the low problem solving ability of students in learning, namely by habituating students in solving mathematical problems related to contextual problems, is through improving learning with an approach that allows achieving better student mathematics learning outcomes, an approach that can be used is the realistic mathematics education (PMR) approach (Khotimah and As'ad, 2020). From Realistic mathematics learning (PMR) is a learning approach oriented to the real world, correlating learning to the population that can be imagined by students in PMR, the process of developing mathematical concepts and ideas starts from the real world (Sonda, 2016). So that by using the Realistic Mathematics Education approach, it is hoped that students will solve math problems and participate in learning activities better.

According to the researcher's observations of students and consultations with other mathematics teachers who both teach class X, it turns out that the material of Rows and series is one of the mathematics materials considered difficult, especially those related to contextual problems in everyday life (story problems) or those related to other subjects. Whereas in the module that has been used, there is very little presentation of material related to contextual problems in daily life (story problems) or related to other subjects. As a result, sometimes students are constrained in understanding the problem and mapping the problem into mathematical form, so that to do this they only rely on explanations from the teacher.

In this situation, teachers need to make changes or innovations to realize a student-centered mathematics learning and increase student activity in understanding mathematics, teachers must be able to prepare, design and develop mathematics learning, so that the learning process that occurs in the classroom is more meaningful. Innovation is not always done with a new concept, because basically what is already there can be extraordinary if it is packaged in a matter of novelty and the right media according to the developmental capabilities of the 21st century.

A good learning media is of course one that follows the development of students' mindset and advances in technological mastery. Thus, a learning tool is needed that is very instrumental in increasing student activities and activities to understand concepts and students can also use technology that is currently developing so that students are more motivated to learn and can make it easier for students to understand the material being studied. From these considerations, the researchers will revise and develop existing modules into e-modules. The e-module developed is expected to make students active, interested, and most importantly

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students can master the material and can apply it in contextual problems so that learning indicators can be achieved.

Karwono, (2023) suggests that learning media is anything in the form of people, materials, equipment or activities used to channel messages that can stimulate the thoughts, feelings, attention and willingness of students so that it can encourage the learning process. Febrita, (2019) added that learning media is anything that can be used to channel messages (learning materials) so that it can stimulate students' attention, interest, thoughts, and feelings in learning activities to achieve learning goals.

E-modules can facilitate independent or group learning students, E-modules are equipped with instructions for self-study, so that students can learn according to their abilities and can meet the competencies that must be mastered by students. Through e-modules the learning process will be more interesting, interactive to be able to convey learning meters. From the exposure of the attached data, it is necessary to develop an e-module with a realistic mathematics approach (PMR) that is appropriate to help students master mathematics material and apply it to solve contextual problems or those related to other lessons, especially in the material of Rows and series. And before being implemented the e-module product will be tested to verify the feasibility and effectiveness of the e-module so that it can be used. This study aims to analyze the feasibility and effectiveness of e-module teaching materials based on realistic mathematics education.

Research Methods

This study is a research and development study using the ADDIE approach (Analysis, Design, Development, Implementation, Evaluation). This study involved 70 Respondents of SMAN 7 Bandar Lampung Students, Data feasibility analysis researchers involved material experts, media experts, design experts, and language experts, Data analysis techniques researchers use tests by looking at pretest and posttest results using the N-Gain formula.

Research Results And Discussion

Research Results

The development of e-modules with realistic mathematics education (PMR) approach is based on students' low mathematics learning problem solving ability. Meanwhile, the purpose of developing e-modules with the PMR approach is to improve the quality of mathematics learning and students' mathematical problem solving skills through learning e-modules. E-modules are designed to help students understand mathematical concepts deeply through real contexts that are relevant to everyday life. The research was conducted by referring to the ADDIE approach, which is as follows.

Phase I Analysis

At the initial analysis stage, research begins with a potential or problem. Potential is anything that when utilized will have added value. A problem is a deviation between what is expected and the reality that occurs. The first step is to conduct research to generate information. The potential and problems obtained in this research and development are From the data, students who have completed or scored ≥ 76 are only 11 out of 36 students in class X IPA1, which means that only 30.6% of students have completed the learning of row and sequence material. From these results it can also be seen that only 2 people, namely student number 4 and student number 28, were really able to solve questions number 4 and number 5

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about the application of rows and series to everyday life. Based on the data obtained, an effective handling model can be designed.

Phase II Design

Based on the results of the needs analysis, the next step is for researchers to design the product to be developed. The final result of this activity is a new product design complete with specifications. This design is still hypothetical, because its effectiveness has not been proven and will be known after going through tests. The media design developed by researchers is carried out in several stages, namely:

a. Conducting interviews with grade X students and grade X mathematics teachers of SMA N 7 Bandar Lampung, to analyze needs so that they can determine what products will be developed so that learning objectives can be achieved.
b. b. Determine the type of media development that is appropriate for the row and sequence material. This is done so that the messages and materials contained in the following IPK (competency achievement indicators) demands on Product Development.

Table 1: Indicators of Competency Achievement

IPK	Problem Indicator	Question Number
3.6 Generalize number and sum patterns in Arithmetic sequence		
3.6.1 Analyze the concept of number patterns	Presented with problems using the PMR approach, students are expected to be able to analyze the concept of number patterns.	1,2
3.6.2 Analyze the concept of arithmetic series and sequence	Presented problems using the PMR approach, students are expected to be able to analyze problems with the concept of arithmetic sequence.	3,4,5

c. Making products that are in accordance with the predetermined material. Making this media is intended to make it easier for teachers to deliver material and students to more easily understand the material in the product. Activities carried out include:
    1) Creating a framework for the preparation of e-modules with the Realistic Mathematics Education (PMR) approach;
    2) Preparation of e-modules with Realistic Mathematics Education (PMR) approach;
    3) 3) Determine the layout of the e-module;
    4) Determining reference books related to class X arithmetic ranks and series material; and
    5) Develop an assessment instrument that is used to assess the e-module that has been developed.

The results of the initial draft development stage on e-module learning resources are as follows:

a. Title of e-module: e-module for learning math rows and series Phase E
b. The e-module consists of: Cover/Title page, concept map, instructions for using the module, learning activities for each meeting containing learning objectives, materials, learning activity sheets, student exercise sheets, answer keys, bibliography.

Here is how the e-module cover looks like

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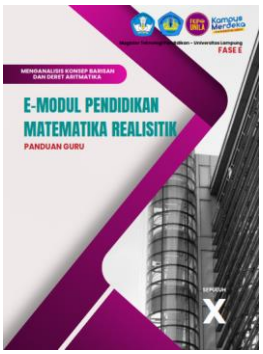

Figure 1 E-module

Phase III Development

The e-module development stage with a realistic mathematics education (pmr) approach to improve students' mathematical problem solving skills is carried out in accordance with the development research design, at this stage of development, it is carried out to determine the validity of the product that has been developed, then tested on material experts, media experts, design experts, linguists and small groups conducted to 5 students of SMAN 7 Bandar Lampung. The results of the feasibility of the development product, as follows:

The results of the product feasibility assessment were assessed by experts who have qualifications in product assessment, the feasibility test was assessed by material experts, media experts, design experts, language experts and practitioners. The recapitulation results of the product development feasibility assessment are as follows:

Table 2 Recapitulation of Product Assessment

No	Expert	Results	Average	Qualificationsi	Eligibility Criteria
1	Material Expert	88	4,4	Very Valid	No Revision
2	Media Expert	89	4,45	Very Valid	No Revision
3	Design Expert	86,5	4,3	Very Valid	No Revision
4	Linguist	90	4,5	Very Valid	No Revision
5	Practitioner	88	4,4	Very Valid	No Revision
Grand Total				**88,3**	
Average				**4,41**	
Qualification				**Very Valid**	
Eligibility Criteria				**No Revision**	

Source: Excel processed data

Based on the data above, it is known that the eligibility criteria for E-Module Development with a Realistic Mathematics Education Approach (PMR) to Improve Students' Mathematical Problem Solving Ability obtained a result of 88.3% with the eligibility criteria not revised. This means that the development of E-Modules with a Realistic Mathematics Education Approach (PMR) to Improve Students' Mathematical Problem Solving Ability gets significant feasibility with a result of 88.3% indicating that product development is very valid for implementation in the field.

Phase IV Implementation

Implementation is an activity of using the product. This stage is the stage of application or implementation of the results of products that have been developed and

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declared valid. After the product has been declared valid, then the product is implemented to class X students (Phase F) in mathematics subjects, and after the implementation is carried out, students carry out activities to work on questions to find out students' responses to the products that have been developed.

The implementation stage carried out by researchers involved 36 students. Learning planning is carried out by conducting four meetings The results of the development effectiveness analysis are as follows:

The pretest and posttest results show the implementation of PMR-based e-module development conducted at SMA Negeri 7 Bandar Lampung, involving 70 respondents as research samples. The results of the implementation itself in the initial test (pretest) found 17 students (24.29%) completed, while 53 respondents (75.71%) students did not complete when the researcher had not used PMR-based e-modules. In the final stage of development, researchers conducted a final test (posttest) found 61 respondents (87.14%) Students reached the minimum completeness criteria (complete), while 9 students (12.86%) were not complete. It can be concluded as follows:

Table 3 Recapitulation of Final Score

No	Description	Pretest	Posttest	Total	Percentage
1	Completed	17	61	44	62,86
2	Not Completed	53	9	44	62,86

Source: data processed using Excel

Based on the development implementation table, there are significant changes in the implementation of PMR e-module development in SMA Negeri 7 Bandar Lampung, with a percentage of 62.86% indicating that students experience changes in arithmetic learning outcomes.

Stage V Evaluation

Evaluation is an activity to assess whether each step of the activity and the product that has been made is appropriate or not. This stage is carried out to assess the quality of the product that has been developed evaluated, also based on the suggestions of validators and students in the implementation stage.

Discussion

Constructivism learning theory is a theory that gives freedom to humans who want to learn or seek needs with the ability to find their wants or needs with the help of other people's facilities. So this theory provides activeness to humans to learn to find their own competencies, knowledge, technology and other things needed to develop themselves.

In the content standards in Permendiknas No. 22 of 2006, it is stated that the ability to solve mathematical problems includes the ability to understand problems, design mathematical models, solve models, and interpret the solutions obtained is one of the objectives of mathematics. According to Soejadi in Fadillah, (2009) mathematical problem solving ability is a skill in students to be able to use mathematical activities to solve problems in mathematics, problems in other sciences, and problems in everyday life. Grouws in Nuralam (2009) states that problems in mathematics are everything that requires to be done. The word "everything" can indicate a question that requires a solution. A math problem is a question whose solution contains mathematical ideas or concepts and without using a routine algorithm.

The development of e-modules based on PMR (Realistic Mathematics Learning) at SMA Negeri 7 Bandar Lampung is an innovative step in improving the quality of

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mathematics learning. The purpose of developing E-modules is to improve students' understanding of mathematical concepts through the PMR approach. This goal includes learning that is more concrete, relevant to everyday life, and motivates students to think critically and creatively in solving problems. The e-module development process involves collaboration between math teachers, information technology experts, and also students as trial users. This method may include curriculum analysis, identification of students' needs, content design in accordance with PMR principles, and testing for validation and improvement. Structure and Content E-modules are organized in a systematic structure and intuitive navigation. The e-module content includes various situations or contexts that illustrate real-life applications of mathematics, in accordance with PMR principles. Relevant case examples, challenges, and assignments are designed to encourage students to think in solving problems.

The use of technology in e-modules is collaborated with multimedia such as images, videos, animations and interactive simulations to explain mathematical concepts visually and dynamically. This e-module platform can be accessed online, both in school and outside school, to support continuous learning. Evaluation and assessment The e-modules are equipped with evaluation tools that enable objective measurement of students' learning progress. Formative and summative tests are included in the e-modules to monitor students' understanding of the mathematical concepts taught. The development of PMR-based e-modules at SMA Negeri 7 Bandar Lampung is an example of how technology can be utilized to enrich and broaden students' mathematics learning experience through an approach that is contextual and relevant to their lives.

The results of research conducted at SMA Negeri 7 Bandar Lampung, the development of e-modules with a realistic mathematics education (PMR) approach is based on students' low math learning problem solving skills. These results are known from the initial needs analysis of researchers using the research and development (R&D) method, with the ADDIE approach (Analysis, Design, Development, Implementation and Evaluation).

Product development in the form of PMR e-modules was implemented in SMA Negeri 7 Bandar Lampung, with the level of expert validation found 88.3% qualification results with a very valid qualification level and no revision. Next. The effectiveness of the development was carried out to determine the effectiveness of e-modules based on Realistic Mathematics Education implemented in the field, the implementation was carried out at SMA Negeri 7 Bandar Lampung with a sample of 70 class X respondents. The results of the implementation were carried out for 4 (four) meetings with details of meeting I researchers conducted learning using textbooks and student learning books and continued with the distribution of pretest questionnaires totaling 5 items of questions whose purpose was to determine the initial ability of students in arithmetic learning, meeting II researchers recognize and use PMR e-modules in the learning process, meeting III researchers conduct learning and evaluation, meeting IV researchers give posttest questionnaires as many as 5 items of questions as the final evaluation of the development of PMR e-modules in the learning process and learning mathematics class X SMA Negeri 7 Bandar Lampung found the results of 62.86% there is an increase in students' mathematics learning outcomes. Furthermore, the classification level shows that 38 students (54.28%) experienced an increase in learning outcomes with a high classification, while 32 respondents (45.71%) were classified as moderate.

The development of PMR-based e-modules at SMA Negeri 7 Bandar Lampung, is an innovative step to improve the quality of mathematics learning, the purpose of this

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development itself is carried out to improve students' understanding of mathematical concepts through a more concrete PMR approach. Research conducted by Damayanti, D. S., & Perdana, P. I. (2023). This development research was motivated by the absence of additional teaching materials and only using thematic books, lack of use of technology, and there are still many students with low thematic learning outcomes. The purpose of this development research is to develop thematic learning e-modules (EMOTICS) that are valid, effective, and interesting. This development research uses the ADDIE development model. The subjects of this research were fifth grade students of SDN Sumberbendo. The validity is obtained from the assessment of material experts 93.75%, linguists 87.5%, teaching material design experts 93.75%, and learning design 95%. Effectiveness is obtained from teacher activity observations with a percentage of 95%, student activity observations with a percentage of 92.26%, and classical completeness of student learning outcomes tests with a percentage of 100%. The attractiveness is obtained from the teacher response questionnaire with a percentage of 87.5% and the student response questionnaire with a percentage of 94.64%. Based on the results of the study, it can be concluded that the development of thematic learning e-module teaching materials (EMOTIK) is considered valid, effective, and interesting so that it can be used in learning.

Research by Sakinah, M., & Hakim, D. L. (2023). With the title of student responses to the use of Barsil interactive e-modules in the independence of learning mathematics, it shows that student responses to the use of Barsil interactive e-Modules based on the graphic aspect have excellent criteria with a percentage of 98.8%, the material aspect has excellent criteria with a percentage of 98.4%, the presentation aspect gets a percentage with 97.8% criteria and the language aspect gets an assessment that is excellent with a percentage of 100%. Overall, students' responses to the use of Barsil interactive e-Modules obtained an average percentage of 98.7%. The conclusion from the research results states that Barsil's interactive e-Module as an interactive teaching material gets a very good response and is suitable for use by students in learning mathematics.

The limitations of the research on the development of a realistic mathematics education (PMR) approach to improve students' mathematical problem solving skills, namely. The research was conducted only at SMA Negeri 7 Bandar Lampung, so the generalization of the research results to a wider population may be limited, The focus of the research on the development of PMR-based e-modules for grade X mathematics subjects, so the results may not be directly applicable to different contexts or levels of education. Limited resources, both in terms of technology and training for teachers and students, may be an obstacle in the widespread implementation of e-modules in various schools.

Conclusion

The development of E-Modules with a Realistic Mathematics Education (PMR) Approach to Improve Students' Mathematical problem solving Ability gets significant feasibility with a result of 88.3% indicating that product development is very valid to be implemented in the field. While the effectiveness of the PMR e-module development obtained percentage results of 45.71% or 32 students with moderate classification, while 38 students or 52.28% were high, with a ratio of 8.57%. the realistic mathematics education (PMR) approach to improve students' mathematical problem solving skills is very effective and beneficial for teachers and students in the learning and learning process, especially in SMA Negeri 7 Bandar Lampung.

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