International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 11, Issue 9
September, 2024
Pages: 380-392

Development of e-Modules Based on Realistic Mathematics Learning Oriented to Mathematical Problem Solving, Divergent Thinking Ability and Learning Interest of Junior High School Students

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http://dx.doi.org/10.18415/ijmmu.v11i9.6187

Abstract

This R&D research is motivated by the non-optimal use of mobile phones in learning, in addition to the low problem-solving ability is a problem in the building materials of flat-sided spaces, students are not used to practicing divergent thinking skills as a factor in solving problems. This research method uses the ADDIE (Analyze, Design, Development, Implementation, and Evaluation) development model. Analyze is the stage of analyzing the needs of students and materials, Design is the stage of product design and product product design, Development is the stage of e-module development which includes product validation and product revision, implementation is the stage of product application on the subject of research, evaluation. It is an improvement stage based on input during implementation. The e-module validity measurement tool uses an expert validation sheet instrument.The e-module practicality measuring tool uses a practicality questionnaire. Meanwhile, the effectiveness measurement tool uses a problem-solving ability test, a divergent thinking ability test and a student learning interest questionnaire. Based on the results of the study, the following results were obtained: 1) the e-module obtained valid criteria with a percentage value of 90% in the media aspect and 90% in the material aspect, 2) the e-module obtained practical criteria with a percentage value of 94% from teachers and 79% from students, and 3) e-module was effective on students' problem-solving skills, divergent thinking skills and learning interests. In the problem-solving ability test, the number of students who obtained scores that reached KKM was 29 students with a percentage of 88%. In the divergent thinking ability test, the number of students who obtained a score of KKM was 29 students with a percentage of 88%. Based on the results of the student learning interest questionnaire, students' learning interest after using the e-module reached very good criteria with a percentage of 82%. Based on the results of the test and the results of the learning interest questionnaire, the e-module obtained effective criteria for students' problem-solving skills, divergent thinking skills and learning interests.

Keywords: *E-module: Liveworksheet: Divergent Thinking Ability: Problem-Solving Ability: Student Learning Interest in Realistic Mathematics Learning (RME): Development*

Introduction

The 21st century is a period of global transformation that brings many changes in the world, advances in technology are one of the most visible changes in the 21st century. Education is one of the fields affected by technological developments in the 21st century. Technological developments are things that must be utilized in the world of education, the application of technology in learning is one of the efforts so that education in Indonesia can adapt to the development of the 21st century.

Cell phones are information and communication technology tools that can be used to increase knowledge. According to data obtained from the Indonesia Statistics Agency in 2021, 65.87% of Indonesia people already have a mobile phone. Based on this, the majority of Indonesia people should be able to use mobile phones to increase knowledge. However, in reality, the people of Indonesia have not been able to make good use of these mobile phones. This was informed by Kominfo through its book entitled Digital Literacy Status in 2022. Based on the book, Indonesia people use mobile phones more as a tool for social media and entertainment than to be used as a learning tool.

Mathematics learning is one of the lessons that are closely related to technology, many studies show that technology is effective to be used as a learning medium in mathematics learning. According to Juliawan et al. (2015) almost all daily tasks carried out by humans are related to mathematics, so mathematics is a topic that is directly related to human existence.

Geometry is one of the basic components of mathematics that plays an important role in everyday life. Geometric objects that are easy for us to find in our daily lives, some of which are classified as flat-sided space building objects. However, the lack of understanding of the building properties of flat-sided spaces causes us not to realize that objects in the form of flat-sided spaces are often found in everyday life. Lack of understanding of the nature of building flat-sided spaces makes students problems when solving the problem of building flat-sided spaces. This problem is in line with Awwalin's (2021) research on the analysis of grade VIII junior high school students on the building material of flat-sided spaces.

The results of Awwalin's research show that students' problem-solving skills in building materials for flat-sided spaces are still relatively low. This is also in accordance with the results of an interview conducted with one of the grade VIII mathematics teachers at SMP N 9 Yogyakarta. In the interview, the teacher explained the difficulties faced by grade VIII students of SMP N 9 Yogyakarta when asked about building a flat-sided space. Students cannot solve it when the difficulty level of the problem is higher or when facing a story problem, and students have difficulty when given the opportunity to answer the problem in their own way. Based on these problems, in addition to experiencing problems in solving problems, students also experience difficulties in divergent thinking when given the freedom to solve problems in their own way.

Divergent thinking ability according to Subali (2013) is the ability to think from one point to various directions, divergent thinking can be defined as a skill in students to elaborate their ideas.

Learning interest is also an important factor to improve problem-solving skills, because students will not learn efficiently if the subject matter studied does not interest them. Interest has a big impact on learning, students will feel lazy to learn and not get pleasure from the material if they are not interested in the material (Slameto, 2013).

The use of learning media is an important tool that can be used to improve the learning experience of students in Indonesia, because the majority of the population of Indonesia already owns and is proficient in using mobile phones

E-modules are one of the learning media that can be accessed via mobile phones. The creation of e-modules is another method to improve the teaching and learning experience and arouse students' enthusiasm for learning. According to Sidiq & Majuah (2020) the modules that we often encounter today

are modules in printed form, these modules tend to be boring and uninteresting for students, thus reducing students' interest in reading these modules. This is because print modules often lack attractive elements that can grab students' attention and stimulate their curiosity. Therefore, an electronic module was created that can be used as an interactive medium (Herawati & Muhtadi, 2018).

Liveworksheet is one of the platforms to convert modules into electronic modules (Widiyani & Pramudiyani, 2020). The use of Liveworksheet can help teachers to create worksheets that make students more involved in the learning process (Rhosyida et al., 2021).

Good material content is a factor that can increase the attractiveness of e-modules, because good material content can make learning more effective. Effective mathematics learning can be done by utilizing objects or surrounding activities related to students' life experiences. Mathematics learning by utilizing objects or surrounding activities is known as Realitstic Mathematics Education (RME). This is in accordance with the opinion of Sevinc & Lesh (2017) stating that one of the important goals of education is to improve teachers' understanding in connecting real events with mathematics.

Based on the description above, to solve problems related to mathematical problem-solving skills, divergent thinking skills, and students' learning interest in building materials for flat-sided spaces, researchers have a solution by developing realistic mathematics-based liveworksheet-assisted e-modules.

Method

This research is a type of development research, and the method used is *Reasearch and Development* (R&D). According to Gay (1990) Development research is an effort to develop an effective product for school use, not to test theories. The development model of this mathematics learning e-module uses the ADDIE development research model. The ADDIE model stands for *Analysis, Design, Development, Implementation and Evaluations* developed by Dick and Carry (2006).

Analysis

The analysis stage involves identifying learning objectives, determining the subject of research, and assessing the current state of knowledge and skills of students. This stage is crucial in establishing the basis for the entire development process, ensuring that the e-module is aligned with the needs and goals of its users. The analysis stage includes an analysis of student needs and materials.

Design

The design stage is the planning stage after conducting an analysis, where the design outlines the overall structure and organization of the e-module. This includes defining the content, lesson sequence, and interactive elements that will engage learners.

Development

At this stage, the aim is to realize or carry out the initial design results that have been analyzed and designed in the previous stage. Furthermore, the researcher developed a liveworksheet-based e-module product by presenting materials for building a flat-sided space using the RME approach.

Products that have been completed at the consultation stage will get permission to be validated by the supervisor. Then expert validation will be carried out with two criteria, namely media experts and research tools/instruments.

Implementation

The validated and revised product is then tested on subjects selected by the researcher as the research site. At this stage, teachers will use e-modules that have been created by researchers in the learning process. After implementation, improvements will be made based on suggestions and input by teachers regarding product constraints and shortcomings.

Evaluation

The products that have been implemented will then be evaluated to improve based on the results of the practicality, effectiveness, and findings in the field. The assessment of the practicality of the product is obtained based on assessments from teachers and students. The practicality assessment instrument uses a questionnaire form. In addition, improvements are made based on the results of observations during the implementation of the product in the classroom. Meanwhile, the effectiveness results were obtained based on the results of the students' mathematical problem-solving ability and divergent thinking ability tests. This evaluation stage is carried out on an ongoing basis to correct errors or inaccessibility of effective products.

This research was carried out at SMP Negeri 9 Yogyakarta, with the subject of class VIII C. The instruments used in this study include a questionnaire on the validity and practicality of the e-module. For the effectiveness of using test instruments for problem-solving skills, divergent thinking skills and student learning interest questionnaires. Data analysis on the validity and practicality of e-modules uses the formula presented by Palelupu and Cholik (2014).

$$X = \frac{F}{N \times I \times R}\%$$

Information:

X : percentage of validity/practicality of the media

F : Number of respondents' answer scores

N : 5 (Highest score of each item)

I : Number of questions

R : Number of respondents

The criteria for the validity and practicality of the e-module are based on the criteria guidelines according to Palelupu and Cholik (2014).

Table 1. Criteria for Validity and Practicality

Interval (%)	Criterion
$0\% \leq X \leq 20\%$	Very Not Good
$20\% < X \leq 40\%$	Not Good
$40\% < X \leq 60\%$	Enough
$60\% < X \leq 80\%$	Good
$80\% < X \leq 100\%$	Excellent

Based on the guidelines above, e-modules can be said to be valid/practical if they obtain a score from a validator with a percentage of > 60% or obtain a minimum of good criteria. The analysis of effectiveness data on problem-solving ability uses the following formula.

$$p = \frac{banyak\ siswa\ yang\ tuntas}{banyaknya\ siswa\ dalam\ satu\ kelas} \times 100\%$$

Information:

p : Completeness of problem-solving skills

The criteria for effectiveness in problem-solving skills according to Simatupang (2023).

Table 2. Criteria for Problem-Solving Ability

Interval (%)	Criterion
0% X<40%≤	Very Low
40% X<55%≤	Low
55% X<70%≤	Keep
70%X<85%≤	Tall
85% X<%≤ 100	Very High

Based on the following table, it can be concluded that learning media is said to be effective in problem-solving skills if the number of students who complete the problem-solving ability test is 70%. The analysis of effectiveness data on divergent thinking ability uses the following formula.

$$p = \frac{banyak\ siswa\ yang\ tuntas}{banyaknya\ siswa\ dalam\ satu\ kelas} \times 100\%$$

Information:

p : Completeness of divergent thinking skills

The criteria for effectiveness on problem-solving skills according to Riduwan in Sa'idia (2020)

Table 3. Problem-Solving Ability

Interval (%)	Criterion
0% ≤ X ≤ 49%	Very Low
49% < X ≤ 62%	Low
62% < X ≤ 75%	Keep
75% < X ≤ 87%	Tall
87% < X ≤ 100%	Very High

Based on the following table, it can be concluded that the learning media is said to be effective in the ability to think divergently if the number of students who complete the divergent thinking ability test > 75%. The analysis of the effectiveness data on interest uses the following formula.

$$X = \frac{F}{N \times I \times R} \%$$

Information:

X : percentage of interest in learning

F : Number of respondents' answer scores

N : 5 (Highest score of each item)

I : Number of questions

R : Number of respondents

The criteria for effectiveness on students' interest in learning according to Arikunto (2010).

Table 4. Learning Interest Criteria

Interval (%)	Criterion
$0\% \leq X \leq 20\%$	Very Not Good
$20\% < X \leq 40\%$	Not Good
$40\% < X \leq 60\%$	Enough
$60\% < X \leq 80\%$	Good
$80\% < X \leq 100\%$	Excellent

Results and Discussion

Results

Analysis

In the early stages of analysis, the researcher limits the material that will be used as the scope or limitation of this product development research material. Based on the background, it has been explained that the impact of technological developments is quite significant, but there is still a lack of use of technology in supporting learning. Therefore, it is important to ensure that technology is used properly so that students can make effective use of existing technology.

Further analysis of the selected mathematics learning materials considers their suitability to be implemented in *the liveworksheet* application. This is to achieve media that supports problem-solving skills, divergent thinking skills, and students' interest in learning mathematics in applying mathematics learning on *liveworksheets*. The mathematics learning material chosen is to build a flat-sided space. The selection of the material is based on problems identified through interviews with teachers and relevant journals.

Design

The initial stage in designing the development of the design of this mathematics learning e-module is to compile the flow of the e-module so that the design is conceptualized. The preparation of the e-module flow aims to determine the flow of using mathematics learning modules that are integrated with *liveworksheets*. In addition, the flow of the e-module will also make it easier for researchers to construct or detect things that are not in accordance with the rules of mathematics learning.

The content designed in this mathematics learning e-module is based on a realistic mathematics learning approach. The stages of realistic mathematics learning include, *world situation, model of mathematics*, *model for mathematics*, and *formal mathematics*. *World situations* are stages by using the context of daily life that is close to the student's experience, such as situations in the classroom that can be used for the context of mathematics learning. *The model of mathematics* is the initial stage of students developing a strategy on a mathematical problem-solving model that is coherent with the context of *the world situation*. *The model for mathematics* is a stage where students begin to get to know the general characteristics of world *situation problems* after going through the stages *of the model of mathematics*. So that at the final stage, namely *formal mathematics*, students already understand the formula to solve problems that are coherent with the material studied.

Development

The next stage after completing the design stage is to create an e-module in which there are learning materials, learning videos, and instructional on the use of *liveworksheets*. The initial appearance of the e-module developed is a *cover* designed using a combination of several flat-sided space building drawing items, titles and other combinations related to flat-sided space building materials. *Canva* is an application that

Picture 1. E-Module Cover

The next section of this e-module presents an introductory section that provides an overview of the material, objectives, and abilities to be achieved after using this e-module. Another important aspect of the introduction is the mapping of core competencies and basic competencies. This mapping is based on material determined by the problems identified in the background.

Picture 2. Foreword and Guide to Using the E-Module

After going through the development process, the product is validated by a validator to assess whether the product is in accordance with the goals to be achieved, the results of the validators are as follows.

Table 5. Validation on Media Aspects

Aspects	**Shoes**	
	Validator 1	**Validator 2**
Design Display	40	42
Ease of Use	19	18
Consistency	13	14
Graphics	12	13
Benefits	9	10
Total	**93**	**97**
Total score of both validators	**190**	
Percentage	**90%**	
Criterion	**Excellent**	

Table 6. Validation on Material Aspects

Aspects	**Shoes**	
	Validator 1	**Validator 2**
Content Eligibility	40	41
Language Qualifications	20	23
Penyajian	36	37
Total	**96**	**101**
Total score of both validators	**197**	
Percentage	**90%**	
Criterion	**Excellent**	

After the product is validated, the product is first improved based on the validators' suggestions. The improved product can be implemented to students to assess the practicality and effectiveness of the product.

Implementation

After the product is repaired, then the product can be tested at school. In addition to conducting trials on research subjects, first the improved e-module was tested on a small scale with a total of 6 students. The goal is to ensure that the e-module is error-free, this stage will test the features in the e-module and material packaging. The following product trial documentation is presented in the following image.

Picture 3. Implementation

After being tested on a small scale, the e-module was first improved according to the problems found in the field. The next stage is to apply or implement the product to the research subjects, namely students of SMP Negeri 9 Yogyakarta class VIII C with a total of 33 students.

After the product is implemented, the product is assessed for practicality by teachers and students. Data on the results of practicality was obtained based on questionnaires distributed to teachers and students. The teacher response questionnaire is a guideline sheet for the assessment by teachers of the products that have been developed. Teachers give assessments after using or testing in mathematics learning classes. This teacher response questionnaire was filled out by one teacher, namely a mathematics teacher in grade VIII C SMP Negeri 9 Yogyakarta.

Table 7. Results of Practicality Assessment

Assessment Criteria	Total Score	Percentage	Criterion
Effectiveness	34	97%	Excellent
Interaktif	23	92%	Excellent
Efficiency	22	88%	Excellent
Creative	34	97%	Excellent
Total Score		**113**	
Percentage		**94%**	
Criterion		**Excellent**	

Based on the assessment of mathematics teachers in grade VIII C SMP Negeri 9 Yogyakarta, the e-module assisted *by a liveworksheet* based on realistic mathematics learning obtained very good criteria with a percentage of 94%. Based on this assessment, the e-module was declared practical with several inputs that needed to be improved, namely adding literacy and numeracy-based questions. Furthermore, the results of the practicality questionnaire assessed by students of grade VIII C SMP Negeri 9 Yogyakarta were presented

Table 8. Practicality Assessment by Students

Assessment Criteria	Total Score	Percentage	Criterion
Benefits	460	70%	Good
Facilities	784	79%	Good
Visualization	695	84%	Excellent
Satisfaction	417	84%	Excellent
Total Score		**2.356**	
Percentage		**79%**	
Criterion		**Good**	

Based on the assessment of students in grade VIII C SMP Negeri 9 Yogyakarta, the e-module assisted by *a liveworksheet* based on realistic mathematics learning, obtained very good criteria with a percentage of 88%. Based on this assessment, the e-module is declared practical with several inputs that need to be improved, namely increasing the interactive features in the e-module. Based on the results of the assessment of teachers and students of grade VIII C SMP Negeri Yogyakarta, the e-module developed by the researcher was declared practical with very good criteria from the assessment of student teachers.

After testing the practicality of the e-module, the next stage is the assessment of the effectiveness of the e-module on problem-solving skills, divergent thinking skills and students' learning interests. The following are tests of problem-solving skills, divergent thinking skills and the results of student learning interest questionnaires.

Table 9. Problem-Solving Ability Test Results

Achievements	Sum	Percentage	Criterion
Number of Completed Students	29	88%	**Very High**
Number of Students Not Graduating	4	12%	

Based on the criteria for the completeness of the problem-solving ability test, the problem-solving ability test is declared complete if the student passes 70%. Therefore, e-modules assisted >*by liveworksheets* based on realistic mathematics learning are effective in testing problem-solving skills.

Table 10. Divergent Thinking Ability Test Results

Achievements	Sum	Percentage	Criterion
Number of Completed Students	29	88%	**Very High**
Number of Incomplete Students	4	12%	

Based on the criteria for the completeness of the divergent thinking ability test. E-modules are declared effective against divergent thinking skills if students who complete > 75%, Therefore, e-modules assisted *by liveworksheets* based on realistic mathematics learning are effective against divergent thinking ability tests.

Table 11. Results of Student Learning Interest Questionnaire

Aspects	Total Score	Percentage	Criterion
Interest in Learning	**671**	**81%**	**Excellent**
Attention in Learning	**667**	**81%**	**Excellent**
Feeling of Pleasure	**835**	**84%**	**Excellent**
Learning Engagement	**401**	**81%**	**Excellent**
Total number of scores		**2574**	
Percentage		**82%**	
Criterion		**Excellent**	

Based on the results obtained through the overall final aspect and percentage, it can be concluded that the e-module assisted *by a realistic* mathematics learning liveworksheet is effective against students' learning interests.

Based on the results of the test of problem-solving ability, divergent thinking ability and the results of the student learning interest questionnaire, it can be concluded that the e-module designed by the researcher is effective on mathematical problem-solving ability, divergent thinking ability and student learning interest.

Discussion

The validity test of the e-module integrated with the liveworksheet was carried out by validators, media experts, and material experts. The validity test is useful for determining the feasibility of the e-module developed. The results of the assessment by the validator stated that the product of developing a liveworksheet-assisted e-module based on realistic mathematics learning oriented to mathematical problem solving, divergent thinking ability and student learning interest was declared valid. According to Nieveen (1999), product quality can be declared valid by material experts and media experts with a minimum category of good. In addition, all components of the product assessment must be based on the validity of the content. If the product meets these requirements, it can be declared valid. Furthermore, Retnawati (2016) revealed that validity is one of the important requirements and needs to be done in a development. Validity can be proven by presenting several experts according to their fields. The results of the experts' agreement can be used as a benchmark in assessing the validity of the product or instrument developed. Based on the results of the validity test conducted in this study, it can be concluded that the product of developing a liveworksheet-assisted e-module based on realistic mathematics learning meets the criteria or is declared valid.

The assessment aspect of product practicality is developed based on the aspect of convenience and attractiveness during the use of e-modules. The value of the practicality of the e-module is obtained through a questionnaire filled out by teachers and students. Practicality assessment instruments by teachers and students are given during the use of the product. The results of data analysis after the use of liveworksheet-assisted e-modules based on realistic mathematics learning meet the practical category. So that the product in the development of learning e-modules can be declared easy to use during mathematics learning.

Akker et al. (1999) stated that high-quality development products are caused by teachers who consider that products can be used easily by teachers and students. In addition, the ease of using the product is also caused by the consistency of the learning and operational goals of the product during use. If consistency is met, it can be stated that the development product is practical. The results of Kusumawati & Nayazik (2018) research show that the problem-based learning mathematics learning module is stated to be easy to use based on the assessment of practicality by teachers and students. This research is different from the research mentioned above in terms of assessing the practicality of RME-

based module design. However, the assessment of practicality in the development of e-modules is based on the results of data analysis of the assessment of the ease of use of the module by teachers and students.

The effectiveness of liveworksheet-assisted e-modules based on realistic mathematics learning is based on students' achievement in solving test questions on problem-solving skills, divergent thinking skills, and student learning interest questionnaires. The minimum criteria for the problem-solving ability test, divergent thinking ability based on the Minimum Completeness Criteria value at the research site is 75. E-modules can be said to be effective if students who get a score that meets the KKM reaches 70% in the problem ability test, and > 75% in the divergent thinking ability test. Meanwhile, the effectiveness of students' learning interests is based on the minimum criteria for converting quantitative to qualitative grades with a minimum criterion of "good" with a percentage of > 60%. Based on the results of data analysis, 29 students were obtained with a score that met the KKM in the problem-solving ability test and 29 students with a score that met the KKM in the divergent thinking ability test. Meanwhile, in the results of the student learning interest questionnaire, 33 students gave a score exceeding the "adequate" category. Based on this data, it can be concluded that the product of developing e-modules assisted by *liveworksheets* based on realistic mathematics learning is declared effective from the results of the problem-solving ability test, divergent thinking ability test and assessment on the student learning interest questionnaire.

Based on the results of the trial, the development of RME-based e-modules has succeeded in increasing students' interest in learning materials for building flat-sided spaces. This is evidenced by research conducted by Fatimah et al. in 2021, showing that RME can increase students' interest in learning. In addition to students' interest in learning, RME-based e-modules can have a positive effect on problem-solving skills. Based on the findings in the field and the results of the problem-solving ability test, it shows that students can take advantage of the e-module developed by the researcher to solve problems related to building a flat-sided space. Research conducted by Halim et. Al (2021) showed the effectiveness of e-modules based on realistic mathematics learning in improving students' problem-solving skills. In addition to developing problem-solving skills, e-modules developed by researchers can also improve divergent thinking skills. The success of RME-based e-modules on divergent thinking skills is relevant to the research conducted by Rahma et. Al in 2022, which shows that RME-based modules can improve divergent thinking skills.

Conclusion

E-modules assisted *by liveworksheets* based on realistic mathematics learning oriented to problem-solving skills, divergent thinking skills and students' learning interests were declared valid in the media aspect and material aspects. In the media aspect, the e-module obtained excellent criteria with a percentage of 89% of validators one and 92% of validators two. Based on the assessment of the two validators, the e-module obtained very good criteria with a percentage of 90%. In terms of material, the e-module obtained very good criteria with a percentage of 87% of validator one and 92% of validator two. Based on the assessment of the two validators, the e-module obtained very good criteria in the material aspect with a percentage of 90%. E-modules assisted *by liveworksheets* based on realistic mathematics learning oriented to problem-solving skills, divergent thinking skills and students' learning interests are declared practical by teachers and students. Based on the teacher's assessment, the e-module obtained very good criteria with a percentage of 94%. Based on student assessments, the e-module obtained very good criteria with a percentage of 79%. E-modules assisted *by liveworksheets* based on realistic mathematics learning are effective on students' problem-solving skills, divergent thinking skills and learning interests. In the problem-solving ability test, the "very high" criterion was obtained with a percentage of 88%. In the divergent thinking ability test, the "very high" criterion was obtained with a percentage of 88%. Based on the results of the questionnaire, the learning interest was obtained with the criterion of "good" with a percentage of 82%.

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