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DEVELOPMENT OF MULTIPLE REPRESENTATION BASED E-MODULS TO IMPROVE ABSTRACT THINKING SKILLS PHYSICS OF HIGH SCHOOL STUDENTS

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Abstract. Students' multi-representational understanding in understanding glasses needs to be raised by educators in various forms of presenting information so that students are able to understand an abstract problem to become concrete in all realms of reflection. One way to apply learning with a multi-representational approach can have a positive influence on students' cognitive abilities which include low cognitive levels and high cognitive levels. The purpose of this research is to develop an e-module of based on multiple representations for high school students' abstract thinking skills. This is to determine the success of module development that has been designed in such a way. The research method used is research and development or research and development. The model used in the development of this e-module is a 4D model which consists of four stages of development, name define, design, develop, and disseminate. The stages used in the development of this e-module reach the develop stage, due to research limitations and in accordance with the research objectives, namely the development of e-modules. From the results of the research and discussion, it can be concluded that several representation-based e-modules to improve the abstract thinking skills of high school students that have been compiled are of good quality and still need to be achieved. . The average test results of material validation experts stated that the module was in the good category with an average value of 3.5 on a Likert scale, then for the media validation results it was also with an average of 3.5 and said to be in a good category.

Keywords: *E-Moduls, Physics, Education*

INTRODUCTION

Efforts to educate the nation's life that have been carried out by the Indonesian government are improving the quality of education in every region throughout Indonesia (Laili, 2019). Improving the quality of education itself requires several supporting components, one of which is the curriculum kurikulum (Munawaroh et al., 2021). In Indonesia, the curriculum is contained in Pasal 1 point 19 UU Number 20 of year 2003 concerning the National Education System, namely the curriculum is a set of plans and arrangements regarding the objectives, content, and learning materials as well as the methods used as guidelines for the implementation of learning activities to achieve certain educational goals (Winatha, 2018).

The curriculum is a system that has goals and components that are intact and interrelated to education. Indonesia is a country that has made changes to its curriculum system several times to date, and now Indonesia is implementing the 2013 curriculum system (Rosyid, 2015).. The 2013 curriculum is a series of improvements to the competency-based curriculum that was initiated in 2004 and then continued with the 2006 curriculum (KTSP). So, the change in the education curriculum is a demand that inevitably must be carried out. Several aspects or domains contained in the 2013 curriculum are interrelated for the implementation of learning in the classroom, because good and effective classroom learning must be appropriate and follow the applicable curriculum. The curriculum that applies in Indonesia, including the 2013 curriculum, utilizes a variety of learning resources, one of which is e-module (Ula & Fadila, 2018).

E-module is an ICT-based module. E-module etymologically consists of two words, namely the abbreviation "e" or "electronic" and "module" (Ricu Sidiq & Najuah, 2020). According to Ramadayanty et al., (2021) states that the module is a unit of planned learning activities designed to help students complete certain goals by organizing subject matter that is tailored to the individual's own personality so as to maximize his intellectual abilities. E-Modules have advantages compared to print modules, namely their interactive nature, making it easier to navigate, enabling displaying/loading of images, audio, video and animation and equipped with formative tests/quizzes that allow immediate automatic feedback (Suarsana &

Mahayukti, 2013). E-module one of the teaching materials that is effective, efficient and prioritizes student independence is teaching material in the form of a module. The module is a way of organizing subject matter that pays attention to the function of education (Winaya et al., 2016).

Talking about e-modules, there are components contained in e-modules that can be adopted from components in the print media module. The main components that need to be available in the module are subject review, introduction, learning activities, exercises, practice answer signs, summaries, formative tests, and formative test answer keys (JH, 2018). This e-module can be embedded in a multimedia technology so that it can be a learning resource that can be better than the usual print media module. E-modules as an alternative solution from learning resources that are integrated with various electronic advantages in packaging material content (integrated with images, animations, videos, and simulations) and can be accessed anytime and anywhere with the help of the internet network.

Physics is a branch of science that studies objects in nature physically and written down mathematically so that they can be understood by humans and utilized for the welfare of mankind (Ramadayanty et al., 2021). Physics is the heart of the development of information and communication technology that has fundamentally changed human life. Based on a global and historical view, physics provides a more dynamic method in helping humans solve complex life problems (Prahani et al., 2015). The packaging of physics teaching materials so far is still linear, namely teaching materials that only present concepts and principles, examples sample questions and their solutions, and practice questions. Teaching materials are less associated with real problems that exist around students so that they do not provide opportunities for students to develop skills in formulating problems, solving problems, and developing understanding.

Physics cannot be separated from mastering concepts, applying them in solving physics problems and working scientifically (Abdurrahman et al., 2015). When students study physics, students are required to master representations. such as simulations, graphs, conceptual/oral explanations, formulas, and pictures or diagrams simultaneously. Representation is a configuration (shape or arrangement) that can describe, represent or symbolize something in a way. Representation is also something that represents, describes or symbolizes objects or processes (Sundaygara & Gaharin, 2017). Multi-representation means re-presenting the same concept in different formats, including verbal, pictorial, graphic and mathematical. Multi-representation has three main functions, namely as a complement, interpretation barrier, and understanding builder (Pratiwi et al., 2016).

The use of various good representations is considered the key to the success of mastering certain scientific concepts. There are two motivations that should be considered in multi-representation-based learning, namely how students use various representations when solving problems and learn how to best teach problem solving using various representation formats or multi-representation (Abdurrahman et al., 2015). There are three main functions of multi-representation, namely as a complement in cognitive processes, helping to limit the possibility of other misinterpretations, and building a deeper understanding of concepts. In addition to the three main functions above, multi-representation also serves to explore differences in information expressed by each interpretation (Irwandani, 2014). Multiple representations tend to be used to complement each other where a single representation is not sufficient to contain all the information conveyed.

Multiple representation becomes important in physics learning in high order thinking skills because getting information on a problem must be obtained by yourself in various forms, for example conveying information in visual form, namely videos and simulations, verbal, namely sentences, mathematics in the form of symbols, numbers, graphs of results (Abdurrahman et al., 2015). research and drawings. Multi-representational understanding, namely students' understanding of visual, verbal, mathematical, images and graphics. In this case the multi-representation raised in the e-module is how students can use the mode as a source for conducting experiments and for working on experimental activities carried out (Irwandani, 2014).

In learning, students are required to master different representations such as experimental results, graphics, conceptual, formulas, images, and diagrams as the taxonomy function of multi-representation learning according to Ainsworth (2006) into three namely, (1) as a complement to information or support to complete students' cognitive processes, (2) representation is used to limit interpretations that allow misuse in other interpretations, and (3) can encourage students to construct in-depth conceptual understanding of various issues. Therefore, the use of multiple representations in learning is expected to understand students' concepts to be a complement in completing learning information (Sundaygara & Gaharin, 201.

Students' multi-representational understanding in understanding physics needs to be raised by educators in various forms of presenting information so that students are able to understand an abstract problem to be concrete in all domains of review (Irwandani, 2014). One way to apply learning with a multi-representational approach can have a positive influence on students' cognitive abilities which include low-level cognitive and high-level cognitive. Understanding is one form of cognitive students in the learning process. Based on the results of the reference problems above, research has been carried out on learning with a multi-representational approach in understanding the concept of straight motion, so that the impact of the results of this research can be useful for teachers and evaluators in formulating an approach to learning representation that is effective, efficient and right on target (Ramadayanty et al., 2021).

Learning will be more meaningful if students are given the opportunity to know and be actively involved in discovering the concept of existing phenomena from the environment with the guidance of the teacher. That is, in this period the child has been able to think logically, think critically with formal theoretical thinking based on propositions and hypotheses. To achieve this goal, the teacher's role in learning is needed (Pratiwi et al., 2016).

Physics learning in the classroom today tends to emphasize mastery of concepts and overrides the ability to think abstractly about students' physics problems so that students' ability to solve problems is still relatively low (Pratiwi et al., 2016). Abstract thinking skills are needed by students in learning physics. This is because problem solving activities can help students to construct new knowledge and facilitate learning physics. One form of higher order thinking skills that must be provided is problem solving skills. This skill is very important for students considering they are currently living in an increasingly complex world (Ramadayanty et al., 2021).

Based on the description above, the purpose of this study is to develop a multiple representation-based physics e-module for high school students' abstract thinking skills. This is to determine the success of developing modules that have been designed in such a way.

METHOD

The research method used is research and development or research and development (Haryati, 2012). The model used in the development of this e-module is a 4D model which consists of four stages of development, namely Define, Design, Develop, and Desseminate. The subject of the product being developed is for high school students, but before the stage of disseminating this e-module, validation is carried out by material experts and validation by media experts. After that, only the e-modules that have been developed will be disseminated to research subjects to determine the success rate of developing this multiple representation-based e-moduls.

The module development procedure uses research and development steps according to Sugiyono (2012: 408-426), namely:

Table 1. Step dnd Goals Research

No	Step	Goals
1	Potential and Problems	at this stage it is carried out using questionnaires, interviews, and direct observations to find out the gap between everything which can be utilized with the realities on the ground
2	Collecting Data and Information	at this stage information is collected by means of literature study by reading directly from books, journals, and article
3	Product Design	the next step is to develop a product design for learning modules that are structured with contextual learning syntax and are presented with many representations
4	Product Validation	after the initial product has been made, the next step is to test the validity of a team of experts consisting of material experts and design experts
5	Product improvement	based on suggestions for improvement from the test team, further improvements are made to the product
6	Product Trial	in this stage the product that has been developed is tested one on one to find out the oldness, convenience, and usefulness of the product
7	Product revision	this stage is carried out by evaluating the results of the trial and reviewing any deficiencies
8	Trial of Use	then the device is tested for use in a wider scope, the aim is to find out student responses regarding the attractiveness, convenience, and usefulness, as well as the effectiveness of using the module
9	Product revision	this stage is carried out by evaluating the results of use and reviewing any deficiencies
10	Production	after being declared effective and feasible, an e-module based on multiple representation is produced to improve the abstract thinking ability of high school students in physics.

Data collection techniques were carried out using pre-observation techniques, questionnaire techniques for media expert validation and material expert validation. In this study, pre-observation was conducted to make an inventory of school resources. The questionnaire used in the form of a list of questions given to respondents to obtain information from respondents about a problem.

The data analysis technique used a Likert scale as the basis for the data collection instrument. Then Likert scale for validation data. The quantitative data obtained were analyzed using the technique of descriptive to determine its validity. The analysis process follows the purpose of the research. To start by validating the model or product used in the context of the research.

Descriptive analysis technique is an analytical technique used to analyze data by describing or describing data that has been collected soberly without any intention of making generalizations or conclusions from the research results. Descriptive analysis is used to determine the description of the frequency of each variable, the level of tendency and influence between the independent variables on the variable dependent, either partially or simultaneously, based on data tabulation.

The score measurement is based on a Likert scale with units starting from the numbers one to four, so that the range/interval of values is obtained as follows:

Highest score value – lowest score value / scale

Example:

=4-1/4

= 0.75

So the interpretation of the range is as follows:

Table 2. Criteria for Product Assessment Category

Score Range (X) Quantitative	Qualitative Criteria
>3,25 – 4	Very Good
>2,5 - 3,25	Fine
>1,75 – 2,5	Less
1 – 1,75	Very Poor

RESULT AND DISCUSSION

The development of this teaching material used a 4D development procedure with four stages, namely finding information, planning, developing the final product, conducting product trials and revising the final product. In the first stage, namely collecting information, researchers conducted pre-observations to the research destination schools to identify the needs of students in learning physics. The results obtained from the media validation questionnaire are as follows:

Table 3. Media validation calculation results

No	Aspek	Validator 1	Validator 2
1	General View	4	3
2	Costum Display	3,857	3,571
3	Media Presentation	3,666	3,33
Total		11,523	9,901
Average		3,841	3,3003333

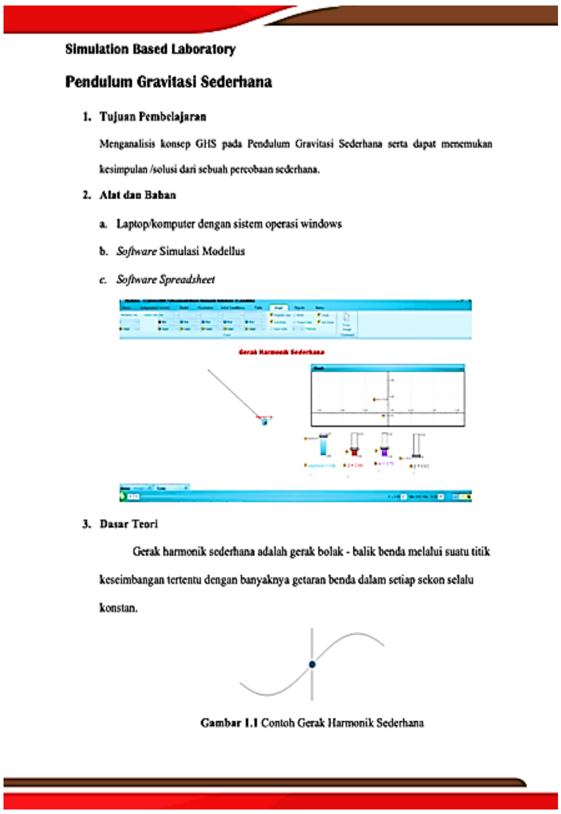
Assessment for media validation includes general display aspects, special display aspects, and media presentation aspects. In the general display aspect, validator 1 gives a value of 4.00 and validator 2 gives a value of 3.00, then on the special display aspect, validator 1 gives a value of 3.857 and validator 2 gives a value of 3.571, the last in the aspect of media presentation, validator 1 gives a value of 3.666 and validator 2 gives a value of 3.33. Meanwhile, the overall average value of each aspect given by the validator is stated to be very good.

The results of the calculation of material validation in table 3 include aspects of the suitability of the presentation, completeness of the presentation, accuracy, and relevance given by each validator. In the aspect of relevance, each validator gives a value of 3.5 (Validator 1) and 4.00 (Validator 2), for the aspect of accuracy the value given by validator 1 is 3.00 and validator 2 is 4.00, then for the aspect of completeness of the presentation validator 1 gives a value of 3.5 and validator 2 gives a value of 3.00, then the last aspect of the adjustment of the presentation of validator 1 gives a value of 3.00 and validator 2 gives a value of 4.00. As for the value of all aspects, namely 3.25 (Validator 1) and 3.75 (Validator 2). These results have met the requirements and are in accordance with the score given by the validator in the the value range is >3.25 – 4 and is declared very good, then with the results given by the product validator it can be disseminated to students.

Table 4. Results of material validation calculations

No	Aspect	Validator 1	Validator 2
1	Relevance	3,5	4
2	Accuracy	3	4
3	Serving Equipment	3,5	3
4	Serving Suitability	3	4
Total		13	15
Average		3,25	3,75

The first stage in the development of this e-module is to determine the subject that becomes the object of development, in this study is the subject of physics. The second stage in the development of physics teaching materials based on multiple representations is needs analysis. Needs analysis is an activity to analyze the material in the subjects from the syllabus to obtain information on the modules needed by students in learning the competencies that have been programmed. At this stage determine the needs carried out related to the problems determined in the first stage. The third stage is the e-module development stage. At this stage is the design stage to the manufacture of media in the form of e-modules, this stage includes analysis of learning conditions, analysis of use case diagrams and activity diagrams and design.


Simulation Based Laboratory

Pendulum Gravitasi Sederhana

1. **Tujuan Pembelajaran**

Menganalisis konsep GHS pada Pendulum Gravitasi Sederhana serta dapat menemukan kesimpulan /solusi dari sebuah percobaan sederhana.

2. **Alat dan Bahan**

a. Laptop/komputer dengan sistem operasi windows
b. *Software* Simulasi Modellus
c. *Software Spreadsheet*

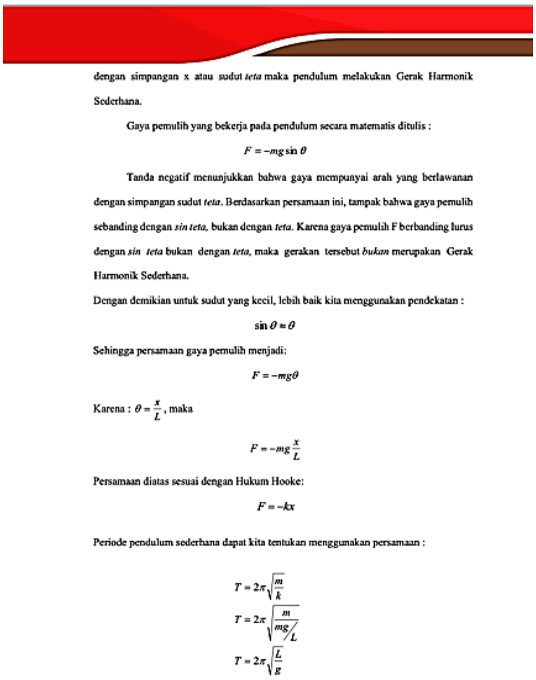
Gerak Harmonik Sederhana

3. **Dasar Teori**

Gerak harmonik sederhana adalah gerak bolak - balik benda melalui suatu titik keseimbangan tertentu dengan banyaknya getaran benda dalam setiap sekon selalu konstan.

Gambar 1.1 Contoh Gerak Harmonik Sederhana

Figure 1. a. Capture Theory


dengan simpangan x atau sudut *teta* maka pendulum melakukan Gerak Harmonik Sederhana.

Gaya pemulih yang bekerja pada pendulum secara matematis ditulis :

$$F = -mg\sin\theta$$

Tanda negatif menunjukkan bahwa gaya mempunyai arah yang berlawanan dengan simpangan sudut *teta*. Berdasarkan persamaan ini, tampak bahwa gaya pemulih sebanding dengan *sin teta*, bukan dengan *teta*. Karena gaya pemulih F berbanding lurus dengan *sin teta* bukan dengan *teta*, maka gerakan tersebut *bukan* merupakan Gerak Harmonik Sederhana.

Dengan demikian untuk sudut yang kecil, lebih baik kita menggunakan pendekatan :

$$\sin\theta \approx \theta$$

Sehingga persamaan gaya pemulih menjadi:

$$F = -mg\theta$$

Karena : $\theta = \frac{x}{L}$, maka

$$F = -mg\frac{x}{L}$$

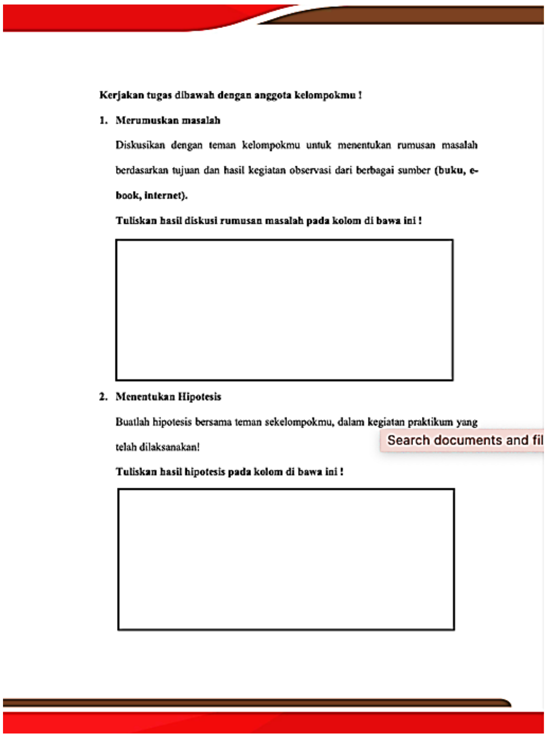
Persamaan diatas sesuai dengan Hukum Hooke:

$$F = -kx$$

Periode pendulum sederhana dapat kita tentukan menggunakan persamaan :

$$T = 2\pi\sqrt{\frac{m}{k}}$$
$$T = 2\pi\sqrt{\frac{m}{mg/L}}$$
$$T = 2\pi\sqrt{\frac{L}{g}}$$

Figure 1. b. Capture Theory


Kerjakan tugas dibawah dengan anggota kelompokmu !

1. **Merumuskan masalah**

   Diskusikan dengan teman kelompokmu untuk menentukan rumusan masalah berdasarkan tujuan dan hasil kegiatan observasi dari berbagai sumber **(buku, e-book, internet).**

   Tuliskan hasil diskusi rumusan masalah pada kolom di bawa ini !

2. **Menentukan Hipotesis**

   Buatlah hipotesis bersama teman sekelompokmu, dalam kegiatan praktikum yang telah dilaksanakan!

   Tuliskan hasil hipotesis pada kolom di bawa ini !

Figure 2. Capture Assigment

Furthermore, the implementation includes a media validation questionnaire and a material validation questionnaire. The results of the content expert's assessment based on the questionnaire have been declared appropriate, this indicates that the material in the e-module is suitable for use in physics learning.

The development of an e-module based on multiple representations is oriented towards improving the abstract physics skills of high school students, requiring various stages from the initial investigation phase, the design phase, the realization/construction phase, the test/evaluation and revision phases as well as the implementation phase. In the initial investigation, two main problems were identified that needed attention and treatment in learning, including: the use of e-learning that was not optimal and the students' low abstract thinking skills. Based on the study conducted, a solution step was designed in the form of developing an e-module oriented towards improving the abstract physics abilities of high school students.

Furthermore, at the design stage, the e-module design and its supporting research instruments such as module assessment sheets, abstract thinking skills tests and student response questionnaires were carried out. In the realization stage, research modules and instruments are prepared based on the design that has been made so that a product prototype is produced. After the e-module prototype is produced, an assessment is carried out by experts in the field. From the results of the assessment, it is revealed that there are several strengths and weaknesses that exist in this developed e-module. Overall, the resulting e-modules are of good quality. This means that the resulting multiple-representation-based e-module has met the feasibility aspects both in terms of content, learning design, visual display and the use of supporting software. These four components are the main components that must be considered in the development of ICT-based teaching materials (Suarsana & Mahayukti, 2013). In order for the resulting e-module to be of good quality and valid enough to be used, it requires several trials. In this study, this cannot be done fully because time does not allow for further research.

Students who learn using high order thinking skill learning with multiple representations differ significantly from learning the lecture method. The reason is because students are required to discover new things in independent learning to gain knowledge by doing scientific work first so that students can better understand science process skills because they are integrated in the learning syntax. The process of learning the high order thinking skill of giving

Opportunities for students to have real and active learning experiences so that students are trained in solving problems as well as making decisions. Learning high order thinking skills is more effective in helping students acquire science process skills because students are directly involved, such as asking questions in an informal setting, testing hypotheses, and building explanations. Through this scientific activity students will be given more opportunities to seek and discover facts, concepts and principles for themselves through direct experience so that the learning process becomes more optimal.

Based on the experience of the learning process for these students, learning with high order thinking places more emphasis on student learning activity to foster students' ability to use science process skills by formulating questions that lead to investigative activities, compiling hypotheses, conducting research, collecting and processing data, and communicating the findings in the learning process. High order thinking skill activities are very important because they can optimize the involvement of students' direct experience in the learning process. Learning with multiple representations does not really affect science process skills science process skills. One of the reasons is due to the not maximal use of multiple representations in learning high order thinking skills by students and teachers who have more roles in using multiple representations. In addition, multi-representation is more inclined to present concepts in various forms so that they are more easily understood by students.

CONCLUSION

Based on the results of the research and discussion, it can be concluded several things, namely the E-Module based on multiple representations to improve the abstract thinking ability of high school students in physics which has been compiled of good quality and still needs to be refined. The results of the average test of material validation experts stated that the module was in good category with an average value of 3.5 with a Likert scale, then for the results of media validation it was also with an average of 3.5 and was said to be in a good category. As for suggestions that can be given for the development of the results of this study, namely the product developed is limited to the development stage, it is recommended for other researchers to study further to the dissemination stage to determine the effectiveness of e-modules when applied in the learning process.

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