23 (3), 2022, 1112-1122
Jurnal Pendidikan MIPA
e-ISSN: 2550-1313 | p-ISSN: 2087-9849
http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Development of ICT-Based Geometry Transformation Module for High School Students

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Abstract: This study aims to develop an ICT-based geometry transformation module for high school students. This research is a development research using the ADDIE model. The results showed that the geometry transformation module developed was valid and received a good response from students. The developed ICT-based geometry transformation module can be used as an alternative for teachers to help students learn geometry transformation material. However, this module can only be run on windows-based computers or tablets. This module has not been able to run on smartphones which are generally owned by students.

Keywords: ICT-based modules, development research, mathematics learning.

Abstrak: *Penelitian ini bertujuan untuk mengembangkan modul transformasi geometri berbasis TIK untuk siswa SMA. Penelitian ini merupakan penelitian pengembangan dengan menggunakan model ADDIE. Hasil penelitian menunjukkan bahwa modul transformasi geometri yang dikembangkan valid dan mendapat respon yang baik dari siswa. Modul transformasi geometri berbasis TIK yang dikembangkan dapat digunakan sebagai alternatif bagi guru untuk membantu siswa mempelajari materi transformasi geometri. Namun, modul ini hanya dapat dijalankan di komputer atau tablet berbasis windows. Modul ini belum dapat dijalankan pada smartphone yang umumnya dimiliki oleh mahasiswa.*

Kata kunci: *modul berbasis TIK, penelitian pengembangan, pembelajaran matematika.*

▪ INTRODUCTION

Geometry transformation is needed by students in building spatial abilities, geometric reasoning abilities, and strengthening mathematical proofs (Edward, 1997: 187). Albab, Hartono & Darmawijoyo (2014) argue that, in learning geometric transformations, students need to use spatial visualization skills and geometric reasoning to obtain mathematical proofs. Geometry transformation learning also provides opportunities for students to think critically about mathematical concepts such as functions, symmetry, congruence and so on and allows students to engage in activities that involve reasoning in developing students (Hollebrans, 2003).

Students must really master the concepts of geometry transformation material in learning. But in reality, students are directed to memorize existing formulas and not be guided to find concepts or formulas used in learning (Gianto, Mampouw & Setyadi, 2019). This certainly makes students have difficulty in applying the concepts used in learning geometric transformations. Clements & Burns (2000) also mentions that students have difficulty identifying mathematical concepts in the material of translation, reflection, rotation and dilation in geometric transformations. So far the school has made various efforts to improve and improve the quality of students in learning. One way to do this is to develop learning media in the form of teaching materials or modules. Modules are teaching materials that can be used independently, in this case the modules are also arranged in a systematic and interesting manner which includes

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DOI: http://dx.doi.org/10.23960/jpmipa/v23i3.pp1112-1122
Received: 08 August 2022
Accepted: 16 September 2022
Published: 18 September 2022

methods, materials and evaluations (Muksar, As'ari & Tjiptyani, 2016). The module is made to achieve a learning goal. The substance of the module itself is a series of material that is neatly and systematically arranged in which it contains material and evaluation.

Module-based learning media, of course, has advantages and disadvantages. Lasmiyati and Harta (2014) mention the advantages of the module, namely; (1) Students can receive feedback from the module so that students can find out their shortcomings and mistakes, so that students can be encouraged to make improvements, (2) the module contains learning objectives to be achieved, so that this makes students more focused in participating in learning, (3) modules with attractive designs will make students more interested in learning learning materials, (4) modules can be studied by students with different speeds, this is because the modules are flexible, (5) with modules, collaboration between students can be established because the module can minimize competition between students, (6) students can be given the opportunity to do remedial, because with the module students can find out their weaknesses and mistakes in learning based on the evaluation given.

According to Morrison, Ross, & Kemp (2004:78) in addition to having advantages, the module also has several drawbacks, including: (1) reduced interaction between students so it is necessary to hold a schedule for face-to-face and group activities, (2) a single approach where things This is considered monotonous, causing students to feel bored. (3) students are left independent, this causes students to feel free and undisciplined and often delays doing assignments, so it is necessary to build a learning culture and provide time limits. (4) planning must be carefully prepared, there is a need for teamwork, there is support for supporting facilities, there is a need for media, sources and so on, and (5) in preparing the material there needs to be additional costs when compared to the lecture method. Seeing the advantages and disadvantages of the module, it is necessary to consider the manufacture of the module, so that the resulting module is able to answer the needs in the world of education and is also able to become a medium that is able to support the development of science and technology.

According to Arsyad (2013: 02) the development of science and technology increasingly encourages renewal efforts in the use of technological results in the learning process. The development of technology today is also marked by the industrial revolution. The industrial revolution started from 1) Industrial Revolution 1.0 occurred in the 18th century through the invention of the steam engine, this allowed mass production of goods, 2) Industrial Revolution 2.0 occurred in the 19-20th century through the utilization and use of electricity as a resource, so that making production costs low, 3) Industrial Revolution 3.0 occurred in the 1970s through the use of computers in various fields, and 4) Industrial Revolution 4.0 itself occurred in the 2010s through intelligence engineering and the internet of things as the backbone of human movement and connectivity and machine (Prasetyo & Trisyanti, 2018).

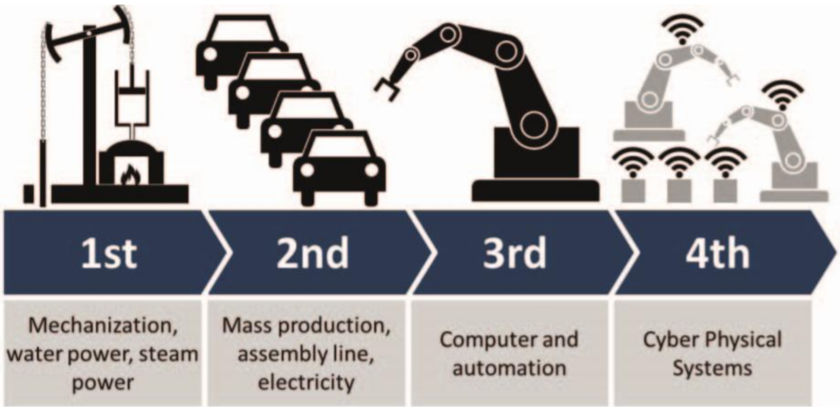

Figure 1. The development of the Industrial Revolution 4.0

Indonesia is currently in the Industrial Revolution 4.0, where many things happen to be limitless through unlimited computing and data technology. This happens because of the influence of the massive development of the internet and digital technology as the origin of the movement and relationship between humans and machines. In this era, it will distribute various human activities, including in terms of Science and Technology (IPTEK) and at the education level.

The ICT-based geometry transformation module in this study was developed by looking at the phenomenon that Indonesia is currently in the Industrial Revolution 4.0, where technological developments have begun to enter human life, especially in the world of education. This module is designed with the characteristics of being easy to use, independent, intact, adaptive, active, and in accordance with the demands of the times. This module is a module that can be applied to PCs or laptops and tablets. This ICT-based geometry transformation module is designed as a module that can be used to adjust students' learning abilities and understanding independently in order to achieve learning objectives. The material components in this module are; raising contextual problems, discovering the concept of geometric transformation by developing their visual skills with colorful module displays, especially in graphic images and illustrations, and module usage rules that ensure students must complete the previous activity to work on the next activity.

▪ METHOD

This research is a development research using the ADDIE development model. The ADDIE development model has 5 stages, namely Analysis, Design, Development, Implementation, and Evaluation.

The module that has been developed is tested for validity by using a material validation sheet and a media validation sheet compiled by the researcher and through revision at the direction of the validator. The material validation sheet consists of three aspects, namely material presentation, evaluation, and language, each of which consists of 4 indicators. The media validation sheet consists of three aspects, namely display quality, software engineering, and implementation. In the aspect of appearance and software engineering there are 6 indicators used, while in the aspect of implementation there are three indicators used. The module is declared valid if it gets a score of 3 for each indicator.

Modules that have been valid are then tested directly on students. The students who were involved or became respondents in this trial were 16 grade 10 students of SMAN 1 Getasan, Semarang Regency, Central Java. All the students were selected randomly. After each student tried the module that had been developed, they were asked to fill out a student opinion sheet consisting of 15 assessment indicators. The data from the students' opinions are then analyzed and become the results or research findings.

▪ RESULT AND DISSCUSSION

The ICT-based geometry transformation module was developed using the ADDIE model which consists of five stages. The following is a description of each of these stages.

Analysis

The development of the ICT-based geometry transformation module begins with an analysis phase consisting of two stages, namely needs analysis and performance analysis. The results at the needs analysis stage show that students need modules that can help them learn about the concepts in the geometry transformation material. In addition, the existing modules must be able to attract students' interest in reading, be addictive, can be used anytime and anywhere, can be used independently, and help students visualize the transformation geometry material. In the performance analysis, information is obtained that the available modules are still texbook-based. The existing modules are not yet connected to the gadgets or computers of students that they often use. This shows the need to develop a module that can be opened via gadgets or students' computers.

Design

The next stage after the analysis stage is the design stage. The design stage is done by designing the module so that it can be used independently and can be used anytime and anywhere. This stage consists of two steps, namely the design of the content of the module and the design of the module in the developed application. At the module content design stage, the researcher designs a module cover that reflects the material content of the developed module, the dividing part between the materials, and the parts of the module. The boundaries between materials are designed using different colors. Green color for translation material, red color for reflection material, blue color for rotation material, and purple color for dilated material. The selection of different colors aims to make it easier for students to find material and to make the module look more attractive.

The design of the parts of the module is done by designing so that the module can be studied by students independently. The parts of the module that appear at this stage are illustrations, finding concepts in each sub-material, Let's conclude, let's try, let's practice, and competency test. After the design of the content of the module is completed, the next researcher designs the module for the application that will be developed later. At this stage, it was decided that the module in the form of an application should be able to run on computers/laptops and tablets. The reason for choosing a computer or tablet is because these two gadgets have large screen sizes which are considered suitable for a module and are easy to carry everywhere.

In the next stage, the module display design is carried out on the developed application. The result at this stage is that the appearance of the module in the form of an application must be like a module in the form of a book so that at the turn of the page there must be an animation like when opening an actual book page. Furthermore, the developed module must also be able to provide opportunities for students to respond to the questions contained in the module. The response can be in the form of sentences or words or numbers or symbols. In the Let's Practice section, the module developed must provide a response to students about the correctness of the answers they input, while in the competency test section the module must display the final score obtained by students.

Development

At the development stage, the actual ICT-based geometry transformation module began to be developed according to the planned design. On the start page, there is the title of the developed module, instructions for using the module, and an exit menu symbolized by a cross. To go to the next page, students can click and drag the corner of the page like when reading an actual module/book. This also applies if students want to return to the previous page as shown in Figure 2.

Figure 2. Page switching view

On the next page, students will find an introductory page. This page contains questions that provoke students to recall whether they have studied or heard material related to transformation geometry. This module is also equipped with a page that contains the purpose and benefits of developing this module and the rules for its use. After students continue to the next page, they will find material related to transformation geometry which consists of translation, reflection, rotation, and dilation. In accordance with the previously planned design, each of these materials will have a different color subtitle display. However, each of these materials has the same characteristics, namely starting with illustrations, finding concepts in each material, concluding, trying to work on problems, and practicing working on problems.

Illustrations contain everyday stories related to the material to be given. This illustration is used to introduce the properties of each material by asking students to complete the table using check marks. After the student completes the table, he or she can write a description/definition of the material provided in the space provided. Here, students can directly write down what they think using the keyboard. For example, students can write the definition of reflection as a transformation that moves each point on a plane using the mirror image properties of the displaced points.

After students complete the illustration stage, they can move on to the next page which contains an explanation of the concept of the material given. The concepts in each of these materials are given to students by providing visual examples to students and are designed so that students complete certain sections as shown in Figure 3. It is hoped that students can find their own formula to find *x*' and *y*'.

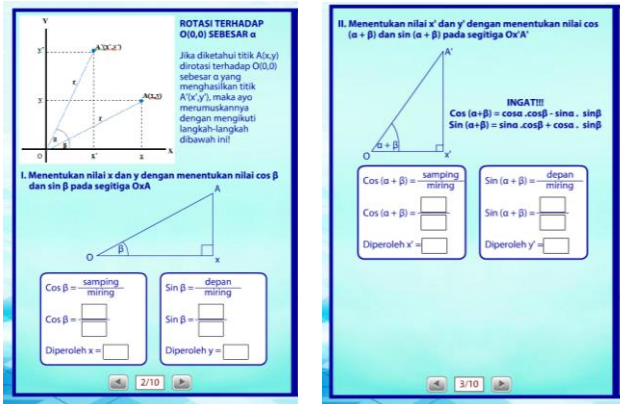

Figure 3. Example of a page display finding concepts

To make sure whether the formulas that students get are correct, they can go to the next page which contains conclusions from the sub-materials they have learned. The conclusion is in the form of a general formula to find the values of x' and y'. Let's try to make it so that students can try to work on questions related to the material that has been studied. This section is designed to provide some answers to help students solve the problem. Some examples of questions in the Let's Try section can be seen in Figure 4 below.

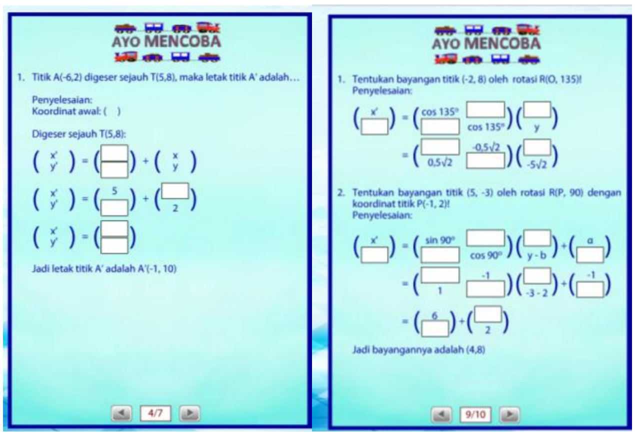

Figure 4. Example of a let's try page display

If on the Let's Try page students work on a problem with the help that has been prepared, on the Let's practice page students have to work on it independently. On this page, there are several questions that have been prepared and students must answer in the space provided. After finishing answering, students can select the check to find out whether the answer he wrote is right or wrong. If the student's answer is correct, a green check mark will appear, while if the student's answer is incorrect, a red cross will appear.

This module is also equipped with a Competency Test. The Competency Test aims to determine students' understanding of the transformation geometry material which consists of 20 multiple choice questions. These questions cover all material on transformation geometry, both translation, reflection, rotation, and dilation. The competency test page can be selected by students before or after students read the material provided. If students select the start button on this page, a display will appear containing instructions for working on the questions. After students select the start button, students can immediately work on the questions given. The questions given are multiple choice questions. Students can choose an answer by clicking on the available answers.

After students answer all the questions given, students can immediately find out the value they get. Students can select the repeat button, to repeat working on the problem or the finished button to return to the competency test page. Before being tested, the developed ICT-based geometry transformation module was validated first. This validation consists of media validation and material validation. Media validation was carried out by Dr. Wahyu Hari Kristiyanto, M.Pd while the material validation was carried out by Dr. Helti Lygia Mampouw, M.Sc. The results of media and material validation can be seen in table 1 and table 2.

Table 1. Media validation results

Aspect	Indicators	Answers			
		SS	S	KS	TS
Presentation	Icons or buttons make it easy to use media	✓			
	Page layouts and layouts	✓			
	Compatibility of color selection, typeface, font size, and font color		✓		
	Appropriate use of the proportion of the image presented with the media display		✓		
	Media capabilities can increase knowledge with the presence of text and images	✓			
Software engineering	Ease and simplicity in operation	✓			
	Ease of finding content (materials, exercises, etc.)	✓			
	The interface or interface has a good layout	✓			
	Display design according to user level	✓			
	The suitability of the format and resolution of the images presented with the media display		✓		
Execution	Ability to encourage student curiosity		✓		
	Media can be used anytime and anywhere	✓			
	Media support for student learning independence	✓			
	The ability of media in improving students' understanding	✓			
	The ability of the media to increase student motivation in learning	✓			

On Table 1 above, it can be seen that each indicator gets an average score of more than 3 with a final average score of 3,733. This shows that the media developed is valid.

In material validation, as shown in Table 2, an average value of 3.667 was obtained. This indicates that the media is valid and ready to be tested.

Table 2. Data validation result material

Aspect	Indicators	Answers SS (4)	S (3)	KS (2)	TS (1)
Presentation	Conformity of the concepts described with the concepts put forward by mathematicians	✓			
	Well organized material	✓			
	Suitability with students' cognitive development	✓			
	Material relationship with everyday life	✓			
Evaluation	The suitability of the evaluation with the material		✓		
	The suitability of the evaluation form with the concept presented		✓		
	Question difficulty level	✓			
	Variation of questions		✓		
Language	Use of communicative language	✓			
	Accuracy of use of terms	✓			
	The suitability of the use of language with the level of development of students		✓		
	Sentences easy to understand	✓			

Implementation

The media that has been developed is then tested on class X high school students. The trial was held at SMAN 1 Getasan in August 2019. In this trial, students were asked to give their opinion on the media developed using the prepared student opinion sheet. The data on the results of the students' opinions can be seen in Table 3 below.

Table 3. Data on student opinions results

Indicator	Average Score
Attractive media display	3.4375
Icons or buttons make it easier to use media	3.3125
Layout and *layout* according to	3.5
color selection, typeface, font size, and font color	3.5625
Appropriate use of the proportions of images presented with media display	3.375
capabilities can increase knowledge with the presence of text and images	3.1875
The interface or interface has a good layout	3.4375
Ease and simplicity in operation	3.75
Ease in content search (materials, exercises, etc.)	3.625
The suitability of the format and resolution of the images presented with the media display	3.125
Media is able to encourage curiosity	3.25
Media can be used anytime and anywhere	3.6875
I can study independently	3.6875

My understanding of the material geometric transformation improved after using this medium	3.375
I became motivated to learn geometric transformation	3.625

Based on n the data in table 3 above, it can be concluded that the developed media received a good response from students. This is because for each aspect, the average score is more than 3.

Evaluation

The geometry transformation module developed is valid and gets a good response from students. Each aspect of the indicator on student responses obtained an average score of 3. The results of the study indicate that the developed ICT-based geometry transformation module is valid. This is based on the results of media validation and material validation, each of which gets a score of 3. The results of trials conducted in schools showed that students gave a positive response to every aspect that was assessed. In the aspect of display, it can be concluded that the media display is attractive and able to encourage students' curiosity and make students motivated to learn. This agrees with the research results of Krissantono, Sukmawati, & Zainuddin (2013), Nurrita (2018), Saida, Wijoyo, & Wicaksono (2019), Priyambodo, Wiyarsi, & Sari (2012), Dilliati, Wiryokusumo, & Leksono (2020) , Setyadi & Qohar (2017), and Yuliani & Winata (2017) that interesting media can increase students' curiosity and motivation to learn.

The geometry transformation module that was developed also received a good response in terms of usage. This can be seen from the aspect of ease and simplicity in operation and ease of searching for content which gets an average score of 3.75 and 3.625. Furthermore, the module developed can also be said to be practical because the score on the media aspect can be used anywhere and anytime, getting an average score of 3.6875. These results support the research of Windarti (2015), Gustinasari, Lufri, & Ardi (2017), Laili, Ganefri, & Usmeldi (2019), that the module is practical in its use.

▪ CONCLUSION

Based on the results of research and discussion, it can be concluded that the ICT-based geometry transformation module developed is valid. The results of the trial showed that the developed module received a good response from students. The ICT-based geometry transformation module that was developed can be used as an alternative for teachers to help students learn geometry transformation material. However, this module can only be run on a Windows-based computer or tablet. This module has not been able to run on smartphones which are generally owned by students.

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