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DESIGNING A DIGITAL TEACHING MODULE BASED ON MATHEMATICAL COMMUNICATION IN RELATION AND FUNCTION

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Abstract

The purpose of this study is to design a digital module based on mathematical communication skills. This a development research which is carried out to determine the use of poor learning media and students' low comprehensive skills in understanding mathematical topics associated with relations and functions. One of the solutions used to overcome this problem is by designing a digital teaching module using media. The research and development method consisting of Analysis, Design, Development, implementation, and Evaluation (ADDIE), were used to carry out this study. The results showed that the digital module is highly valid with a total expert validation of 95.1% and in the very good category. Also, the students' response to the digital module is in the very good category, with a total response criterion of 89.8%. Therefore, the designed digital module has the ability to improve students' independence in learning because its use is not limited to classrooms.

Keywords: Mathematical communication skill, Digital module, ADDIE

Abstrak

Tujuan dari penelitian ini adalah untuk merancang modul digital berdasarkan keterampilan komunikasi matematika. Ini adalah penelitian pengembangan yang dilakukan untuk menentukan penggunaan media pembelajaran yang buruk dan keterampilan komprehensif siswa yang rendah dalam memahami topik matematika yang terkait dengan hubungan dan fungsi. Salah satu solusi yang digunakan untuk mengatasi masalah ini adalah dengan merancang modul pengajaran digital menggunakan media. Metode penelitian dan pengembangan yang terdiri dari Analisis, Desain, Pengembangan, implementasi, dan Evaluasi (ADDIE), digunakan untuk melaksanakan penelitian ini. Hasil penelitian menunjukkan bahwa modul digital sangat valid dengan validasi ahli total 95,1% dan dalam kategori sangat baik. Juga, respons siswa terhadap modul digital berada dalam kategori sangat baik, dengan kriteria respons total 89,8%. Oleh karena itu, modul digital yang dirancang memiliki kemampuan untuk meningkatkan kemandirian siswa dalam belajar karena penggunaannya tidak terbatas pada ruang kelas.

Kata kunci: Kemampuan komunikasi matematis, Modul digital, ADDIE

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The rapid development of information and communication technology tends to affect all aspects of life. Advancement in technology, education and media by using mobile phones, computers, and the internet, has encouraged humans to improve efficiency and effectiveness in their daily activities. In addition, teachers need to develop the right learning strategies to ensure the right skills are inculcated into students (Prahmana, Zulkardi, & Hartono, 2012). Presently, education in Indonesia has been greatly influenced by globalization, technological development, information, and communication (Asrial et al., 2019). Furthermore, some technologies have been developed in the field of mathematics, thereby, making it easier for students to comprehend.

The application module and mathematics interactive learning media are some of the products developed with the advancement of information technology (ICT), to improve student skills, and enable them to work productively (Saadati, Tarmizi, & Ayub, 2014; Muhtadi et al., 2018). Furthermore, Hamdunah et al. (2016) stated that the module contains summaries of material, training and covers how students build knowledge. Modules play an important role in achieving the goals of education by enabling students to adjust to the characteristics of the social environment (Rosita, 2016). Therefore, module with mathematics interactive learning media plays an important role in improving students' achievement and skills.

Communication is a way to solve and clarify a problem through understanding. It is a central force used by students to develop and formulate concepts (Sundayana et al., 2017). Qohar & Sumarmo (2013) stated that the purpose is to connect mathematical ideas to express situations or problems. This process is also used by students to think and provide answers to mathematical problems, as well as to communicate their results to others verbally or in writing. In other words, mathematical communication skills are the ability of students to express ideas with symbols, tables, diagrams or the use of media to solve mathematical problems (Saragih &Yusra, 2016). These skills are very important for students to learn how to solve mathematical problems using good reasoning (Tinungki, 2015). This is in line with the research carried out by Junita (2016) which stated that mathematical communication skills are important, for students to have a deep understanding of the subject and be able to solve problems. Lastly, Alhaddad et al. (2015) explains that communication skills tend to support problem-solving ability, which is properly resolved.

Rachmayani's study (2014) showed that students' communication skill is still low. Therefore, further evaluation with different methods is needed to motivate them in developing mathematical ideas. The interview results on teachers and several students in State Junior High School 1 Beber showed their poor ability to communicate the lesson material on relation and function. Based on the initial observation using a try-out test, it was found that student's mathematical communication is still low, with an example shown in Figure 1.

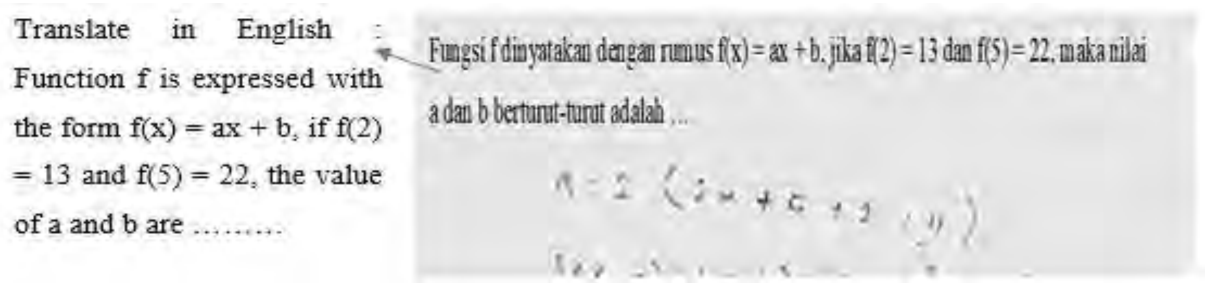

Figure 1. An example of students' answer

Figure 1 shows that the student is unable to properly explain mathematical ideas of algebra both verbally and in written form. However, this is actually an easy problem that can be solved by substituting the value of the function to the formula. Similar mistakes were also found in many answer sheets at a percentage of approximately 86.7%. Furthermore, the students were also unable to relate real object, pictures, and diagram to mathematical expressions, at an error rate of 80%. Meanwhile, approximately 70% of the students were unable to express contextual problems, therefore, due to the above-mentioned reasons, it is necessary to evaluate the achievement of good learning and provide an understanding of the material to students.

Saifiyah, Ferdianto, & Setiyani (2017) carried out research on modules based on mathematical communication skills. The results showed that the use of teaching modules tends to improve students' abilities and affect their learning motivation. This led to the current increase in the development of modules to facilitate students' ability to learn and absorb the teaching material. The widespread use of computer and internet has urged the development of software (Yalman, 2015). Digital technology has the potential of creating new ways for students to build and understand mathematical knowledge (Bray & Tangney, 2017). One of such technologies is the flipbook media which uses 3D page flip and considered effective in overcoming student learning problems due to the variety of interesting features compared to printed books (Arsyad, 2011). Students tend to achieve better insight using flipbook multimedia compared to other tools (Andini, Budiyono, & Fitriana, 2018). In addition, a research carried out by Jazim, Anwar, & Rahmawati (2017) showed that the use of constructivism-based mathematics modules makes students active in discussions and effective in building understanding abilities on algebraic materials. Previous studies urged the author to develop a digital learning material in mathematics using 3D page flip professional for Junior High School level. The developed material is more interesting because it contains learning videos, interactive exercises and questions focused on mathematics communication skill.

This research, therefore, used the 3D page flip professional application, with videos and flash to produce fun and interesting textbooks for students to develop their mathematical skill and self-confidence. Furthermore, this research would be answering several research questions about what are the benefits of the e-module design assisted by 3D page flip software, how are the digital materials in teaching the topics, and what are the possible response of students after using digital teaching materials.

METHOD

Presently, many methods have been developed with a common basis on instructional designing, namely ADDIE, Kemp, Thiagarajaan, ASSURE, Dick & Carey, etc. However, according to Gümüş (2010), ADDIE, which comprises of Analysis, Design, Development, implementation, and Evaluation is the plainest model amongst the above mentioned. By conducting research and development methods, the author provided good design and produced an efficient learning module. Data were obtained from a total of 40 students of class VIII D in State Junior High School 1 Beber.

This research was conducted to compile a module design that corresponds to the ADDIE research stage. Development is an effort to manufacture a product used to overcome the problems associated with classroom learning (Tegeh & Kirna, 2013). On the other hands, Purbasari, Kahfi, &

Yunus (2013) stated that the ADDIE research model is able to maximize the role of valid learning media. Furthermore, Aldoobie (2015) reported that it consists of systematic research and development stages namely Analyze, Design, Development, implementation, and Evaluation.

Analyze stage is carried out to obtain an overview of students' need and math curriculum in junior high school. The activities conducted in this stage include an interview with students and teachers to obtain information on problems in learning math, creating textbooks, the possibility of using digital learning material in schools, using try-out questions, and analyzing math curriculum in junior high schools. Secondly, the product design stage consists of media concept, preparing teaching material formats, choosing a non-scientific presentation approach based on the 2013 curriculum, and making a blueprint. Thirdly, after the design stage, a product is developed and utilized. The activities carried out at this stage include product creation and expert validation. Fourthly, the implementation stage tends to try the digital teaching materials directly on students using pre-test questions and through the formation of study groups. After learning, they fill out a questionnaire and work on the post-test questions. Lastly, the evaluation stage is carried out to ensure the developed product is appropriate or needs revision. Activities at this stage include product revision by the validator, implementation reflection, and revision of digital teaching materials. This aims at analyzing the validator's suggestion, as well as the obstacles faced by students and teachers in learning using the developed digital teaching materials. Data collection techniques used include tests of mathematical communication skills, interviews with teachers and students, and the use of validation sheets to determine the modules validity level.

RESULTS AND DISCUSSION

The result of this media development is in the form of a digital teaching module based on the 3D page flip application by loading lesson material on relations and functions. The developed module is accessible anywhere, however, due to the use of flash, the finished images and videos are only seen on a Windows-based PC. The following is the result of module analysis based on the ADDIE design.

Analyze Phase

At the analysis stage, the data obtained from the questionnaire and tests were analyzed to determine the ability of students to understand the lesson material. The results showed that students still have difficulties understanding the lesson material on relations and functions. This is associated with numerous factors which include the material presented by the teacher, the monotonous teaching method, and lack of media which tends to make learning boring. In addition, students need new strategies to help them learn mathematics easier. Also, when the author conducted an initial test on student knowledge, the results were fairly low because some failed to understand the learning material.

Design Phase

This study utilized the digital media visible in electronic devices, thereby making learning more enjoyable for students. The initial stage of designing a digital module starts by creating a framework using Microsoft Word applications. In this stage, the preparation of the framework is essential because it includes the design of the module layout, placement of materials and image layouts, as well as motivational words for students. After the completion of this stage, the module framework is converted into a PDF format, following by a systematic arrangement of the questions using the Adobe Flash CS 6 application. Furthermore, complementary accessories for the modules are added, which includes making an initial video for learning using Camtasia and Wondershare filmora applications. The next stage is the creation of reinforcement images using Corel draw and photoshop. The final stage is the core process of making digital teaching modules by inserting and designing the process using the 3D page flip professional application. In the discussion stage, questions in the form of SWF format, videos, and images are designed by connecting the problem files with the 3D page flip application. The digital teaching module framework is shown in Figure 2.

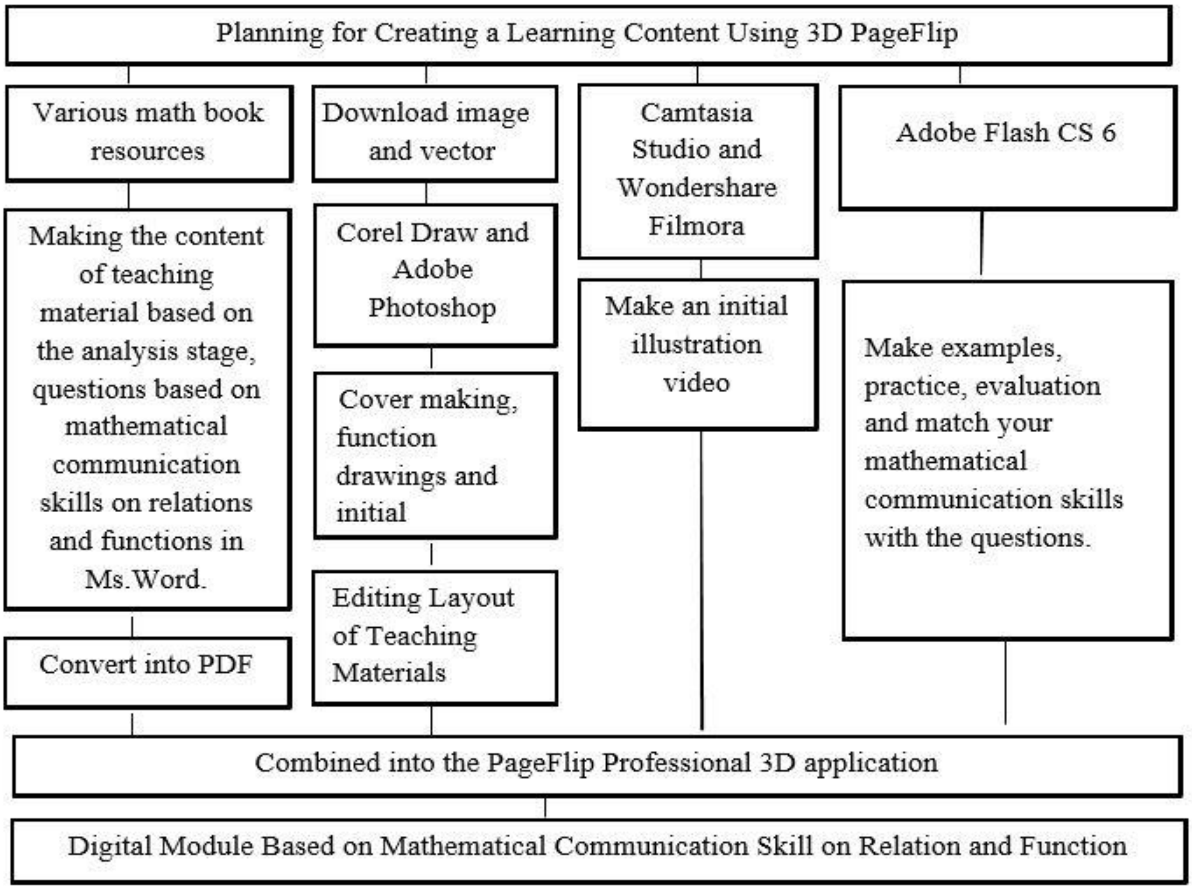

Figure 2. Framework of digital module

Development Phase

After the digital module has been completed, the final step is to change the format using a 3D page flip application in the EXE format, thereby, making it possible to be opened on a PC. After ensuring that the module runs properly, validation is carried out by experts. Also, students' responses as media users are also collected. Operate the digital teaching module by clicking the right or left arrow to change the page and click the icon to view videos, pictures and reinforcement questions, as shown in Figure 3.

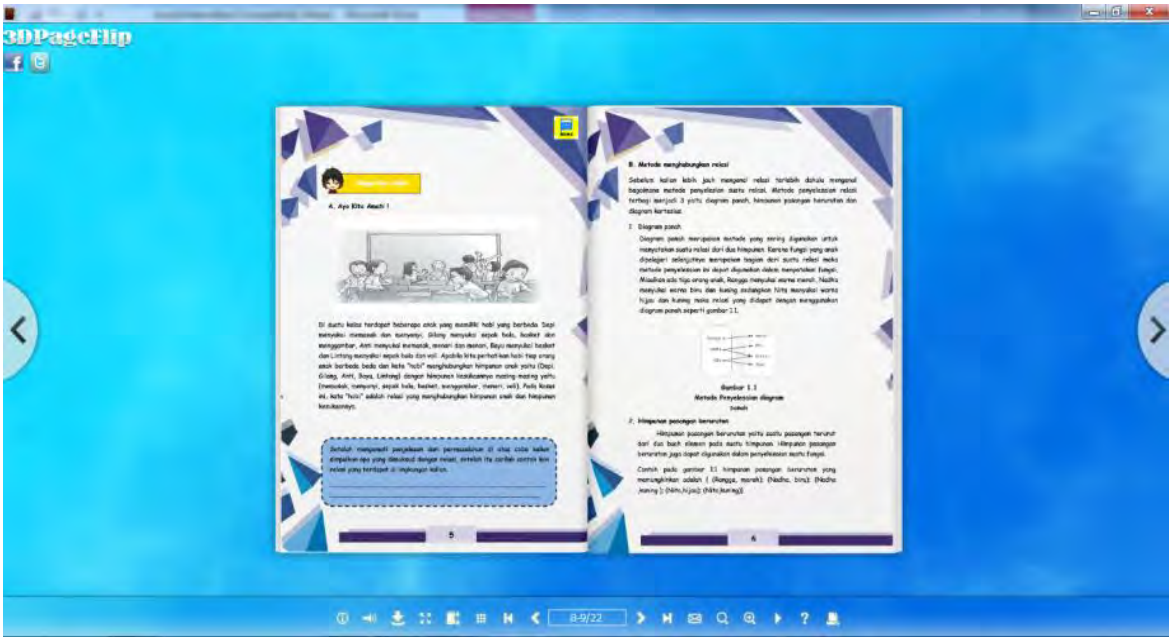

Figure 3. Left and right arrow for turning page

The main page display of the digital teaching module is shown in Figure 4, followed by the preface and table of content. The menu list is linked to facilitate the user in the operation directly.

Figure 4. Initial display of the digital module

Also included in the digital module are some interesting features to motivate students in learning abilities. These include an introductory video of the teaching module, reinforcement material, and discussion questions, as shown in Figure 5.

Figure 5. Some Features in the Digital Module

At this stage, the module is tested by validating a number of good validators from the field. This is followed by conducting tested on several students that represent each desired aspect. Media validation was carried out by four validators, with three from Swadaya Gunung Jati University lecturers and the other a mathematics teacher. The results are shown in Table 1.

Table 1. Results of validation for each aspect of indicators

Validator	Scores Achieved at Each Aspect				Validation Criteria for Each Aspect			
	1	2	3	4	1	2	3	4
Validator 1	37	22	31	12	92.5%	92%	86.1%	100%
Validator 2	39	24	33	12	97.5%	100%	91.7%	100%
Validator 3	37	20	31	12	92.3%	83%	86.1%	100%
Validator 4	40	24	36	12	100%	100%	100%	100%
	Average for each aspect				95.6	93.4	91	100

Information:

Aspect 1: Content Feasibility

Aspect 2: Feasibility of Presentation

Aspect 3: Language Feasibility

Aspect 4: Mathematical Communication Skill

The average score of content feasibility is 95.6% and in the very valid criteria, used to assess the suitability of the material from KI and KD, and stimulate students' curiosity. This is in line with BSNP (2014), which stated that a good module corresponds to basic competencies, accurately, and up-to-date. The module contains the current 2013 curriculum with the syllabus on the relationship, which defines the relations, and determines the one-on-one correspondence functions

The presentation obtained an average feasibility value of 93.4% and in the very valid criteria.

Therefore, the presentation consists of how the concept presents a digital teaching module and the thinking flow coherence. A good module needs to possess a systematic, consistent, coherent and complete presentation (Islamiyah, 2015). The illustrations of the feasibility modules consist of bibliography, introduction, and glossary. In addition, the module needs to be properly arranged for students to easily understand the textbooks.

The language feasibility obtained an average of 91% in the valid criteria. It tends to obey the applicable language rules, associated with the grammar which needs to be straightforward, communicative, dialogical and interactive. This is in line with the statement by Islamiyah (2015), which stated that a good module needs to adjust to the level of student development, readability, and motivational ability. It also aims to make the digital module useful for students and motivates them to learn mathematics, especially in the topic of relations and function.

The questions in the module need to be in accordance with the mathematical abilities. On the aspect of mathematical communication ability, the average validity is 100% with very valid criteria. In this case, the questions contained in the module were referred to three indicators of mathematical communication skills for students to improve their learning ability.

Overall, the average validation results were 95.1% of the total interpretation. This is in accordance with Akbar's (2013) validity criteria which are between 85.01-100% at a validity level without revision.

Implementation Phase

The implementation of teaching modules was not carried out in class VIII D of State Junior High School 1 Beber. Therefore, the preparation stage consists of the digital module, lesson plan, and media such as laptops and projectors. In addition to preparing the tools and equipment needed by researchers, students carried out the learning process to determine the information material as well as the required devices. It is intended that when the learning process takes place, students are ready to enjoy the process.

The stage of regulating the learning environment is the final process in the implementation phase. At this stage, the author arranges the classroom atmosphere and determines the success of a study. After carrying out the research, digital modules and laptops were used as learning media, as shown in Figure 6. Questionnaires were also prepared to determine students' responses to the teaching modules used.

The implementation starts with the introduction, which explains the core/basic competencies and learning objectives. The learning material associated with the core competencies were used to explain the relation and function with examples of the questions in the form of picture slides or videos. In this process, it appears that students pay attention to and enjoy observing the material provided by the author. The media used arouse curiosity on the questions provided.

Based on the results of the overall data analysis on mathematical representation using 3D Page

Flip Professional in learning activities in the classroom experienced a significant increase with average N-Gain results of 0.41 in the medium criteria. The gain test analysis with moderate criteria obtained an average interpreted increase in students' mathematical communication skills. Therefore, learning media helps teachers to educate students that are mostly "Digital Natives", by integrating technology as a necessity (Umar & Yusoff, 2014). Therefore, teachers need to possess the initiatives, with the competent in utilizing ICT materials.

Figure 6. The implementation of digital module

After the teaching module is tested for validation, it is used to produce a digital teaching module in the form of an exe application that can be opened anywhere, and tested to determine the user's response. The results of the media response from each indicator are shown in Table 2.

Table 2. Responses of students from each class

Ability Classification	Total response score	Percentage	Criteria
High	520	90,3%	Very good
Medium	509	88,4%	Very good
Low	522	90,7%	Very good

The research conducted on 18 users in the high, medium, and low levels ability, was in the very good criteria. The criteria for interpreting responses of 81% - 100% are in the very good category (Riduwan, 2013). The overall data obtained was 89.8%, and this concluded that students' responses to digital teaching materials are very good. Interactive teaching materials are preferred by students and do not make them get bored easily (Abadi, Cahya, & Jupri, 2017). The results of the response test for digital textbooks for each aspect are seen with the following assessment.

The average percentage of the learning process is in the very good criteria at 92.6%. The aspects of the learning process include the ease of modules in the teaching and learning process, which provides motivation during learning and supports the appropriate learning steps. Modules were used in explaining the teaching and learning process. Modules have the ability to explain learning material for students to understand easily (Prastowo, 2015). The use of technology in making modules help students understand the material, thereby, improving their learning outcomes (Mendoza & Mendoza, 2018).

The aspects of the module content obtained an average percentage of 96.3% with very good criteria. It includes students' interest in the contents of the modules, which include an understanding of the clarity of language and terms, practicality and ability to support the contained information. Daryanto (2013) stated that the use of language is easily understood because its characteristics are coherent with a good module with the ability to improve students' understanding

Research on digital teaching modules has also been conducted by Andini, Budiyono, and Fitriana (2018). The study focused on elementary school teaching, therefore, a digital module was specifically designed for junior high school children due to the urge to learn. This is to increase students' creativity and knowledge in information technology. The study of the junior high school used module was also conducted by Johar, Yusniarti, & Saminan (2018) to increase their creativity and knowledge in information technology. However, the weakness associated with this research is the monotonous strategy used which is a textbook, thereby, making it difficult to solve mathematical problems. Textbooks provide limitations on the manipulation of objects, images and symbolic representations; however, these are overcome using electronic textbooks (Hoch et al., 2018).

In this study, the authors tried to answer the problems mentioned by students regarding the obstacles to finding textbooks. A digital module was created in such a way so that it is easily understood by students, and used anywhere. It also allows the addition of questions with the help of the Adobe Flash application.

Evaluation Phase

This evaluation phase occurs in accordance with the student's needs. At the development stage, product evaluation is carried out based on the suggestions from several validators for improvement, as shown in Table 3.

Table 3. Validators' suggestion

Validator	Suggestion	After revision
Validator 1	A glossary is needed	There is a glossary in the revised module
	Improve writing	The writing is in accordance with the grammar
Validator 2	Improve writing and punctuation	The writing has been improved and in accordance with the grammar rules
	Questions of discussion and evaluation should be added with story problems	Questions of discussion and evaluation include story problems related to daily life
	It is better to include the benefits and origin of the relation function	There is the biography and benefits or learning lesson material on relations and functions both in the classroom and in everyday life's context
Validator 3&4	No suggestion	-

Furthermore, the evaluation phase is also carried out on the implementation of learning using a digital module and a revision of the digital module. The obstacles that occur during the learning process are limited to students' inability to use the application and the inability to pay attention to the teacher's instructions. The application of technology is an important factor for improving student learning outcomes, however, the main factor is associated with the learning and teaching process (Nadiyah & Faaizah, 2015). Further development of the digital module is designed to support mobile phones and provide online access to students, irrespective of their location. Online digital modules are viewed in web browsers such as Firefox, Chrome, Safari, and lots more, with new functionalities for interaction, and personalized learning which include improving the supplements (O'Halloran, Beezer, Farmer, 2018).

Also, the number of laptops provided is still limited, therefore, some students passively pay attention to the lesson. These barriers are also found in teachers that act as observers. Therefore, further training is needed for teachers to make their own module according to students' needs and material. Teachers' collaboration is very useful and provides new opportunities in designing digital modules (Pepin, Gueudet, & Trouche, 2017).

CONCLUSION

The digital module developed in this study is in accordance with students' needs and acts as an alternative source of learning that is not monotonous. It is valid based on the evaluation of four validators, and after implementation using a digital module, students responded positively, with developed mathematical knowledge. Some obstacles experienced by students in using digital module include the lack of focus on what is explained by the teacher. Therefore, for further development, a digital module capable of supporting mobile phones needs to be created for students to learn irrespective of their location. In addition, the digital module provides a stimulus for teachers to develop on other topics. The results of this study provide recommendations to test the effectiveness of the use of digital modules in the classroom.

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