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DEVELOPMENT OF ELECTRONIC MODULE WITH AUGMENTED REALITY ON PYRAMID FOR VIII GRADE

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Abstract

In order to create a joyful learning environment, especially during a pandemic that requires learning to be carried out online, an innovation is needed such as the use of interactive learning media for mutual learning which can be accessed online. Electronic modules with Augmented Reality are packaged in the form of learning media that can be used independently everytime and everywhere. This study aims to develop an electronic module with android-based Augmented Reality named "AR LIMAS" as a media to improve students' learning motivation and mathematical abilities, especially on pyramid geometry problem. The selection of pyramid material in the electronic module was based on several previous studies regarding the misconceptions experienced by students on pyramid. The development of this electronic module used the ADDIE research method by taking into account the scores of validity, practicality, and effectiveness for the creation of good learning media. This electronic module was tested on 3 students of VII grade who have low, medium, and high mathematical ability. The categorization of students' mathematical ability was based on the final examination scores in the previous semester. Based on the assessment of experts, this electronic module was declared to have a good category with a validity percentage of 86.59%. Then the results of the questionnaire using the electronic module obtained a practicality percentage value of 98.35% with a very good category. The results of pretest with an average score of 15 increased in posttest with an average score of 82.5, so the module was considered effective in improving students' understanding on pyramid.
Keywords: electronic module, android, augmented reality, pyramid, development.

Abstrak

Untuk menciptakan suasana pembelajaran yang menyenangkan, terlebih di masa pandemi yang mengharuskan pembelajaran dilakukan secara online, dibutuhkan suatu inovasi seperti penggunaan media pembelajaran interaktif untuk pembelajaran timbal balik antara satu dengan yang lain serta dapat diakses secara *online*. Modul elektronik dengan *Augmented Reality* dikemas dalam bentuk media pembelajaran yang dapat digunakan secara mandiri kapanpun dan dimanapun. Penelitian ini memiliki tujuan untuk mengembangkan modul elektronik dengan *Augmented Reality* berbasis android bernama "AR LIMAS" sebagai media untuk meningkatkan motivasi belajar dan kemampuan matematika siswa, khususnya dalam materi limas. Pemilihan materi limas pada modul elektronik didasarkan pada beberapa penelitian sebelumnya mengenai miskonsepsi yang dialami siswa pada materi bangun ruang limas. Pengembangan modul elektronik ini menggunakan metode penelitian ADDIE dengan memperhatikan nilai validitas, kepraktisan, dan keefektifan demi terciptanya media pembelajaran yang baik. Modul elektronik ini diuji cobakan pada 3 peserta didik kelas VII dengan kemampuan matematika rendah, sedang, dan tinggi. Pengkategorian kemampuan matematis siswa didasarkan pada nilai ujian akhir semester pada semester sebelumnya. Berdasarkan penilaian dari para ahli, modul elektronik ini dinyatakan memiliki kategori baik dengan persentase validitas sebesar 86.59%. Kemudian hasil dari angket penggunaan modul elektronik memperoleh nilai persentase kepraktisan yaitu 98,35% dengan kategori sangat baik. Hasil *pre-test* dengan perolehan nilai rata-rata 15 mengalami peningkatan pada *post-test* dengan perolehan nilai rata-rata 82,5, sehingga modul dinilai efektif dalam meningkatkan pemahaman siswa pada materi limas.
Kata kunci: modul elektronik, android, augmented reality, limas, pengembangan.

INTRODUCTION

Online learning has become one of the learning models planned by the government aimed at all levels of education, from kindergarten to university. This alternative was chosen because of the industrial revolution 4.0 development. The development of the industrial revolution supports the implementation of online learning because online learning is learning that sets aside time and distance with an internet-based digital platform which is able to support learning that will be carried out without physical interaction between teachers and students (Putra & Irwansyah, 2020).

Even though Indonesia is currently entering a transition period for the Covid-19 outbreak, online learning is still being used. In online learning, teachers use electronic learning more instead. E-learning is a flexible formal learning system with the help of electronic resources (Maatuk, et. al 2022). E-learning allows teachers to teach and be creative. Online classes are structured in such a way, so that online learning can be convenient for students. Some examples of electronic learning are electronic modules, videos, and learning applications. The electronic module is one of the learning media that was prepared by taking into account several characteristics of a good module, such as self-teaching, all learning materials are contained in the module used, not use other learning media except the module used, high adaptability, and friendly (Rahdiyanta, 2016).

Some examples of the application of Augmented Reality that have been applied in the world of education are learning games, inquiry learning, robots, books, mobile applications, and other technologies that can be developed with the Augmented Reality feature. Augmented Reality is an application that combines the real and virtual world in the form of two-dimensional and three-dimensional projected in a real environment simultaneously. Augmented Reality is also called as tethered reality (Mustaqim, 2017). Research proves that the use of Augmented Reality technology with marker-based tracking methods in Unity and Vuforia helps students in understanding geometry material (Pujadi et al., 2018). According to Hardiyanti, Rosyadi, and Mellawaty (2020), Augmented Reality application media is proven to be able to help students of VIII grade in geometry learning. Based on research conducted by Nurlatif, Muchiyidin, and Nursuprinah (2020), it was found that a number of students had misconceptions about the surface area and volume of 3D shapes. One of the 3D shapes mentioned is pyramid. According to Fajari (2020), this is caused by several factors, one of which is the lack of students' understanding of the concept of three-dimensional shapes, therefore the solution to avoid misconceptions is to use interesting media to assist students in modeling abstract material of three-dimensional shapes comprehensively. Several previous studies related to misconceptions on pyramid only focused on analyzing without mentioning solutions to overcome these misconceptions. The selection of geometry was based on the suitability of using Augmented Reality which combines 2 dimensions and 3 dimensions, while the pyramid subtopic was chosen because there were still some misconceptions experienced by students in understanding the material. The application of Augmented Reality in geometry learning of VIII grade is intended to make it easier for students to understand the concept of three-dimensional shapes through the integration of the real world and three-dimensional visualization so that misconceptions can be avoided.

R	:	Bagaimana sistem pembelajaran online yang dilakukan di sekolah kalian? *(How is the online learning system in your school?)*
S1	:	Diberi tugas melalui grup mata pelajaran untuk satu kelas pada WhatsApp *(We were given assignments through subject groups for one class on WhatsApp)*
R	:	Mana yang lebih kalian suka, kelas online atau offline? *(Which one do you prefer, online or offline class?)*
S1	:	Lebih suka kelas offline, kalau online pusing kebanyakan online *(I prefer offline class, because i got my head dizzy when i did the online class oftenly)*
S2	:	Setuju *(I agree)*
S3	:	Lebih suka offline *(I also prefer offline class)*
R	:	Bisakah kalian memahami materi yang diberikan selama pembelajaran online? *(Could you understand the material given during online learning?)*
S3	:	Lumayan, tapi lebih banyak enggaknya *(Not bad, but more often don't understand)*
R	:	Apakah tidak ditanyakan? *(Don't you ask to the teacher?)*
S1	:	Tidak pernah tanya *(Never)*
R	:	Pernahkah menggunakan media yang menarik selama pembelajaran? Misal penggunaan permainan pada kelas matematika, atau yang lain *(Have you ever used an attractive media during learning? For example the use of games in mathematics class, or others)*

S1 : Pernah
(Yes, I have)
S3 : Tidak pernah
(Never)
S2 : Tidak pernah
(Never)
R : Bagaimana pendapat kamu jika pembelajaran matematika dikemas dalam bentuk *game android*?
(*What do you think if mathematics learning is packaged in the form of an android game?*)
S1 : Mungkin, lebih seru sih
(*Maybe, it will be more exciting*)
S2 : Biar nggak bosen juga, apalagi online gini
(*I think, we won't get bored, especially in online learning like now*)
R : Apakah sebelumnya pernah menggunakan teknologi Augmented Reality seperti yang saya tunjukkan?
(Have you ever used Augmented Reality technology as I showed you before?)
Ss : Tidak pernah
(Never)

The result of interviews with several students in Bojonegoro showed that online learning activities only contained teacher activities that gave assignments from the Student Worksheet (LKS). Students admitted that some difficulties are experienced during online learning, especially in understanding the material given.

Electronic media is not used by teachers optimally to support online learning. Students preferred face-to-face learning because it could be easier to understand the material being taught. The result of the interview also showed that many students are still unfamiliar with Augmented Reality technology. Therefore, this study aims to develop an Electronic Module with Augmented Reality on Pyramid for students of VIII grade with the hope of making it easier for students to understand the concept of pyramids in material of VIII grade.

RESEARCH METHOD

This research used Research and Development research with ADDIE research model. The steps used are analysis, design, development, implementation, and evaluation (Cahyadi, 2019). This development model is used because it is proven to be effective and clear for helping in organizing and designing training programs needed in developing Augmented Reality-based electronic module learning media.

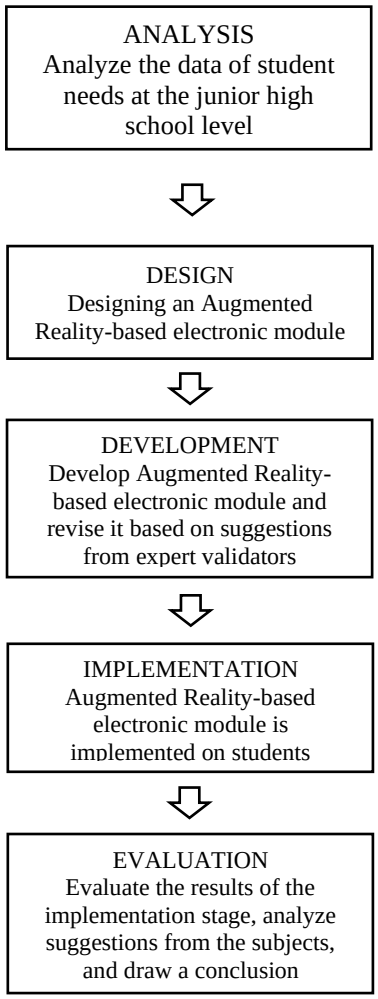


Figure 1 ADDIE Diagram

The analysis stage is used to determine the development of the media. The condition of learning facilities from all aspects needs to be observed to get the right analysis (Sunaryarthy et al., 2022). The analysis stage is form evaluation is carried out at each stage, but this step is carried out by clarifying students with the appropriate criteria formulated with an analysis that includes curriculum analysis, material analysis, and analysis of student characteristics (Tahulending, 2019). The results of the analysis stage were obtained from interviews about the teaching media used with local students who are carrying out online learning. The results of the analysis are then used to determine the next step in the Design stage.

The design stage aims to determine some plans such as learning objectives and then determine the design to be implemented. The design stage has several general procedures, namely determining the needs to be implemented, determining media objectives, producing instruments to measure media success, and assessing the results of subject instruments (Hidayat et. al., 2021). The design stage is needed to minimize errors when developing media at a later stage. This stage needs to be done so that developers know what is needed to develop media with

appropriate goals. At the design stage, everything needed to make an electronic module is determined such as details of the theme, features, module flow, and quiz for students to practice understanding the material.

The stage where the activity is to create, replace, or make variations of teaching materials by making supporting objects such as writing, videos, animations, and various other things is the development stage (Permana, 2022). The output of this stage is the media which will then be validated by experts. When the teaching material developed in the previous stage has been evaluated proper to use, then the developer can apply the media to students at the implementation stage. According to Kurnia (2019), knowing the media assessment using the instruments that have been prepared is a function of the implementation stage. The implementation stage is the stage used to apply the media that has been developed so that it can be continued to the next stage, namely the evaluation stage.

Evaluation is the final stage of the ADDIE research model which aims to assess the effectiveness of the media that has been developed. Essentially, evaluation is carried out at each stage, but this step is carried out by clarifying students' mathematical ability which is carried out through a learning process that is in accordance with learning objectives (Rokhim & Anwar, 2021). The developer can determine the advantages and disadvantages as well as the improvement of the media after the evaluation stage is carried out.

The subjects of this study were 3 of VII grade students who had not studied the pyramid material yet at the junior high school level. The application of this research was carried out at one of junior high school in Surabaya with students who have been classified on high, medium, and low mathematical abilities in order to find out whether the developed media can be used effectively for all students regardless of their mathematical abilities. This classification is based on the results of the end of the odd semester assessment for the 2021/2022 academic year which are categorized through the following table (Pesona & Yunianta, 2018).

Table 1 Classification of Students' Ability

Interval of Scores	Category
$75 < S \leq 100$	High ability
$60 \leq S \leq 75$	Medium ability
$0 \leq S \leq 60$	Low ability

Instrument is a tool used to measure the value of the media validity. The instrument in this study is a validation sheet with expert validation details (aspects of format, content, language, display), practicality assessment sheet, student response questionnaire assessment, pretest, and posttest.

Quantitative and qualitative data were obtained from the instruments that had been prepared and processed. Quantitative data is the result of questionnaire validation from experts, pretest, and posttest which is then processed with a predetermined formula. Qualitative data was obtained from the interviews result, suggestions, and criticisms from experts and students which are then used to improve the learning media developed. The data that has been obtained will be analyzed to determine the quality of the electronic module developed based on the validity, effectiveness, and practicality of (Putra & Atik, 2021).

Validity Analysis

Analysis of validity of the electronic module is carried out by referring to the results of the experts' validation questionnaire by converting the numerical data into a percentage of validity with the formula:

$$\text{Validity percentage} = \frac{TSe}{TSh} \times 100\%$$

With: TSe = The sum of scores of the expert validation questionnaire
TSh = The total maximum scores on quiestionnaire

Based on the percentage of validity obtained, the value of media validity can be determined through the following table of media eligibility categories (Wijayanti et al., 2018).

Table 2 Table of Validity Percentage Category

Validity Percentage Interval	Category
91% – 100%	Very Good
81% – 90%	Good
71% – 80%	Acceptable
61% – 70%	Poor
0% – 60%	Very Poor

The electronic module is declared valid if it has reached a percentage score of 81% based on the results of the experts' validation questionnaire. Then a qualitative analysis of criticism or suggestions is carried out on the developed electronic module.

Practicality Analysis

The questionnaire used as the research instrument was used to analyze the practicality of the electronic module according to experiences of students who were the subject of the research while using module. The data obtained from the questionnaire will be the percentage of practicality data by:

$$\text{Practicality percentage} = \frac{SRe}{SRh} \times 100\%$$

With: SRe = The average score of questionnaire results
SRh = The maximum score of questionnaire results

After being processed with the above formula, the existing percentage is adjusted to the following practicality category table (Akbar, 2017).

Table 3 Table of Practicality Percentage Category

Practicality Percentage Interval	Category
$85\% < P \leq 100\%$	Very Practical
$70\% < P \leq 85\%$	Practical
$50\% < P \leq 70\%$	Less Practical
$0\% \leq P \leq 50\%$	Not Practical

With: P = Practicality Percentage

The electronic module must account for 70% of the questionnaires filled out by students to be declared as practical electronic module.

Effectiveness Analysis

At this stage, a small group trial was conducted with 3 students of 7th Grade as subjects in SMP Cahaya Surabaya. Criteria of research subjects in this study were students who had not received pyramid material yet at the junior high school level. There are pretest and posttest instruments that were used with details of the pretest being tested on students before using the electronic module, while the posttest was tested on students after using the electronic module. Students' scores of the pretest and posttest were compared to consider the effectiveness of the electronic module. If there is an increase of the scores after the pretest and posttest, then the electronic module has succeeded in increasing students' ability and understanding on pyramid. According to Murni (2016), the posttest average value which is higher than the pretest indicates the effect of the success of the media used in improving student learning outcomes.

RESULT AND DISCUSSION

The product of this research is a learning media called "AR LIMAS". This media is an Augmented Reality-based electronic module on pyramid material that can be accessed through smartphones and android-based with apk form format. This electronic module was developed through several research stages of ADDIE (Analysis, Design, Development, Implementation, Evaluation).

Analysis Stage

Analysis Stage includes: a) Curriculum Analysis. The Curriculum of 2013 is used as a guide in determining the competencies to be achieved. The following were basic competencies chosen: 3.7 Distinguish and determine the surface area and volume of a pyramid and 4.7 Solve problems related to the surface area and volume of a pyramid; b) Content Analysis. At this stage the researcher determined the material that will be the learning focus of the media to be developed. The material used is a pyramid, covering surface area and volume which are packed with contextual or non-contextual problems. The prerequisite material that students need to understand are areas of two-dimensional shapes and pythagoras; c) Characteristics Analysis. It is based on interviews in the early stages of the study. This interview was conducted on students and teachers of Junior High Schools in East Java who carry out online learning. From the results of interviews with students obtained that: 1) students find difficulties in learning the existing materials because online learning is more emphasized on reading books independently; 2) students need a learning media that can be used flexibly; 3) students feel bored while doing online learning because the learning media used is only limited to textbooks; and 4) students prefer to play games or social media than learning to use smartphones.

Design Stage

After the data from the previous stage obtained, the next stage is Design Stage, to create an electronic module by determining the visual theme and flow of the electronic module. The initial visual theme used is blue as a test application. The flow of the electronics module begins with the appearance of the "home", after that the material includes various supporting materials that have been detailed such as prerequisite material, Egyptian pyramids, definition of pyramids, pyramid surface area, and pyramid volume. Furthermore, there is the AR Menu which consists of the concept of pyramid, types of pyramids, the concept of pyramid surface area, and the concept of pyramid volume. Last, a quiz will be given which user can also immediately find out the scores obtained in doing the quiz.

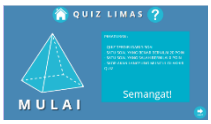
The initial versions have been compiled using storyboard to clarify and make it easier for developer in the process of arranging text, buttons, images or videos, and other things on each slide. The function of the storyboard is to provide a clear picture of the concept (Kunto & Ariani, 2021). The initial version of the storyboard on the electronic module is as follows:

Table 4 The Storyboard Initial Version of E-Module

Storyboard of the Augmented Reality	
Sketches	**Description**

	This feature is one of the screenshots of Augmented Reality animation about the types of pyramids
	This feature is one of the screenshots of the Augmented Reality animation regarding the concept of a pyramid with attributes such as side length, base, pyramid height, and side height.
	This feature is a screenshot of an Augmented Reality animation regarding the surface area of a pyramid with an animation concept such as an opened pyramid so that the nets of the pyramid are visible. The nets are colored so that the existing color shows the concept of the surface area of the pyramid.
	This feature is a screenshot of an Augmented Reality animation regarding the volume of a pyramid, which is showed by filling pyramid with water. It explains that water in a pyramid is assumed as the volume of a pyramid.

Storyboard of the Media Menus and Features

Sketches	Description
	The slide is the loading screen to go to the main menu
	This slide is the main menu that contains various menu options such as Material, AR Menu, Quiz, Exit Button, and Guide
	This slide is a menu content of guides containing AR explanations and Basic Competencies presented in this electronic module
	This slide is a menu content of pyramid material, including knowledges and fun facts related to the Egyptian pyramids, the definition of pyramids, the surface area and volume of pyramids
	This slide is a menu content of Augmented Reality, including the concept of pyramid, types of pyramids, the concept of pyramid surface area, and the concept of pyramid volume
	This slide is the part of quiz, which users can immediately find out the scores after completing the quiz

Furthermore, the researcher compiled the contents of the electronic module such as materials, quizzes, and so on which had been arranged according to the theme and plot in the initial version.

Development Stage

At the Development Stage, the first stage is to arrange the complete design. The next stage is to use Blender 3D for modeling 3D objects and the planned animation

Figure 2 Process of creating an AR Limas design using Canva

according to the initial concept. The Blender 3D application was chosen because it is quite flexible in designing an object, can be used as animation, the features presented are complete, and can be downloaded freely on the official website. Beside, this application is open-based source to make it easier to trace the results of projects that have been done as a reference for developing 3D objects. Then, the researcher used Unity 3D to create an overall

design and existing features. Unity 3D software was chosen because it has full features for making electronic module.

There are many studies on the development of electronics modules with augmented reality using Unity

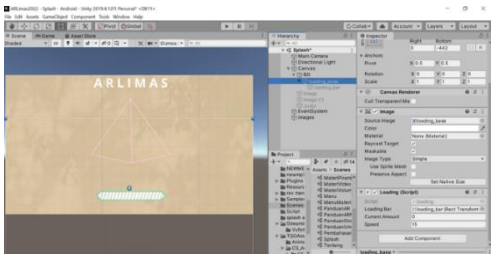


Figure 3 Electronic module arrangement in Unity 3D

3D, one of which is research conducted by Amelia, Wedi, and Husna (2022) about the development of Augmented Reality-assisted module with puzzles on geometric three dimensional shapes. Researcher also use the Vuforia SDK tools so that 3D objects that have been created in 3D Blender can detect markers so that they become Augmented Reality that function properly. Augmented Reality contained in the electronic module is the concept of pyramid, which includes pyramid attributes, various types of pyramids with animation, the concept of pyramid surface area with animated concepts showing that the surface area is such as the concept of colored pyramid nets, and the concept of pyramid volume which is animated such as pyramids filled with water.

After the media is compiled, at this stage the electronic module is validated by experts who are experts of material, media, and practitioners to determine the appropriateness of using this electronic module. There are three validators, including lecturer in the Department of Mathematics, FMIPA UNESA, who is expert in materials and media, previous researcher who has developed an Augmented Reality-based electronic module, and junior high school teacher as practitioner of the results of expert validation questionnaires. Based on the results of expert validation, it can be concluded that the developed electronic module is in the good or valid category with a percentage of 86.59%. In general, material expert validator provides an evaluation that the developed e-module is feasible to use with many revisions. Meanwhile, media expert and practitioner stated that the e-module was feasible to use without revision. All expert validators provide some suggestions so that the e-module can be revised before being tested on students as research subjects.

Based on the experts validation questionnaire result, there were several criteria for aspects of module development that are considered less than optimal so that revisions are needed, especially in aspect of format such as 1) direction of Augmented Reality-based Electronic Module in discovering the concept of pyramid surface area and pyramid volume to be studied, and in aspect of content such as 1) clarity of instructions for using Augmented Reality (AR) on Augmented Reality-Based Electronic Module; and 2) the suitability of Augmented Reality objects with the material used in Augmented Reality-Based Electronic Module. The following are suggestions or comments from experts that validate the development of electronic module and some of the differences of the display before and after revision:

Table 5 The Revision Results of Media Expert Validator

Suggestions	Before	After Revision
Developer should consider the selec-tion of application design	The previous design selection used a blue theme with a simple design without accessories	The design after the revision uses a design with a pyramid color theme but still looks futuristic so that students are more interested
Adding an symbol to the sides of a regular n-sided pyramid to indicate the same length	There was no symbol to indicate the equal sides on a regular pyramid	There is a symbol to indicate equal sides on a regular pyramid
Some buttons couldn't work	Some slides had previously unclickable buttons	All buttons on the application are clickable and work well and some buttons deemed inefficient have been removed
Some slides have typos	Previously unusable slides due to the wrong slide input in unity	The error has been fixed so that all unused buttons are removed or the correct command is given
Less communica-tive, add appli-cation flow and clear instructions	The flow was descriptive only and quite difficult to understand	The flow and instructions of the application have been designed with pictures and using short sentences to make it easier to understand

Suggestions	Before	After Revision
Add another pre-requisite material, such as the area of the field	There was only pythagoras as prerequisite material	There is an additional prerequisite material, namely area
Add another type of pyramid, such as irregular pyramid	There were only regular pyramids as examples of various types of pyramid	It has been added irregular pyramid
The marker has an image of pyramid that is distracting enough to run 3D animations	Used a marker with a picture of pyramid in the center of the marker	There is only a QR Code that does not interfere with 3D animation. QR Code is also given a function as a code to download applications when scanned with a smartphone barcode scanner

Implementation Stage

After the e-module has been validated and revised according to the suggestions of experts, the next stage was the implementation of the electronic module for subjects of media trial, they were 3 students who had not studied the pyramid material for junior high school level. Students were given a pretest before using the electronic module. After using the electronic module, students were again given posttest and questionnaires on the use of educational games. From the results of the questionnaire on the use of electronic module, the percentage of practicality is 98.35%. This showed that the electronics module developed is categorized as very practical in terms of practicality criteria.

Based on the results of the pretest and posttest, the average pretest score was 15 and the average posttest score obtained by students was 82.5. It is known that there were score increases from pretest to posttest. This showed that the electronic module is able to improve student learning outcomes on the pyramid material. This is also supported by Arifin, Pujiastuti, and Sudiana (2020) in their research which states that the Augmented Reality feature in learning can improve students' mathematics.

Evaluation Stage

At the evaluation stage, an analysis of the previous stages was carried out. Based on the analysis of the previous stages, this electronic module has succeeded in meeting the criteria for good learning media, namely: valid, because the results of expert validation (material and media expert, previous research expert, practitioner expert) showed a good or valid criteria at percentage of 86.59%; practical, because the results of the practicality questionnaire filled out by research subjects of 98.35% with a very good category; and effective, because the test score results of the subjects increased from the average pretest score of 15 to 82.5 in the posttest score. The benefit of the media that has been developed is that this electronic module can improve students' ability in learning pyramid and assist teachers in providing learning media.

The advantages of the electronic module developed are in addition to using new technology, augmented reality, which makes students interested in learning, the design of the module used is also very interesting so that students do not get bored in learning the material on developed electronic module. This module also used an easy-to-understand language and almost all Android smartphone users can use this electronic module.

While the disadvantages of the developed electronic module are that there are still many bugs in augmented reality animation such as the sound of water and the explanation of the pyramid volume that are colliding on some smartphones, the color of the edge is not clear, and other things that make the animation quite difficult to see. Another disadvantage is the lack of practice questions and interactions that can be carried out by students, especially in the AR animation feature. Researcher hope that further research can avoid the existing shortcomings.

CONCLUSION

This research has an output in the form of learning media, namely an electronic module with Augmented Reality which is named "AR LIMAS" with an .apk application format. After several stages of development, the module was evaluated and it can be concluded that the electronic module has met the criteria of a good learning media based on several evaluation results, including (1) the validity score percentage of the electronic module reaching the percentage of 86.59%, (2) the percentage of practicality of use the electronic module reached 98.35% with a very practical category, and (3) the results of the pretest and posttest showed that there is score increasing which showed that this media is effective in increasing students' understanding on pyramid.

This electronic module still has limitations in its development, such as making 3D animations that are less than optimal so that some animation features are not very

clear for students to understand. Based on the results of this study, the author suggested to make improvements related to electronic modules as interactive learning media in further research.

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