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ACTIVITIES FOR USING THE PMRI E-MODULE ASSISTED BY AUGMENTED REALITY

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Abstract

This research is motivated by changes in the curriculum that require students to learn independently. This study aims to describe the activities carried out by students using the PMRI e-module assisted by augmented reality. The research method used is descriptive qualitative. The stages of the research are preparation, implementation, and reporting. The data collection techniques used are observation and documentation. Qualitative data are analyzed using data reduction, data presentation and drawing conclusions. The subjects of the study were 17 students at SMP IT Islam Al Azhar 33 Palembang. The results of observations of the implementation of learning during 2 meetings with 4 activities were in accordance with the stages of problem solving. In the first activity, students were not yet familiar with the stages of problem solving, namely providing temporary answers and writing down what is known and asked. However, after carrying out the second activity, students were accustomed to the activities given systematically and using the help of augmented reality which can help students be more independent in the visualization process. Thus, the activity of using the PMRI e-module assisted by augmented reality can help students learn flat shape material easily.

Keywords: Augmented Reality, E-module, PMRI

Abstrak

Penelitian ini dilatarbelakangi oleh perubahan kurikulum yang menuntut siswa untuk belajar mandiri. Penelitian ini bertujuan untuk menggambarkan aktivitas yang dilakukan siswa menggunakan e-modul PMRI berbantuan augmented reality. Metode penelitian yang digunakan yaitu deskriptif kualitatif. Adapun tahapan penelitian yaitu persiapan, pelaksanaan, dan pelaporan. Teknik pengumpulan data yang digunakan adalah observasi dan dokumentasi. Data kualitatif dianalisis dengan menggunakan reduksi data, penyajian data dan menarik kesimpulan. Subjek penelitian yaitu 17 siswa di SMP IT Islam Al Azhar 33 Palembang. Hasil observasi pelaksanaan pembelajaran selama 2 pertemuan dengan 4 kegiatan telah sesuai dengan tahapan pemecahan masalah. Pada kegiatan pertama siswa belum terbiasa dengan tahapan pemecahan masalah yaitu memberikan jawaban sementara dan menuliskan yang diketahui serta ditanya. Akan tetapi, setelah melakukan kegiatan kedua siswa sudah terbiasa dengan aktivitas yang diberikan secara sistematis dan menggunakan bantuan augmented reality yang dapat membantu siswa lebih mandiri dalam proses visualisasi. Sehingga, Aktivitas penggunaan e-modul PMRI berbantuan augmented reality dapat membantu siswa mempelajari materi bangun datar dengan mudah.

Kata kunci: Augmented Reality, E-Modul, PMRI

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To overcome educational problems in Indonesia, the Ministry of Education and Culture launched a curriculum called the independent learning curriculum (Kemdikbud, 2022). One of the meanings of freedom to learn is independent and creative learning (Daga, 2021). Independent learning is interpreted as learning on one's own will and initiative, with or without help from other people (Tampubolon, 2020). Independent learning gives students the freedom to determine their own learning method, time and materials. This allows students to take an active role in their learning process, seek out additional

information, work on assignments in creative ways, and take responsibility for their own learning (Kania, 2022; Rizky & Astutik, 2021). This not only helps them understand the course material better, but also encourages students to become more responsible for their academic progress and can increase their motivation and engagement in the learning process.

In mathematics lessons it seems difficult to learn independently, this is because the majority of students think that mathematics is a lesson that is very difficult to imagine (Bela et al., 2021). Reality shows that many students have difficulty understanding mathematical concepts without direct guidance from the teacher. In overcoming these problems, efforts are needed to utilize advances in science and technology (IPTEK). Teachers are required to innovate in learning and develop digital-based teaching materials (Ramadhani & Fitri, 2020). Without innovative and easily accessible teaching materials, students often feel overwhelmed and unmotivated to learn independently. Innovative teaching materials are teaching materials that are creative and interesting and can be used at any time (Irmawati et al., 2020). The teaching materials currently needed are teaching materials that can support the quality of learning, such as e-modules (Arjana & Upayogi, 2022).

E-modules are flexible teaching materials because they can be used during online and offline learning (Lestari et al., 2022). The use of e-module teaching materials also allows students to learn independently (Muzijah et al., 2020). The e-modules provided are tailored to the problems around students (Widiastuti, 2020). This is adapted to the existing context of the PMRI approach (Efriani et al., 2018b; Maghfiroh et al., 2021). PMRI is a mathematics learning approach that places emphasis on student activities and relies on real problems for students (Dewi & Agustika, 2020; Efriani et al., 2019). E-modules that use the PMRI approach with stages of using context, model of, model for and formal are able to understand abstract mathematical concepts, so they can increase learning interest and achievement (Efriani et al., 2023; Mashuri et al., 2019).

Facts on the ground show that learning has not been carried out effectively. Learning still uses teaching materials available on the market. Even though there has been a lot of research on e-module development which has been categorized as valid and practical, such as research by Sukmawarti & Pulungan (2022) using the context of Malay traditional houses, Nurqolbi (2020) using RIAU batik motifs, Efriani (2018a) using a sports context, Arifin (2023) uses a shooting auction context, Thahara (2023) uses a Malay cultural context, Hartatiana (2023) uses gending sriwijaya context, Efriani (2023) and Efriani (2024) use sweet potato balls, Fika (2020) uses problem posing. However, the use of the e-module developed has not been optimal.

To overcome the ineffectiveness of learning in schools, it can be overcome through the use of PMRI e-modules assisted by augmented reality (Gao et al., 2023; Koparan et al., 2023). The use of augmented reality as a manipulation of models in a form that matches reality so that it can be well received by students (Rachmawati et al., 2020). AR technology can combine virtual world objects into

real-world displays in real time (Adrian et al., 2020; AM Arifin et al., 2020). Apart from that, the use of AR can also construct abstract learning to be more contextual according to the characteristics of PMRI. AR enables integration between the real world and the digital world, so that abstract mathematical concepts can be visualized in three-dimensional form that is interactive and real for students. The use of AR in mathematics learning not only makes abstract concepts more real and easier to understand, but is also in line with the PMRI approach which focuses on using real context and models to bridge students' understanding from the real world to the more formal world of mathematics.

The use of PMRI e-modules assisted by Augmented Reality in mathematics learning can help achieve one of the competencies that students must have, namely problem-solving abilities. Because in learning using e-modules, paying attention to problem-solving abilities can begin with the use of context in the problem (Arifin et al., 2023; Thahara et al., 2023). In the process of solving problems through the PMRI stages, namely at the stage of constructing students' thinking from concrete to abstract, they can be assisted using augmented reality media. So with the use of augmented reality, students gradually learn mathematics. This is in accordance with the stages in PMRI, namely model of and model for. Referring to the description above, so researchers are interested in conducting research with the aim of describing student activities using e-modules assisted by augmented reality.

METHOD

This research uses descriptive research (Fraenkel et al., 2012). This research was conducted at Al Azhar 33 Islamic Middle School in Palembang with 17 students from class VIII.C as research subjects. Random selection of subjects from 3 digital classes at the school (Suliyanto, 2018). The reason underlying the selection of SMP or MTs students as research subjects is the characteristics of SMP or MTs students who generally still tend to think concrete operationally towards formal thinking, so they still need real situations in learning. Apart from that, junior high school students also have a lot of mathematical facts and concepts.

This research consists of three stages, namely preparation, implementation, and reporting (Sugiyono, 2016). In the preparation stage, researchers prepare research instruments, learning scenarios, and arrange permits. Meanwhile, at the implementation stage, treatment was carried out in the trial class, namely conducting learning using the PMRI e-module assisted by augmented reality, making observations during learning. At the reporting stage, the researcher analyzes the results of the data obtained at the implementation stage, analyzes the results of observations to see the achievement of the activity. After completing the analysis results, the results are presented in the form of a report.

Data collection techniques are carried out using documentation and observation. Documentation is a data collection technique by searching for and analyzing documents related to research (Sugiyono, 2016). Documentation was carried out to see the suitability of the device with the PMRI approach, the

use of augmented reality in the e-module, and problem-solving abilities in the e-module work process. Furthermore, observation is a complex process of various biological and psychological processes (Sugiyono, 2016). Observations were carried out to obtain data about students' activities following learning using the PMRI e-module assisted by augmented reality. The assessment component is related to student activities, namely academic changes, attitudes, skills, and behavior based on PMRI indicators and problem-solving.

The data was analyzed using qualitative data analysis, namely reducing data, presenting data, and drawing conclusions (Rijali, 2018). Reducing data means selecting, focusing, simplifying, and transforming the data obtained from data collection carried out through documentation in the form of e-modules used by students and observations made in the classroom to see the learning process carried out by the teacher. Then in presenting the data, the data that has been collected is presented and arranged in the form of narrative text to describe the student activity process using the PMRI e-module assisted by augmented reality. The description of the activity process is adjusted to the principles and characteristics of PMRI as in table 1.

Table 1. PMRI Principles

PMRI Principles	*PMRI Activity Descriptor*
Rediscovery *guided reinvention and progressive mathematizing*	1. Exploring context 2. Respond to questions 3. Ask about the lesson material 4. Pay attention to the explanation
Learning phenomena *didactical phenomenology*	1. Complete activities in stages 2. Using information
A model that builds itself *self-developed models*	1. Discuss between students 2. Finding connections 3. Sums up the whole 4. Complete the assigned tasks

In addition to considering the principles and characteristics of PMRI as in table 1, the description of the activity is seen based on problem solving indicators as in table 2.

Table 2. Problem-Solving Descriptors

Problem-solving indicators	*Problem-Solving Activity Descriptor*
Understanding the problem	1. Provide a temporary answer 2. Write down what you know and answer it

Strategy discovery	1. Make a plan 2. Estimating strategy
Strategy implementation	1. Solve the problem 2. Arrange a solution
Re-examination	1. Checking correctness 2. Make conclusions 3. Delivering work results

Tables 1 and 2 are descriptors of problem-solving indicators and PMRI principles. There are 20 descriptors used to see student involvement in learning activities as in tables 1 and 2. The descriptors in tables 1 and 2 are presented in the form of observation sheets. Then the observer checks the activities that occur when students use the PMRI e-module assisted by augmented reality according to the instructions provided.

Finally, conclusions are drawn, the conclusions drawn are based on the results of activities using the PMRI e-module assisted by augmented reality. The validity of the data will be tested based on various sources, namely matching the data obtained with the problem-solving stages being measured like in table 2.

RESULT AND DISCUSSION

This research consists of three stages, namely preparation, implementation, and reporting. In the preparation stage, researchers prepare research instruments. The results of the preparation stages that have been carried out are analysis, design, product development. The results of the analysis obtained are needs analysis, curriculum analysis, and student analysis. The results of the needs analysis concluded that what students need are geometry teaching materials that can help students visualize objects. The results of the curriculum analysis showed that students still had difficulty with the material on flat-sided spatial figures. Also, the results of the student analysis showed that students liked the problems given according to their environment.

The design results were carried out starting from collecting reference materials such as selecting applications that would help in the process of making e-modules, namely Canva, applications that help in visualization, namely augmented reality, and selecting problems raised in the flat-sided spatial geometry e-module, namely the typical Palembang cupboard and the Lawang Kidul Mosque. In addition, the design was carried out by making a flowchart so that the material presented was systematic. After the flowchart design was completed, it was continued with the design of the storyboard (paper base). In the process of designing the flat-sided spatial geometry e-module, the characteristics and principles of PMRI were still considered as well as problem-solving indicators according to the results of the needs analysis and student analysis. Then continued with product development and validity testing by experts. The following is an example of a product that has been developed as in figure 1.

Figure 1. E-Module Product

The instruments produced at the preparation stage were not only made but also went through development stages so that the instruments to be tested had validity, practicality and had potential effects. The results of the Instrument test have been published in one of the articles, namely (Thahara et al., 2023) regarding the e-module on flat-sided spatial figures using the Malay cultural context of pyramid material using the Lawang Kidul mosque context.

At the implementation stage, treatment was carried out in a trial class, namely carrying out learning using the PMRI e-module assisted by augmented reality and observing activities during learning. The research implementation process was carried out at Al Azhar 33 Islamic Middle School in Palembang in 3 meetings. The first meeting was held on 7 September 2023 related to the pre-test and providing material for activities 1 and 2. The second meeting was held on 8 September 2023 related to activities 3 and 4. The third meeting was held on 11 September 2023 related to reflection and post-test. To answer problems, the activities carried out by students during the learning process are at meetings 1 and 2. The details of the implementation of research activities are as follows.

The first meeting was carried out by giving a pretest, activity 1 and activity 2. In the pretest, students were given 2 description questions related to flat-sided shapes, namely cubes and blocks. Next, learning is carried out by doing activity 1 and activity 2. In activity 1, students are given material related to cube nets and the surface area of cubes. Students work on problems according to the stages of problem-solving. At the problem understanding stage, students are asked to read the e-module and understand the problems in activity 1 as in Figure 2. Also at this stage, students simulate nets and the surface area of a cube using the augmented reality that has been provided. Augmented reality is used using the EDU assembler application. Next, students work individually on the problems given. Then, after students have worked individually, students are asked to discuss together with their classmates. Then students present the results of the discussion of the problem given and draw conclusions from the

activities that have been carried out regarding nets and the surface area of the cube. In activity 2, students are given material related to the volume of a cube. The same thing was done in the second activity. Students work on problems according to the stages of problem-solving. At the problem understanding stage, students are asked to read the e-module and understand the problems in activity 1. At this stage, students simulate the volume of a cube using the augmented reality that has been provided as in Figure 3. Next, students work individually on the problems given. Then, after students have worked individually, students are asked to discuss together with their classmates. Then students present the results of the discussion of the problems given and draw conclusions from the activities carried out regarding the volume of the cube.

Figure 2. Understanding Process Problems in Activity 1

Figure 3. Cube volume simulation using *Augmented Reality*

The second meeting was carried out by giving reflection, activity 3 and activity 4. The reflection activity was carried out to review the material on the area and volume of the cube that had been given previously as in figure 4. Next, learning was carried out by doing activity 3 and activity 4.

Figure 4. Reflection on Meeting 1

Figure 5. Students write strategies for problems

In activity 3, students are given material related to block nets and the surface area of blocks. Students work on problems according to the stages of problem solving. At the problem understanding stage, students are asked to read the e-module and understand the problems in activity 1. At this stage,

students simulate nets and the surface area of blocks using the augmented reality that has been provided. Next, students work individually on the problems given. Then, after students have worked individually, students are asked to discuss together with their classmates. Then students present the results of the discussion of the problem given and draw conclusions from the activities that have been carried out regarding nets and the surface area of blocks.

In activity 4, students are given material related to the volume of blocks. The same thing is done in the second activity. Students work on problems according to the stages of problem solving. At the problem understanding stage, students are asked to read the e-module and understand the problems in activity 1. Also at this stage, students simulate the volume of blocks using the augmented reality that has been provided. Next, students work individually on the problems given by writing down strategies for the problems as in Figure 5. Then, after students work individually, then students are asked to discuss together with their classmates. Then students present the results of the discussion of the problem given and draw conclusions from the activities carried out regarding the volume of the block.

Meetings 1 and 2 were carried out using the PMRI e-module assisted by augmented reality. The e-module used also trains students' problem-solving abilities. So, the stages used to complete the e-module also use problem solving stages. Then the implementation process is observed in accordance with PMRI indicators and problem-solving abilities.

At the reporting stage, researchers analyzed the data obtained at the implementation stage. Reporting of observation results is obtained from the results of activities carried out by students using the PMRI e-module assisted by Augmented Reality at each meeting by adjusting PMRI indicators and problem-solving.

The implementation activity of learning using PMRI e-modules assisted by augmented reality is reviewed from 2 aspects, namely the PMRI aspect and problem solving. At the first meeting, there was 1 out of 10 aspects of PMRI that was the lowest, namely related to the descriptor asking about lesson material that was not yet understood. While in the problem-solving aspect, there were 3 out of 10 aspects that were the lowest, namely providing temporary answers to problems raised by the teacher related to the material to be studied, compiling problem solving with different steps, and making conclusions from the problems/materials given. while at the second meeting, there was no aspect that was the lowest, both the PMRI aspect and problem solving. It's just that the results are not optimal but are above average.

From these two aspects, the weaknesses that occurred were seen in the problem-solving aspect at the first meeting. After further review, students are not yet accustomed to carrying out the problem-solving process using problem-solving stages. Students are not used to giving temporary answers and writing down what is known and asked. Students only answer directly to the problems given. Students consider the final answer to be the important point of the problem given. Based on the results of Aulia's research (2021) the treatment given to these students included technical errors. This is in line with

Sulistio et al. (2019) who stated that technical errors occurred because the subjects were not careful even though they actually knew the meaning of the questions. The same error was also expressed by Patricia & Zamzam (2020) who explained that students did not write down the requirements given because they were not thorough in their work. Actually, students know what they know and are asked, it's just that students don't write it down. After being given an understanding regarding the importance of writing down the information provided by the questions, at the second meeting students began to get used to writing down the information. This is also in line with the opinion of Farida (2015) that technical errors can be anticipated by teachers frequently reminding students to read the questions carefully and rechecking the results of the work carried out in order to minimize mistakes made by students.

The results of the study indicate that the use of PMRI e-modules assisted by augmented reality can train students' problem-solving skills. This can be seen from the activities contained in the e-module which initially students were not accustomed to carrying out the problem-solving process but with the stages in the e-module it can train students to work systematically according to their problem-solving abilities. In addition, with e-modules that are already systematic and use augmented reality assistance, students are more independent in the visualization process, making it easier for them to rotate the objects given in the problem.

CONCLUSION

Student activities during the learning process can be seen through observations of the implementation of learning. The results of observations of the implementation of learning during 2 meetings with 4 activities showed that at the first meeting students were not yet accustomed to carrying out the problem-solving process with problem-solving stages. Students were not yet accustomed to providing temporary answers and writing down what was known and asked. However, after carrying out the second activity, students were accustomed to the activities given systematically and using augmented reality assistance which could help students be more independent in the visualization process. Thus, the activity of using the PMRI e-module assisted by augmented reality can help students learn flat shape material easily, only students need to be given an understanding regarding the importance of writing down the information provided by the questions to solve problems according to the stages of problem solving. This is because students consider the final answer to be the important point of the problem given, resulting in students not yet accustomed to providing temporary answers and writing down what is known and asked.

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