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# PythaMath: Interactive mathematics learning media based on problem-based learning oriented to the numeracy ability of grade VIII students

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**Abstract:** Previous studies have explored interactive mathematics media and Problem-Based Learning (PBL). However, PBL-based interactive media oriented toward students' numeracy skills on the Pythagorean theorem remain limited. Therefore, this study aims to develop and test the validity, practicality, and effectiveness of interactive learning media 'PythaMath' based on PBL on the Pythagorean theorem material that is oriented towards the numeracy skills of grade VIII students. The method used in this study is Research and Development (R&D) with the ADDIE development model (Analysis, Design, Development, Implementation, and evaluation). The subjects of this study were grade VIII students of SMP Negeri 2 Salaman. The results of the validity test showed that 'PythaMath' was in the "good" category, the practicality test showed a very positive student response with the "very good" category, and the effectiveness test showed that this interactive learning media was effective for use in learning seen from the significance of the posttest of the control class and the experimental class which showed that the significance value was less than 0.05. The interactive mathematics learning media 'PythaMath' is also able to provide a more active and independent learning experience and its ease of access offline.

**Keywords:**
Interactive Mathematics Learning Media, Mathematics, Numeracy Skills, Problem-Based Learning

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## 1. Introduction

The process of teaching and learning is an important thing in education because the process that is passed determines success or achievement for students (Lestari et al., 2023; Shutaleva et al., 2023). However, in the current learning process, teachers often teach material only by the lecture method, so that learning is teacher-centered (Guntur & Setyaningrum, 2021; Nugroho et al., 2024). This causes the learning process to be ineffective, making the next concept more difficult for students to understand because the previous concept (which is the basis) has not been mastered properly (Darmayanti et al., 2022; Ningsih et al., 2021). Furthermore, the use of learning media that has not been optimally carried out by teachers

can make it easier for students to understand, considering that technology is currently developing rapidly.

It is undeniable that the development of technology and information in Indonesia has brought people's civilization to a new era called the digital era (Ade et al., 2024; Geiger et al., 2015; Mellawaty & Taufan, 2021). In this latest era, the world of education is in dire need of technology because it can facilitate the teaching and learning process so that students become more active and independent in seeking information about the field of education (Ishartono et al., 2024). There are several forms of technology that can be used to support the learning process itself, such as Learning Management System (LMS), interactive multimedia, mobile learning applications (M-Learning), educational games, learning videos, AI, and many others (Nugroho et al., 2024). One of the technologies that is easy and can be applied by teachers is interactive multimedia, which can help teachers to create more interactive modules.

According to Boadu & Boateng (2024), a learning media is said to be suitable for use by teachers and students when it has several characteristics, namely (1) it has a clear learning objective, (2) the material is in accordance with the competencies to be achieved, (3) the concepts of the material are presented correctly, (4) the explanation of the material is in accordance with the student's thinking ability, (5) the learning flow in the media is clear, (6) there are clear instructions, (7) there is an apperception section, (8) there are conclusions, examples, and exercises accompanied by feedback, (9) can arouse students' motivation to learn, (10) there is an evaluation accompanied by discussion, (11) images, animations, text, and colors are presented in harmony, (12) it is interactive, (13) navigation or direction is easy, and (14) the language used is easy for students to understand.

The use of interactive learning media is very supportive of the sustainability of learning today (Abdullah et al., 2022; Andari et al., 2024; Choirudin et al., 2020; Damayanti et al., 2023; Irawan et al., 2023; Nugroho et al., 2024; Suendarti et al., 2022). Of course, this cannot be separated from the application of the learning model that will be used in learning. One of the learning models that can be applied is problem-based learning (PBL). According to Patmara et al. (2020); Suratno & Waliyanti (2023), PBL or Problem-Based Learning is a learning model that has a distinctive characteristic, namely the use of daily life problems as a problem that students must learn to train and improve critical thinking and problem-solving skills, as well as gain knowledge of important concepts. Patmara et al. (2020); Suratno & Waliyant (2023) said that there are five steps in problem-based learning, namely (1) orienting students to problems, (2) organizing students in learning, (3) guiding individual and group investigations, (4) developing and presenting the results of work, and (5) analyzing and evaluating the problem-solving process. The selection of this problem-based learning model is suitable for numeracy skills because the components of numeracy skills are related to daily life.

According to the World Economic Forum (WEF), numeracy is one of the 16 skills needed in the 21st century. Based on the latest PISA results in 2022, the results show that the numeracy or mathematics literacy scores of Indonesian students are still below the international average score of 359, even though the international average score is 500 (OECD,

2023). In addition, based on the 2023 education report card, the results of the AKM in the field of numeracy also show that the numeracy ability of junior high school students is still in the poor category (Astuti et al., 2024). In numeracy, several components must be considered, such as (1) content, (2) context, and (3) cognitive level.

Based on the content of numeracy skills, one of the subjects that can improve numeracy skills is the Pythagorean theorem material, because, based on the PISA results, the average Indonesian geometry score on the space and shape mathematics content scale is 367, which is far below the OECD average of 471 (OECD, 2023). Students must master several concepts related to the Pythagorean theorem because students or students will find it difficult if they are not able to master these concepts. According to Cahyanindya & Mampouw (2020); Rangkuti & Siregar (2020) said that the causes of difficulties in solving Pythagorean theorem material problems are (1) students are not used to writing down things that are known and asked, (2) students are still not used to concluding a mathematical problem, and (3) participants have not fully understood the concept of the Pythagorean theorem so that there are still conceptual errors in students.

Several previous studies have discussed a lot about interactive mathematics learning media to improve numeracy skills, ranging from learning videos, e-modules, e-LKPD, comics, to educational games. One of them is research conducted by Tanjung & Widodo (2024). The development product produced by the website-based numeracy learning application is "Metricfy. This "Metricfy" learning media has advantages and disadvantages. The advantages are (1) learning materials in complete numeracy, ranging from numbers to geometry, (2) admins can process data modules, users, blogs, or quizzes, (3) can be accessed anytime and anywhere through any device. In addition to the advantages, the learning media developed also has weaknesses, namely (1) cannot be accessed offline, (2) is not suitable for elderly teachers, (3) requires coding in the preparation of the website. Therefore, the researcher has the idea to develop an interactive mathematics learning media 'PythaMath' with a problem-based learning model oriented to numeracy skills.

## 2. Methods

The type of research used in this study is R&D (Research and Development). R&D research is a research method that aims to produce a certain product, which will then be tested for its effectiveness of the product (Molenda, 2003; Nugroho et al., 2024). The development model used is ADDIE, with five stages carried out to produce a product. The five stages consist of the analysis stage, the design stage, the development stage, the implementation stage, and the evaluation stage. The subjects used in this study were grade VIII students at SMP Negeri 2 Salaman, Magelang, with the provision of class VIII A as the experimental class and class VIII B as the control class. The data analysis technique used is the Likert Scale, which involves converting qualitative data into quantitative data with the following score provisions.

## 2.1 PythaMath Media Validity Test

According to Widoyoko (2012), there are several steps to complete to test the validity of a learning media product as follows.

$$Mean = \frac{\Sigma_x}{N} \quad (1)$$

**Note:**

Mean : Average score

$\Sigma_x$ : Total scores obtained

N : The total number of items

Furthermore, after the calculation of the mean of each data is carried out, it is necessary to match the average with the criteria of the validity of the learning media that have been set (see Table 1).

**Table 1.** Convert Quantitative Data to Qualitative Data

| Score Interval | Quality Criteria |
|---|---|
| X > Xi + 1,8 Sbi | Excellent |
| Xi + 0,6 Sbi < X ≤ Xi + 1,8 Sbi | Good |
| Xi - 0,6 Sbi < X ≤ Xi + 0,6 Sbi | Enough |
| Xi - 1,8 Sbi < X ≤ Xi - 0,6 Sbi | Less |
| X ≤ Xi - 1,8 Sbi | Very less |

**Note:**

X (Empirical score) : Average score of evaluators (media and material experts)

Xi (Average) : $\frac{1}{2}$ (Maximum score + minimum score)

Sbi (Standard Deviation) : $\frac{1}{6}$ (Maximum score + minimum score)

Then, based on the table, the quality criteria for interactive mathematics learning media can be seen in Table 2.

**Table 2.** Criteria for Quality of Learning Media Validity

| Score Interval | Quality Criteria |
|---|---|
| X > 4,2 | Excellent |
| 3,4 < X ≤ 4,2 | Good |
| 2,6 < X ≤ 3,4 | Enough |
| 1,8 < X ≤ 2,6 | Less |
| X ≤ 1,8 | Very less |

## 2.2 PythaMath Media Practicality Test

The practical test of this interactive learning media was obtained from the analysis of the results of the response questionnaire from students by calculating the average score of each existing aspect (see Table 3).

**Table 3.** Assessment Scale of Student Response Questionnaire

| Criteria | Score |
|---|---|
| Strongly agree | 4 |
| Agree | 3 |
| Disagree | 2 |
| Strongly Disagree | 1 |

Based on the assessment scale in Table 3, the average score that has been obtained will then be converted into quality criteria referring to Table 1 so that media practicality assessment criteria are obtained based on the following student response questionnaire (see Table 4).

**Table 4.** Assessment Criteria for Student Response Questionnaire

| Score Interval | Quality Criteria |
|---|---|
| $X > 3,4$ | Excellent |
| $2,8 < X \leq 3,4$ | Good |
| $2,2 < X \leq 2,8$ | Enough |
| $1,6 < X \leq 2,2$ | Less |
| $X \leq 1,6$ | Very less |

## 2.3 PythaMath Media Effectiveness Test

This effectiveness test is measured using a test based on the numeracy ability of students in the form of *a posttest*. The data analysis used to determine the effectiveness of the media is as follows.

### *Classification of numeracy ability*

According to Wijaya (2023) The score or score obtained by each student has four levels of numeracy ability to classify it.

**Table 5.** Classification of Numeracy Ability

| Level | Score |
|---|---|
| Need special intervention | $\leq 25$ |
| Basic | 25,01 – 50 |
| Deft | 50,01 – 75 |
| Advance | 75,01 – 100 |

Furthermore, an effectiveness analysis was also carried out based on the classification of the effectiveness of learning media on the results of the students' numeracy ability test.

Based on Table 1, a classification of the effectiveness of the media against the numeracy ability test will be obtained, which can be seen in Table 6.

**Table 6.** Classification of Media Effectiveness with Numeracy Ability Test

| Score Interval | Criteria |
|---|---|
| X > 80 | Very High |
| 60 < X ≤ 80 | High |
| 40 < X ≤ 60 | Medium |
| 20 < X ≤ 40 | Low |
| X ≤ 20 | Very Low |

*Using an independent sample t-test*

The test is carried out with the Kolmogorov – Smirnov Test, which we often abbreviate as the KMO Test. This test was carried out by comparing *the posttest* scores of students' numeracy ability between the control class and the experimental class using SPSS. Hypothesis testing is done by making decisions from comparing values $t_{value}$ dengan $t_{table}$ with the following provisions.

$H_0$ : There was no average difference between the two groups.

$H_a$ : There was an average difference between the two groups (95% confidence level)

1) If $\pm t_{hitung} < \pm t_{tabel}$, it $H_0$ was accepted and $H_a$ was rejected.
2) If $\pm t_{hitung} > \pm t_{tabel}$, it $H_0$ was rejected and $H_a$ was accepted.

In addition, decision-making can also be seen from the significant level of p (Sig(2-tailed)), namely if p > 0.05 then $H_0$ accepted and if p < 0.05 then $H_0$ was rejected (Triton, 2006).

## 3. Results And Discussion

### 3.1 Analysis

This research began by analyzing several things needed, such as needs analysis, curriculum analysis, material analysis, student analysis, and *software* analysis. Based on the results of observations and interviews with mathematics teachers at SMP Negeri 2 Salaman, some information was obtained that teachers at the school had never used learning applications because of the limitations possessed by teachers in developing them. As for the material that is a challenge in understanding for students, one of them is the Pythagorean theorem material in grade VIII. This can happen because the abilities possessed by each student are different, which affects the learning process. Therefore, the researcher developed a learning media using *software* that is easy to apply by people who may not be proficient in coding. One of the *software* that can be used is *Articulate Storyline* 360.

### 3.2 Design

After obtaining some of the necessary needs, the researcher designs the learning media or products to be applied. This learning media is named 'PythaMath', which stands for Pythagorean *Mathematics,* according to the material that will be used in this interactive learning media, namely the Pythagorean theorem material for class VIII. The next steps are (1) Creating *a storyline* and *storyboard* to explain the plot or storyline in an outline that will later be presented in the media and to show the visual appearance of the 'PythaMath' learning application; (2) Collecting interactive learning media assets ranging from *background assets*, character assets, object assets, musical assets, and *sound effects*, as well as other supporting assets needed in the creation of learning media; and finally (3) Compiling instruments that will be used in research such as validation sheets, media response questionnaires, and test questions that will be used to measure numeracy skills.

### 3.3 Development

This stage is an important stage, namely the development of interactive learning media 'PythaMath'. The creation of this learning media was carried out using *the Articulate Storyline* 360 software. The principle of *this software* is almost like the one in *PowerPoint*, but what distinguishes it is that this *software* has additional features to make it easier to make interactive buttons. The initial view, login page, and main menu of the interactive learning media 'PythaMath' can be seen in Figure 1.


**Figure 1.** 'PythaMath' App

The start page of the learning media can be seen in Figure 1. To get to the login page, the User must press the start button on the home page. Next, the User will be asked to fill in the name and class as shown in Figure 1. After filling in and pressing the next button, the User will enter the main menu of the 'PythaMath' learning media. On this page, there are several menus such as learning outcomes, materials, practice questions, and references. The contents of each menu can be seen in Figure 2.

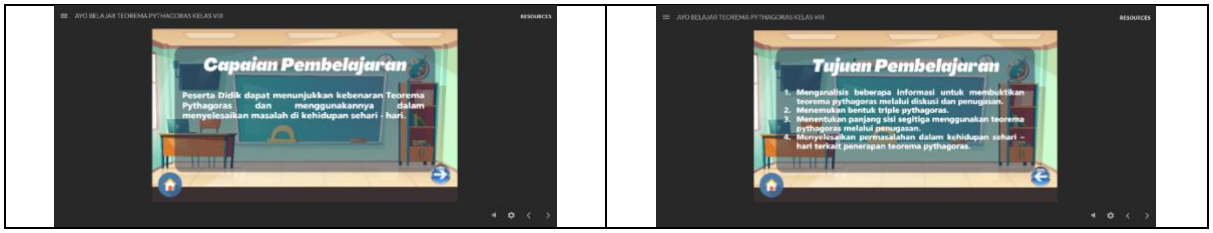


**Figure 2.** Learning Outcomes

This learning outcomes menu section contains information about the achievements and objectives of learning the Pythagorean theorem material, which can be seen in Figure 2.

Furthermore, in the material menu section, it begins with a triggering information, namely Did You Know, and in this material, there is also a sub-menu of material that is separated into three, as in Figures 3. This material menu is also equipped with explanations through videos to increase knowledge and has been adapted to the problem-based learning model, or Problem-Based Learning (PBL).

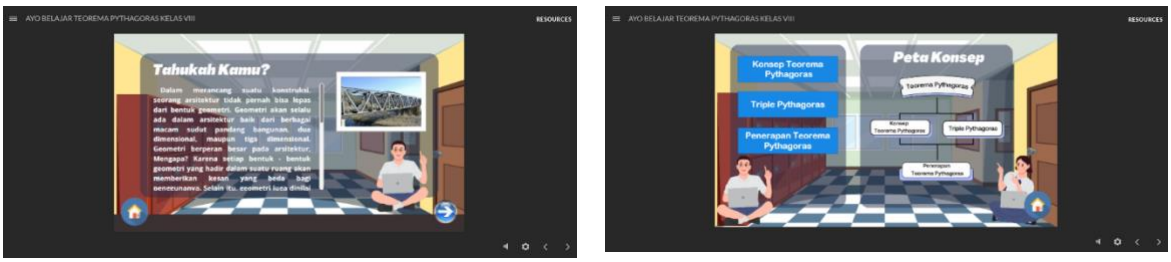


**Figure 3.** Materials Menu

Another menu contained in the main menu is practice questions and references. This practice question consists of 2 different practice questions. For practice question 1, it includes the concept material of the Pythagorean theorem and Pythagorean triple, while for practice question 2, it contains material about the application of the Pythagorean theorem, which is close to daily life, can be seen in Figure 4. Furthermore, the last menu that exists is the reference menu, which provides links related to the material of the Pythagorean theorem and can be accessed by the User as additional information about the material that can be seen in Figure 4.

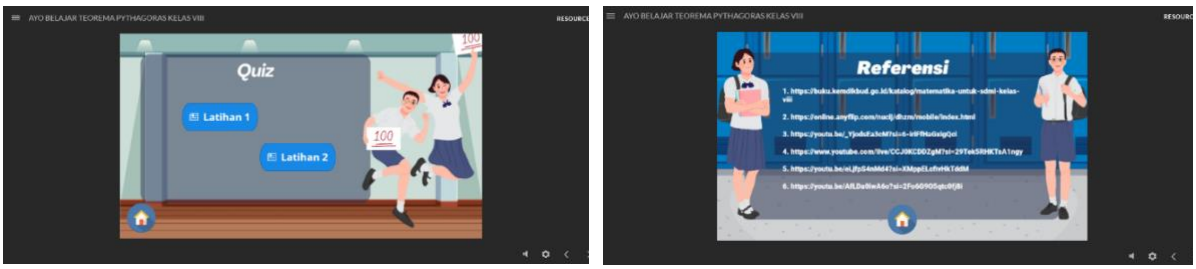


**Figure 4.** Practice Questions and References Menu

## 3.4 Implementation

After this media has gone through improvements based on suggestions from the validator team, the next stage is to conduct a trial of the interactive learning media 'PythaMath'. The trial was carried out with students of class VIII A as an experimental class and class VIII B as a control class, which took place at SMP Negeri 2 Salaman, with each class totaling 27 students. The application of this learning media is carried out by direct or face-to-face learning in the classroom with a total of three meetings starting from November 14, 2024, to November 21, 2024.

## 3.5 Evaluation

After the previous stages of the trial, enter the final stage, namely the evaluation stage, where the results will be processed and conclusions drawn on the interactive mathematics learning media 'PythaMath'. The stages of assessing the media are divided into 3, namely the validity

test, the practicality test, and the effectiveness test. In the validity analysis, the assessment was carried out by three validators who were mathematics teachers at SMP Negeri 2 Salaman. According to Nieveen (1999) The assessment criteria of this validity are divided into 3, namely content quality, instructional quality, and technical quality.

**Table 7.** Validity Assessment Results

| Aspects | Result | Kriteria |
|---|---|---|
| Content Quality | 4, 1267 | Good |
| Instructional Quality | 4,0278 | Good |
| Technical Quality | 4,125 | Good |
| **Total Average** | **4,093** | Good |

Judging from Table 7 above, the average total obtained for validity is 4.093, with the category obtained being good based on Table 2. After validity, the next test is a practicality test obtained from the questionnaire of students' responses to the interactive learning media 'PythaMath' with statements containing a total of 15 statements. The following results were obtained (can be seen in Table 8).

**Table 8.** Results of Practicality Assessment

| Items | Average | Items | Average |
|---|---|---|---|
| 1 | 3,2963 | 9 | 3,55556 |
| 2 | 3,37037 | 10 | 3,40741 |
| 3 | 3,40741 | 11 | 3,222222 |
| 4 | 3,48148 | 12 | 3,44444 |
| 5 | 3,59259 | 13 | 3,55556 |
| 6 | 3,25926 | 14 | 3,33333 |
| 7 | 3,14815 | 15 | 3,55556 |
| 8 | 3,44444 | **Total Average** | **3,404939** |

Based on Table 8, the average obtained for this practicality is 3.404939, with the category obtained, which is very good when viewed from Table 4. The last test is a test of the effectiveness of learning media, which is processed through 3 analyses, namely (1) classification of numeracy ability, (2) classification of learning media on numeracy ability, and (3) an independent sample t-test. The results of each of the effectiveness tests can be seen as follows (see Table 9).

**Table 9.** Results of Numeracy Ability Classification

| Experimental Class | | Control Class | |
|---|---|---|---|
| **Criteria** | **Percentage** | **Criteria** | **Percentage** |
| Need special intervention | 0% | Need special intervention | 0% |
| Basic | 0% | Basic | 18,52% |
| Deft | 18,52% | Deft | 81,48% |
| Advance | 81,48% | Advance | 0% |

Next, it is the result of the classification of learning media on the results of numeracy skills obtained by students from both the experimental class and the control class.

**Table 10.** Results of Media Classification on Numeracy Ability

| Experimental Class | | Control Class | |
|---|---|---|---|
| **Criteria** | **Percentage** | **Criteria** | **Percentage** |
| Very High | 55,56% | Very High | 0% |
| High | 44,44% | High | 37,04% |
| Medium | 0% | Medium | 51,85% |
| Low | 0% | Low | 11,11% |
| Very Low | 0% | Very Low | 0% |

The last effectiveness test is the independent sample t-test using the help of SPSS software. The results of the test of the control class posttest with the experimental class are as follows (can be seen in Table 11).

**Table 11.** Independent sample t-test Result

| Data Source | Sig* | Description |
|---|---|---|
| *Control* class posttest and experiment class | 0,000 | $H_0$ was rejected |

Based on the results of the independent sample t-test with the help of SPSS, the value of Sig(2-tailed) is 0.000, which means it has a significance value of less than 0.05. When viewed from the independent sample t-test decision-making, the interactive mathematics learning media 'Pythamath' is effective to be used oriented towards numeracy skills because of the significant differences between the two classes that were tested.

The findings of this study demonstrate that the interactive mathematics learning media PythaMath, developed using a Problem-Based Learning (PBL) approach and oriented toward numeracy skills, is valid, practical, and effective for grade VIII students. The validity results indicate that PythaMath meets good standards in terms of content, instructional design, and technical quality. These results are in line with previous studies that reported interactive learning media as an effective tool for supporting students' understanding of mathematical concepts (Baharun et al., 2020; Darmayanti et al., 2022; Mabruri et al., 2019; Nugroho et al., 2024). The alignment of learning objectives, materials, and interactive features in PythaMath supports meaningful learning, particularly in the context of the Pythagorean theorem.

The practicality results show that students responded very positively to the use of PythaMath. Students found the media easy to operate, engaging, and helpful in facilitating independent learning. This finding supports earlier research which emphasized that interactive multimedia could increase students' motivation and active participation in mathematics learning (Andari et al., 2024; Puspitarini & Hanif, 2019; Suripah & Susanti, 2022). Compared to previous studies that developed online-based learning media requiring internet

access, PythaMath offers an advantage through its offline accessibility, making it more suitable for schools with limited technological infrastructure.

In terms of effectiveness, the results of the independent sample t-test reveal a significant difference in numeracy skills between the experimental and control groups, with higher achievement observed in the experimental class. This finding is consistent with studies that reported the effectiveness of PBL in improving problem-solving and numeracy-related skills through contextual and real-life problems (Patmara et al., 2020; Suratno & Waliyanti, 2023). However, unlike previous studies that focused mainly on general mathematical achievement, this study specifically highlights the contribution of PBL-based interactive media to students' numeracy skills in the Pythagorean theorem topic.

Despite these positive findings, this study has several limitations. First, the research was conducted in a single school with a relatively small sample size, which may limit the generalizability of the results. Second, the implementation was carried out within a short time, so the long-term impact of PythaMath on students' numeracy skills could not be examined. Third, this study focused only on one mathematical topic, namely the Pythagorean theorem. Therefore, future studies are recommended to involve larger and more diverse samples across different schools and regions. Further research could also examine the long-term effects of using PythaMath on students' numeracy development and learning retention. In addition, future studies may expand the use of PBL-based interactive learning media to other mathematical topics or integrate it with online or mobile learning platforms to enhance flexibility and learning effectiveness.

## 4. Conclusion

Based on the results of the research, it can be concluded that the interactive mathematics learning media 'PythaMath' based on *Problem Based Learning* (PBL) on the Pythagorean theorem material has characteristics, namely (1) the arrangement of the material in the 'PythaMath' learning media uses a clear and directed problem-based learning model, (2) there is a problem practice menu related to the numeracy ability component, (3) the learning media 'PythaMath' provides feed return instantly to the User, (4) this learning media can be accessed without the internet or network so that it is flexible to open. PBL-based interactive mathematics learning media 'PythaMath', which is oriented towards numeracy skills, can be declared valid, practical, and effective based on the results of research that has been conducted. With this research, it is hoped that it can be an additional means for educators to be able to implement the use of interactive learning media in helping the delivery of learning materials so that students do not feel bored and can create a more effective, active, and conducive learning atmosphere to mathematics learning.

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## Declarations

| | | |
|---|---|---|
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