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Development of Animated Video-based Mathematics Learning on The Three-dimensional Material of Class XII SMA to Improve Mathematical Literacy

Abstract

This article discusses the development of animation-based learning videos on three-dimensional materials to improve mathematical literacy. This development research uses the Plomp model, that is, preliminary research, development or prototyping, and assessment phase. The results of the learning video in this development are viewed under three aspects, namely validity, practicality, and effectiveness, involving students of SMA Negeri 3 Pekanbaru as research subjects. The animated video-based learning media was declared very valid with a result of 73, very practical with a result of 56, and effective in improving mathematical literacy. This states that animation-based video learning media is good and worthy of being used as a mathematics learning media to improve mathematical literacy.

Keywords: Learning media; Adobe after effect; Mathematical literacy

Abstrak

Artikel ini membahas pengembangan video pembelajaran berbasis animasi pada materi tiga dimensi untuk meningkatkan literasi matematika. Penelitian pengembangan ini menggunakan model Plom, yaitu tahap penelitian pendahuluan, pengembangan atau prototyping, dan penilaian. Hasil video pembelajaran dalam pengembangan ini dilihat dalam tiga aspek, yaitu validitas, kepraktisan, dan efektivitas, dengan melibatkan siswa SMA Negeri 3 Pekanbaru sebagai subjek penelitian. Media pembelajaran animasi berbasis video dinyatakan sangat valid dengan hasil 73, sangat praktis dengan hasil 56, dan efektif dalam meningkatkan literasi matematika. Hal ini menyatakan bahwa media pembelajaran video berbasis animasi baik dan layak digunakan sebagai media pembelajaran matematika untuk meningkatkan literasi matematika.

INTRODUCTION

One of the movements emphasized by the minister of education for students today is literacy skills. Literacy skills are currently indispensable to supporting the achievement of educational goals (Muzaki & Masjudin, 2019). As for the literacy needed by humans in the field of education, one of them is mathematical literacy.

Mathematical literacy is the ability of an individual to formulate, use and interpret mathematics in various contexts, including the ability to perform mathematical reasoning and use concepts, procedures, and facts, as a tool to describe, explain and predict a phenomenon or event. Good mathematical literacy skills will make it easier for students to solve mathematical problems in their daily lives. Mathematical literacy also requires students to be able to communicate and explain the phenomena they face with mathematical concepts (Fatwa et al., 2019; Khoirudin et al., 2017; Mansur, 2018; Masmufah & Afriansyah, 2021; Muzaki & Masjudin, 2019, Maryati et al., 2021).

PISA (*The Programme for International Student Assessment)* is a program initiated by the OECD *(Organization for Economic Cooperation and Development)* that focuses on literacy that emphasizes the skills and competencies of students obtained from school and can be used in everyday life (Johar, 2012). PISA conducts a triennial assessment to determine student literacy in reading, science, and mathematics (Syawahid & Putrawangsa, 2017). This program pays more attention to what students do than what they learn in school, especially in having mathematical literacy skills.

But in fact, based on the PISA (The Programme for International Student Assessment) assessment, shows that the mathematics literacy score in Indonesia is still below the mathematics literacy score of other countries. Students in Indonesia

ranked 39th out of 40 sample countries in 2003, 38th out of 41 countries in 2006, 61st out of 65 countries in 2009, and 62nd out of 70 countries in 2015 with a score of 403 out of an OECD average score of 493. This is in line with the fact that there are still many students in Indonesia who feel that mathematics is a difficult lesson. As corroborated by the findings (Djidu & Retnawati, 2018),(Zana et al., 2022) that students in Indonesia still have difficulty in mastering higher order thinking skills (HOTS). In fact, mathematics learning is one of the subjects that have an important role in the needs of students' lives (Afifah et al., 2018). Therefore, the teacher must be able to apply methods, strategies, or possible ways so that students can master mathematics well (Habibi & Suparman, 2020; Masfufah & Afriansyah, 2021; Muzaki & Masjudin, 2019).

One of the efforts to improve students' mathematical literacy is the existence of learning media. Learning media play an important role in conveying learning between teachers and students. Learning media is a useful tool to convey information between teachers and students, and support student learning success (Abidin, 2017; Aghni, 2017; Hartanto, 2016; Yanto, 2018). Learning media can also help teach abstract concepts so that they are more easily accepted by students (Hasiru et al., 2021; Maharani et al., 2018). Especially in mathematics subjects, learning media is very important so that it can develop imagination and can improve mathematical literacy as well.

One of the mathematical materials that need to be used in learning media is the third dimension. The difficulties or problems that arise in learning three-dimensional material include (1) Understanding the theory and drawing of three-dimensional materials requires a fairly high level of abstraction; (2) The concepts given to students have a high degree of difficulty because they must be related to other concepts such as trigonometry and triangle; (3) Teaching methods that still use the lecture method; and (4) Limited learning media, both in terms of quantity and quality. The use of learning media in three-dimensional material is expected to provoke and develop students' imagination in the material presented.

Therefore, the learning media that is suitable for use of three-dimensional material is animated video-based learning media. One of the software that can be used to create animated video-based learning media is Adobe After Effect. Adobe After Effect is a software that creates animation works and visual effects that are used for multimedia presentations and various advertising animations, one of which is tutoring animation (Azhar et al., 2021; Yenti, 2020, Fauzi & Chano, 2022). The Adobe aftereffects application serves to create animated works with real visual effects such as melted solids, snowy atmospheres, or the addition of fire effects to a movie.

Several studies related to animated video-based learning media on three-dimensional material to improve mathematics literacy was carried out by (Handoko, 2017; Masfufah & Afriansyah, 2021; Tamu et al., 2020; Yenti, 2020). Based on the problems found and research that has been done previously, learning media in the form of animation-based videos on three-dimensional materials is needed to improve mathematical literacy. The difference between this study and previous research is the use of technology in making animated video-based learning media using Adobe After Effect. By using the effects available in adobe after effect, animated video-based learning media is expected to cause and increase the imagination of students so that students' mathematical literacy can increase.

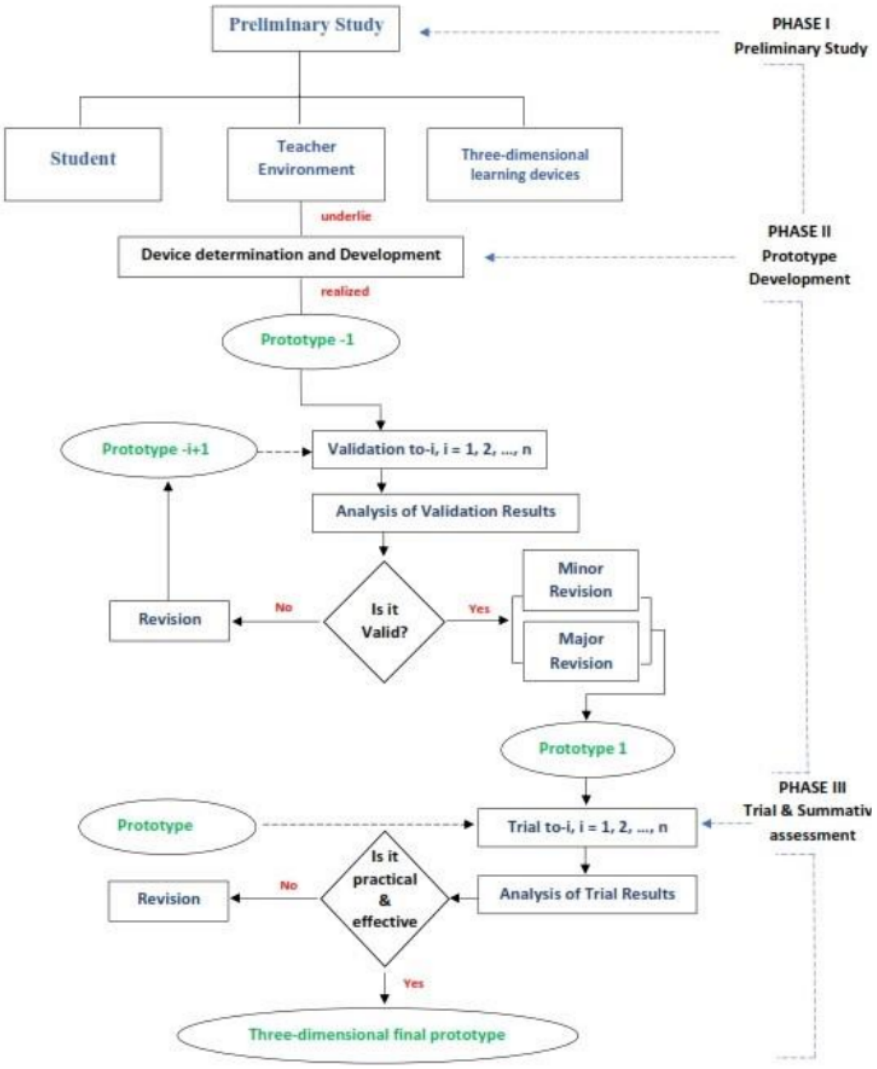

Figure 1. Ploomp Development Process Stage

METHODS

This type of research is development or Research and Development (R&D). This development research aims to produce products. The development model used in this study is the Plomp model. There are three stages used in the Plomp model, namely preliminary research, development or prototyping, and the assessment phase. The development process forms a cycle, where the development cycle will stop if the product being developed is suitable for use, that is, it meets valid, practical, and effective criteria. Schematically presented in Figure 1.

As for each stage of the activities carried out at each stage of development are described as follows. The first stage is Preliminary research. In this stage, the problems analyzed were problems of

learning mathematics, problems of learning by teachers, the media used, material that was still problematic, reviewing the literature and reviewing relevant supporting research results. The results of this preliminary study serve as the basic concept for further development of the prototype design.

After the preliminary research has been carried out, the next stage of development is compiling the initial prototype. This stage aims to prepare prototypes of learning media and supporting devices. To make it easier for researchers in the development process, it is necessary for the researcher to make a work plan and estimate the time needed at each stage of development and testing on respondents. At this stage the researcher designed a media prototype, learning tools (syllabus, lesson plans, validation instruments, and evaluation in the form of math literacy questions). The results of the initial prototype development were validated by material experts and media experts. After validating the expert, the researcher revised it until the prototype was declared feasible for testing.

Furthermore, the results of the initial prototype that had been developed were declared feasible, then it was continued with field trials. In this case the researchers conducted trials on students of SMA N 3 Pekanbaru. The research location was conducted at SMA Negeri 3 Pekanbaru with the subject of research of as many as 36 students of class XII MIPA 1. The data obtained is quantitative data. Data collection in this study used media expert instruments, response questionnaires, and student learning outcome sheets. Media expert instruments to measure how valid animated videos are produced, response questionnaires to measure the practicality of learning media, and student learning outcomes sheets (pre-test & post-test) to measure effectiveness in improving students' mathematical literacy.

Data analysis for validity instrument by calculating the average of scores that have been assessed by experts is converted into quantitative criteria referring to Table 1. Learning media are declared valid if the average score of experts is in a valid statement.

Table 1. Validity Criteria

Interval	Validity Criteria
$X \geq 65$	Very Valid
$65 > X \geq 50$	Valid
$50 > X \geq 35$	Less Valid
$X < 35$	Very Invalid

Description:
X = average actual score

Furthermore, data analysis for practicality is obtained through the assessment of response questionnaires by students. The data obtained are converted into quantitative criteria referring to Table 2. Learning media are declared practical if the assessment that has been converted is in a practical description.

Table 2. Practicality Criteria

Interval	Practical Criteria
$X \geq 48.75$	Very Practical
$48.75 > X \geq 37.5$	Practical
$37.5 > X \geq 26.25$	Less Practical
$X < 26.25$	Very Impractical

Description:
X = average actual score

Finally, data analysis for the effects of learning media aimed at improving students' mathematical literacy. Data were obtained from the comparison of values (pretest & posttest) with paired sample t-test. If a Sig. (2-tailed) value is obtained < 0.05, the learning media is declared effective for improving mathematical literacy, and vice versa.

RESULTS AND DISCUSSION

The media produced in this development is an animated video-based learning media on three-dimensional material. The results of the development of animasi-based video learning media on three-dimensional material are as follows.

Preliminary Research

This research first begins with conducting a needs analysis. At this stage, an analysis of learning tools at SMA Negeri 3 Pekanbaru was carried out. To find out about the problems that exist in schools, interviews are first conducted with mathematics teachers and students who have taken three-dimensional lessons. After the interview, it was found that the mathematics teacher had used learning media, but he felt that it was less effective when using the media because of the large number of students who were remedial during the daily test of the three-dimensional material. This is reinforced by the answers of the students who stated that they find it difficult to imagine three-dimensional material because of the learning media they do not fully own and are very limited.

Furthermore, an examination of the learning devices and media used by mathematics teachers was carried out. Based on the analysis carried out, it was obtained that learning activities on three-dimensional material are quite good with rough learning media. However, based on the learning media used by mathematics teachers, it is also very limited, it is also difficult to make students' imaginations formed which causes mathematical literacy in three-dimensional materials to also be lacking. This problem is justified by research that has been carried out before so that students think that dimension three is one of the mathematical materials that is quite difficult (Gustiadi et al., 2021) ; (Noto et al., 2019).

Based on the analysis that has been carried out, teachers and students need effective learning media that can improve students' mathematical literacy. In addition, it requires learning media that are easy to obtain and use for three-dimensional materials. Based on this analysis, it can be concluded that there is a need for animated video-based learning media to support learning activities on three-dimensional material. This has also been supported by previous research studies that animated video-based learning media is an effective medium and easy to obtain by teachers and students (G. P. P. Hapsari & Zulherman, 2021).

Furthermore, this stage is carried out by analyzing the study of material, namely dimension three. In this activity, learning outcomes will be detailed in the three-dimensional material by referring to the curriculum used. Then the material is adjusted to the learning outcomes in the learning device design (RPP) which is then used to design material on animated video-based learning media in the design phase and prototype development.

Development or Prototyping

This phase begins with determining learning objectives based on learning outcomes and referring to material adapted to the lesson plan, determining the test subject and the design of the learning media to be produced. Referring to the RPP, then an animated video-based learning media design is designed which is divided into 3 sub-materials, namely the distance between points, the distance from the point to line, and the distance from the point to the plane. Each video-based learning media is accompanied by a learning opening, the material to be delivered, and the closing. The result of the design is in the form of an animated video to bridge and facilitate the learning of the dimensions of the three classes in high school.

The results at this stage are referred to as prototype 1 which will be validated by the media expert validators.

Validation of animation-based videos is carried out at this stage. Animation video validity data were obtained from two validators to provide an assessment of the feasibility and quality of the video from the material, media, and language aspects with a total of 15 statements. Expert validators are lecturers from Riau Islamic University and practitioners from Telkom University. When the validation process was carried out on prototype 1 carried out by lecturers and practitioners, there were several inputs and comments, namely asking for the replacement of characters (who did not wear hijab to wear hijab) contained in the opening of the animated video from the first sub-material, namely the distance between points. Next, the font used at the opening of the animated video from the first sub-material, namely Comic Sans MS, was changed to Eras Demi ETC, because the previous font was considered more suitable for elementary or junior high school students, not in accordance with the target students, namely high school students. This is one of the indicators of the improvement process from the initial design to adjust the level of student development. As the results of previous research by Indriyani (2019); Ulfa & Suripah (2021) which corroborate the author's opinion that, the development of learning media must pay attention to the level of cognitive development and the stages of student development academically.

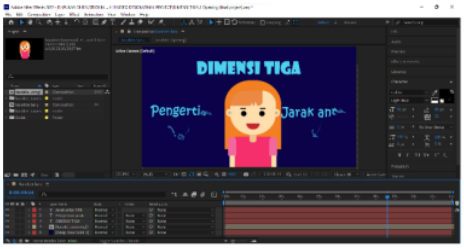

Figure 2. (Prototype 1)
Opening Character of The Distance Between Points On Prototype 1 And Using The Comic Sans MS font

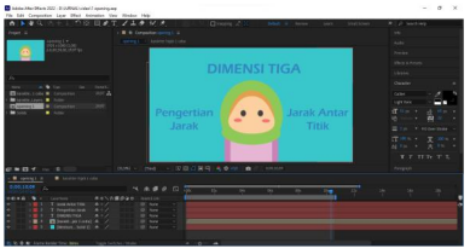

Figure 3. (Prototype 2)
Opening Character of The Distance Between Points On Prototype 2 And Using Eras For ETC Fonts

The last part is design changes such as font colors and backgrounds that are tailored to the needs of the animation video. The font and background colors are not suitable because there are too many colors that will make students who watch them become unfocused with the content of the animated video. After receiving and making improvements to the revised animated video, improvements to prototype 1 that have been developed can be referred to as prototype 2.

Furthermore, prototype 2 is shown back to lecturers and practitioners. After prototype 2 was watched and viewed in its entirety, validators had enough of the animated video and assessed the video through filling out a 15-item video feasibility and quality assessment. So that the success of prototype 2 produced after being given input and suggestions at the validation stage can be declared valid. In the validation process carried out 2 times, the activities carried out are providing product input by validators and filling out validation questionnaires. Validation activities will start on June 21, 2022, and end on July 30, 2022. The results of the validation assessment from the two experts are 72 with very valid criteria. The overall results can be seen in Table 3.

Table 3. Validation results of animation-based video learning media

Validators	Actual Total Score	Criteria
Validators 1	67	Very Valid
Validators 2	77	Very Valid
Combined Validators	72	Very Valid

The results of the assessment by the validators in Table 3 show that the resulting product has very valid criteria. So that the animated video-based learning media created and developed has met the validity. Overall, the improved results of prototype 1 developed are referred to as prototype 2. The existence of prototype 2 then the validation process also ends at this stage. The end of the validation process at this stage is based on the results of revisions, inputs, and suggestions at the validation stage qualitatively. Likewise, based on the results in Table 4, which are stated to be very quantitatively valid. So that prototype 2 is ready to be tested in the Assessment phase.

Assessment Phase

Furthermore, at the assessment stage, a trial will be carried out on prototype 2 to find out the practicality and effectiveness of animated video-based learning media. In this assessment phase, there are two stages of trials, namely limited trials, and extensive trials. First, a limited trial was carried out by providing animated video-based learning for 10 students of class XII MIPA 1 on August 9, 2022. The purpose of the limited trial to 10 students is to see the practicality of learning media developed in a limited scope through a response questionnaire that will be filled in. In the limited trial, 10 students were allowed to watch three animation-based learning videos.

Figure 4. Students Watch Animation-Based Learning Videos

After the 10 students watched the animation-based learning video, they were given a response questionnaire to assess the animated video and asked to respond. So that student response data to animated video-based learning media is processed and can be presented in Table 4 below.

Table 4. Student Response to Animated Video-Based Learning Media

Respondents	Actual Score	Criteria
Student 1	60	Very Practical
Student 2	48	Practical
Student 3	58	Very Practical
Student 4	60	Very Practical
Student 5	45	Very Practical
Student 6	60	Very Practical
Student 7	58	Very Practical
Student 8	60	Very Practical
Student 9	56	Very Practical
Student 10	59	Very Practical
Total	564	Very Practical
Average	56.4	Very Practical

Based on Table 4, eight out of ten students give very practical assessments, and the other two people give assessments with practical criteria. Overall, out of ten 10 students obtained an average of 56.4 which can be concluded that the video-based learning media developed has met practicality with the criteria of "Very Practical". This is in line with previous research (Mandalitasari & Muthmainnah, 2022; Reinita, 2022, Wijayanti & Utami, 2022) that learning media using

Adobe After Effect can meet practical criteria. So that previous research refining prototype 2 can be said to have met valid and practical criteria.

Furthermore, prototype 2 was distributed by continuing to widely trial to 35 students of XII MIPA 1 to find out the effectiveness of the products developed to improve mathematical literacy. The activity was carried out on August 16, 23, and 30, 2022. Before prototype 2 is given to all students, students are first instructed to do a pre-test regarding three three-dimensional sub-materials, namely the distance between points, the distance from a point to line, and the distance from the point to plane with each sub-material having 1 question item. After all, students have done the pre-test, then given prototype 2 to the students and given time to watch animation-based learning videos on their respective students' smartphones. They can use animated video-based learning media independently and do not feel difficult in terms of numbers because they have their own smartphones and can watch them repeatedly. After all the students finished watching the animation-based learning video, they were instructed to go back to do a post-test on the three sub-materials they had watched. Thus, the results of the pre-test and post-test answer sheets of all students are processed using SPSS and presented in Table 5.

Table 5. Pre-test and Post-test Answer Sheet Results on Animation-Based Learning Videos

	Mean	Sig. (2-tailed)
Pre-test	49.43	.000
Post-test	83.86	

Based on the results of Table 5, the data obtained were analyzed using the SPSS version 25 program obtained through a paired sample t-test. The value of Sig. (2-tailed) is 0.00 which is known if 0.00 < 0.05 then there is a significant difference between pre-test and post-test learning outcomes, so it can be concluded that animated video-based learning media on the material of the third dimension of class XII to improve mathematical literacy is declared effective. In other words, there is an increase in students' mathematical literacy after using animated video-based learning media. Then prototype 2 has met the criteria of valid, practical, and effective. Therefore, the products that have been produced in this development research can be used by teachers and students in teaching and learning activities in the classroom. In addition, students become easier and can have their own learning media.

Animation-based learning media that has met valid criteria with a score of 73, practically with a score of 56, and has been declared effective provides implications, namely that it can be used by teachers in the process of teaching and learning activities in the classroom for material to build curved side rooms. This learning medium can also be owned by all students, and they will not feel short of learning tools because they can have each of them. In addition, this learning media are also easy to obtain and can be seen repeatedly anywhere and anytime, which can make students' mathematical literacy increase and can make students' imaginations develop. In the long term, students are expected to have their own interest in learning mathematics. As a result, students realized that learning mathematics was no longer considered a difficult and rigid subject that dealt with numbers and numbers alone. But on the contrary, mathematics is one of the memorable subjects and can also be learned through media and applications as a group of other subjects that are not only struggling in books and struggling with formulas.

Figures 4 & 5. Animation-Based Learning Video Results

The results of the research that have been described according to the stages of Plomp development and a thorough discussion is carried out as follows. At the preliminary research stage, an analysis was carried out related to learning tools at SMA Negeri 3 Pekanbaru. Based on interviews with mathematics teachers and class XII students that learning media have been used, but it is not considered effective, students find it difficult to imagine three-dimensional material because of the limited learning media provided by the teacher. This is because three-dimensional material requires high imagination to make students' mathematical literacy at dimension three low. This is reinforced by the statement by Kusumawardani dkk (2018) and Mandailina dkk (2016) which states that the lack of media learning leads to low students' mathematical literacy which requires high imagination on three-dimensional material. Therefore, learning media are needed that can facilitate three-dimensional material learning activities for all students that are effective and can increase imagination three. This became the basis for creating and developing animation-based learning videos on three-dimensional material to improve students' mathematical literation.

In the development or prototyping stage, before designing the learning media, three sub-material sub-materials are analyzed. This stage will produce animation-based video-based learning media that will facilitate teachers and students in teaching and learning activities for three-dimensional material. The draft results of this stage are called prototype 1. Furthermore, prototype 1 is validated by 2 validators both from the aspects of the material, media, and language. Validation activities were carried out 2 times starting on June 21, 2022, and ending on July 30, 2022. Based on the validation results of the learning video developed, it meets the criteria of "Very Valid" with a score of 72. There are several improvements, namely the change of characters who do not wear a hijab to a hijab, then the Comic Sans MS font to Eras Demi ETC, as well as changing the color of the font and background that is too colorful and is considered not fit for high school students. After revisions to the video-based learning media, improvements have been made to change prototype 1 to prototype 2. In the future, the product that is developed is referred to as prototype 2.

After prototype 2 was declared valid, it was continued with the assessment stage, which was to conduct a limited trial by 10 students to test the practicality by filling out a response questionnaire to students. Students watch animation-based learning videos. After students finish watching the animation-based learning video, students are instructed to fill out a response questionnaire. The results of the response questionnaire showed that animation-based learning videos were considered practical with the criteria of "Very Practical" with a score of

56.4. After being declared practical prototype 2, the animation-based learning video is ready to be widely tested involving 35 class XII students.

Prototype 2 was then widely piloted to test the effectiveness of learning videos to improve students' mathematical literacy on three-dimensional materials. Before prototype 2 is deployed, students are instructed to do a pre-test of three questions with three sub-materials, namely the distance between points, the distance from the point to the line, and the distance from the point to the plane. After doing the pre-test students are asked to watch prototype 2 or animation-based learning videos through their respective smartphones. After watching the animation-based learning video, students were asked to continue by doing a post-test of three questions. The results were obtained through the analysis of SPSS version 25 with a paired sample t-test which stated that the value of Sig. (2-tailed) is 0.00 and if 0.00 < 0.05 then there is a significant difference between pre-test and post-test learning outcomes. So it can be concluded that animated video-based learning media on the three-dimensional material of class XII to improve mathematical literacy is declared effective. Or in other words, animated video-based learning media is declared effective because of students' increased mathematical literacy through watching animation-based learning media. In addition, students seem more enthusiastic and motivated to follow the learning (Suripah & Susanti, 2022; A. S. Hapsari & Hanif, 2019). The implication of the results of developing animation-based learning videos is that they can be used by mathematics lesson teachers to facilitate teaching and learning activities (Fatchurahman et al., 2022, Cao et al., 2021). In addition, students can easily use animation-based learning videos through their respective smartphones and not feel less facility than before. Furthermore, students are also expected to continue to improve their mathematical literacy skills only through problems in the classroom, but also through media-based mathematics learning.

Especially in this era full of technological integration today. Students are not only required to be able to master mathematics. But more than that, by mastering mathematical literacy, students can connect the basic concepts to reasoning and solving everyday contextual problems (Hayati & Kamid, 2019), (Yang et al., 2020).

Limitation

Students' expectations of the results of media development are not yet interactive. Students can only watch material explanations via video, and students cannot use the media interactively for both the learning process and practice questions.

Implication

The impact of the results of this study is directly related to the integration of technology in pedagogical content knowledge. This is in line with the existence of learning objectives in the independent curriculum which is currently a trending topic. Of course, the development of learning media will help the learning process be more flexible and not monotonous.

CONCLUSION

The results of the study showed that animasi-based video learning media on three-dimensional material that had been developed obtained the "Very Valid" criteria with a score of 72 based on assessments and comments from media expert validities at the design stage as well as

prototype development. In the assessment stage, a limited trial was carried out by involving 10 students of class XII MIPA 1 SMA Negeri 3 Pekanbaru. The results of a limited trial showed that the development of animation-based video learning media had met the "Very Practical" criteria with a score of 56.4, of which 10 students filled out the response questionnaire. In addition, a widespread trial was carried out involving 35 students of class XII MI-PA 1 SMA Negeri 3 Pekanbaru. The results of the trial widely obtained "Effective" results through paired sample t-test with 36 grade 12 MIPA 1 students who worked on the pretest and posttest, the results showed that the Sig. (2-tailed) the score of 0.00 < 0.05 which means that learning animation-based video on the third dimension material of class XII to improve mathematical literacy was declared effective. This also indicates that one of the problems faced by students related to mathematical literacy can be used alternative Video Animation-Based Mathematical Learning Media Using Adobe After Effects.

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