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Development of Problem-Based Math Learning Media using Adobe Animate to Improve Fourth-Grade Students' Learning Outcomes on Fraction

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Abstract: This study aims to develop interactive learning media based on Adobe Animate with the Problem-Based Learning (PBL) model to improve student learning outcomes on fraction material in class IV SDN Kedungpane 02. The background of this research is based on students' low understanding of the concept of fractions, which is caused by the lack of use of innovative learning media and less interesting learning methods. Therefore, Interactive Math media was developed that integrates animation and interactivity in the learning process to increase student engagement and understanding. This research uses the Research and Development (R&D) method with the ADDIE development model which consists of five stages, namely Analysis to identify learning needs, Design to design appropriate media Development to build products, Implementation to test on students, and Evaluation to assess the effectiveness of the media that has been developed. Data were collected through observation, interviews, questionnaires, documentation, and learning outcomes tests. The validity test was carried out by media experts and material experts, while the media effectiveness test was carried out through experiments with a pretest-posttest control group design. The results showed that the Interactive Math media based on Adobe Animate is very valid and feasible to use in learning based on expert validation with a score of 91.07% from material experts and 91.66% from media experts. In addition, there was a significant increase in student learning outcomes after using this media, as evidenced by the difference in the average scores of the pretest and posttest in the small and large groups. Thus, Adobe Animate-based interactive learning media with PBL model can be an innovative solution in improving students' understanding and learning outcomes on fraction materials. This study recommends the use of similar media on other materials to improve the effectiveness of learning in elementary schools.

Keywords: adobe animate, interactive learning media,fraction, problem based learning (PBL), learning outcomes.

▪ INTRODUCTION

Education has a very important role in shaping human character and creating the next generation of smart, integrity and responsibility. Education cannot be separated from the teaching and learning process that creates interaction between students and educators and other learning resources in the surrounding environment. Through education, individuals can gain knowledge that they did not previously have. In the current era of globalization, self-development through education is a must so that individuals can contribute optimally in society. Education Law No. 20/2003, Chapter 1 Article 1 states that education is an effort that is structured to create a learning environment that supports the development of students, both in spiritual aspects, self-control, personality, intelligence, morals, and skills needed for personal life, society, nation and state. At the elementary school level, education acts as the main foundation in preparing students for the next level of education. Every subject taught in primary schools contributes to character building and the development of students' academic potential. Quality education must refer to the National Education Standards (SNP). Based on Government Regulation

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No 4 of 2022, every education unit must comply with the standards set by the National Education Standards Agency (BSNP). There are eight main standards that must be met, namely Content Standards, Process Standards, Graduate Competency Standards, Educator and Education Personnel Standards, Facilities and Infrastructure Standards, Management Standards, Financing Standards, and Assessment Standards. To maintain the quality of education, all aspects of education, from the curriculum, learning process, to school management, must be in accordance with the established national standards.

Mathematics is a subject that is closely related to other disciplines. Mathematics learning plays a role in developing logical and analytical thinking skills, which support the understanding of other subjects. Therefore, mathematics education is provided from an early age, starting from kindergarten to college. A good understanding of math concepts not only contributes to students' academic success, but also plays a role in our lives. In fact, learning mathematics has a very important role in everyday life, because its concepts are applied in various aspects of life and human activities (Afifah et al., 2019). With Mathematics lessons we are trained in critical thinking skills as well as problem solving, so that students can face various challenges and complex situations in the real world in a more structured and systematic manner (D. V. Rahayu & Afriansyah, 2015).

Rapidly developing technology always brings visible changes around human life, including the world of education. Now the teaching and learning process is no longer limited to a conventional classroom environment, but can be done in various places and times by utilizing technology. This progress allows learners to access learning resources flexibly, thus supporting effectiveness and efficiency in acquiring knowledge (Komarudin et al., 2018). With technological advances, it has a positive impact in various aspects of life, including in the field of education. Along with the times, education around the world is required to be able to adapt to advances in science and technology. This allows for continuous improvement in the quality and quality of each individual. This improvement in individual quality, in turn, will affect the quality of a country, because one of the characteristics of a developed country is having qualified and competent human resources. In the world of education, significant changes have occurred. According to (Pramadana et al., 2019). Technological advances have brought significant changes in the learning system. Currently, the learning process is no longer only centered on the role of the teacher as the main source of information, but also helps bring about changes for learners to be able to actively find and process information independently. Modern learning is not only limited to conventional methods such as listening to lectures, but also utilizing various digital media, such as educational videos, interactive learning applications, and internet-based information sources. These developments make it easier for teachers and learners to access and disseminate knowledge more effectively. Thus, the use of technology in education can increase learner engagement, make the learning process more interesting, and support the achievement of academic goals optimally. Using smartphones or other technologies as learning media allows learning to be carried out in various places and with unlimited time (Drigas & Angelidakis, 2017). As a result, learning materials are conveyed easily and clearly with the use of technology by teachers.

Mathematics learning in elementary schools has the authority to shape students' conceptual understanding. Therefore, educators must be able to present material in a simple and easy-to-understand way according to the level of cognitive development of students. Mathematics includes various fundamental concepts, such as arithmetic,

geometry, logic and fractions, which are closely related to everyday life. A good understanding of the concept of fractions, for example, can help learners in solving practical problems, such as fair division in various situations. In addition, learning mathematics at the primary level acts as a foundation for mastering more complex concepts at the next level of education (Sri mulyani et al., 2018). Thus, strengthening early understanding of mathematics is crucial in developing learners' logical thinking and problem-solving skills in the future.

Fraction material is material listed in both the independent curriculum and the 2013 curriculum. Fractions are parts of numbers that show the division of a whole into smaller parts. Fractions are also called parts of a whole that are divided into smaller parts. In grade IV SD, fraction material is introduced to provide a deeper understanding of the division of parts of a whole, which is very useful in everyday life. At this stage, students begin to learn how to read, write, and operate fractions, be it in the form of simple, mixed, or decimal fractions. In everyday life, we often encounter situations that involve division, such as dividing a piece of cake into several pieces or counting change. For that, we need the concept of fractions. An understanding of fractions is very important because it provides a solid foundation for students to understand more complex mathematical concepts, such as decimals, percents, and other mathematical operations. As one of the important subjects, this fraction material is considered insufficient and is still poorly understood by fourth grade students of SD Negeri Kedungpane 02, especially on fractions worth.

Grade IV elementary school students are required to solve more complex math problems. One of the materials taught to grade IV elementary school students is fraction material. Fractions are part of a number that shows the division of a whole into smaller parts. Or it is also called part of a whole that is divided into smaller parts. As one of the important subjects, this fraction material is considered insufficient and is still poorly understood by fourth grade students of SD Negeri Kedungpane 02, especially on fractions worth. Students feel still confused and do not understand the concept of fraction material, especially in its application. Difficulty in understanding the concept of fractions is often caused by limitations in performing calculation operations, such as addition, multiplication, and division. In addition, a weak understanding of the concept of whole number operations also contributes to students' difficulties when solving problems related to fractions. Therefore, a systematic and gradual learning approach is needed so that students can understand fraction material to the maximum and be able to apply it to mathematical situations. So that fraction material is considered difficult by students. The contributing factors are the diverse cognitive abilities of students, the curiosity of students in learning is not so high, and the learning carried out still uses the lecture method and powerpoint shows, so that the use of learning media is less than optimal.

Based on research (Nasiruudin & Hayati, 2019) explained, learning difficulties experienced by students can be caused by various factors, including speed in completing tasks without paying attention to deep understanding, a less conducive classroom environment that hinders concentration, and the influence of peers who do not support the learning process. Problems faced by students in understanding mathematics material can be caused by the limitations of educators in developing innovative and interactive learning media. The lack of variety in the use of learning media can have an impact on students' low interest and understanding of mathematical concepts (Siregar et al., 2020).

In addition, lack of interest in certain subjects, such as mathematics, can also be a major factor that causes low learning motivation. In the era of rapidly developing technology, students are not only required to master mathematical concepts, but also to have mathematical literacy that allows them to understand, reason, and apply these concepts in solving contextual problems in everyday life (Hayati & Kamid, 2019). Therefore, effective and innovative learning strategies are needed to increase students' interest and understanding so that the learning process becomes more interesting and optimal. Not only that, other factors can come from teachers who have not been optimal in utilizing technology that can produce interesting and interactive learning media. Therefore, it requires teacher innovation and creativity in learning, one of which is by using interactive learning media so that it can attract enthusiasm and help children understand the material during the learning process. The use of educational media is one way for teachers to implement better learning (Kuway et al., 2023).

The means used by students in helping the learning process to be effective is called learning media. The use of learning media can facilitate the delivery of complex concepts so that they are more easily understood by students. In addition, learning media also plays a role in increasing student involvement in the learning process, making it more interactive and interesting. Along with technological developments, various forms of digital-based learning media, such as videos, images, and interactive games, are increasingly being utilized to increase learning effectiveness and support a more thorough understanding of concepts and can be used and accessed easily (Silvia & Bukhori, 2021).

Interactive learning media allows learners to interact directly with the material presented. Through interactive features, users can provide responses, choose answers, and manage the learning flow according to their needs (Aulia et al., 2024). (Jafnihirda et al., 2023) added, with the features contained in interactive media will also make students active. Interactive media also makes learning materials can be provided effectively (Andrian et al., 2018). In addition, this media can be accessed through computers or mobile devices, thus providing flexibility in learning and increasing the learning process to be more interesting and effective understanding (Samsudin et al., 2019). Interactive media has a space given to learners to interact with the teacher casually so that they can understand what the teacher has taught them. The implication of using animation-based and interactive learning media is to assist teachers in delivering mathematics material more effectively, so as to increase students' fluency and involvement in the teaching and learning process (Bulkani et al., 2022). Creative, productive, innovative, and efficient learning can be realized through the utilization and use of learning media so that a series of learning stages become exciting and reduce student boredom. There are various types of learning media that vary, from simple to more extensive. Examples include visual, audio, sound and visual media, and multimedia. The selection of media utilization needs to be appropriate in order to create a pleasant learning experience and be able to attract students to be involved in the learning process. In Edgar Dale's Cone Theory of Research highlights that educational activities that combine visible activities, namely, playing games as well as experiments, can help students learn material up to 90%. Therefore, it is recommended that teachers use interactive learning materials to improve student understanding and learning outcomes. Where learning outcomes are something that plays a role and has a high position in the learning process (Bernacki et al., 2020).

In choosing an application to be developed into interactive media, it should know the advantages and disadvantages of the media and be adapted to the character of students (Osborne et al., 2019). One example of digital interactive learning media is Adobe Animate. (Akmal et al., 2022) added, Adobe Animate is a software designed by Adobe systems, Adobe Animate was previously called Adobe Flash Professional, Macromedia Flash, and Future Splash Animator. Adobe Animate is a learning media that can increase interactivity in the learning process (Astari et al., 2021). Adobe Animate is a multimedia-based software used to create vector-based animations . This application is a development of Adobe Flash that has been updated with more advanced features (Green & Labrecque, 2017). With Adobe Animate, users can create various types of animations, interactive videos, and digital-based educational content that can be used in learning. The utilization of Adobe Animate in education has the potential to increase student engagement and make the learning process more interesting and interactive (Suhadah & Mufit, 2023).

Developing software-based interactive learning media is one solution to overcome the problems of students who find it difficult to learn Mathematics. This research is in line with research conducted by (D. D. Rahayu et al., 2022) which shows that the use of laptop or computer-based learning media is very practical, valid, and efficient. Therefore, the media developed is very appropriate to be applied with a percentage value of 84% by teachers and 91% of students. Other research conducted by (Orbit Thomas et al., 2024) with the use of Adobe Animate-based interactive media has a positive influence by making students actively participate in history lessons compared to learning before using Adobe Animate media.

The previous studies presented show similarities in the development of interactive media that can be accessed with laptops and computers. In this development research study, researchers update the development of studies that have been developed by others, namely interactive math development media on fraction material that can be accessed with Android. It is easy to use Android because it is small in size rather than having to use computers and laptops. The small size makes it more flexible and more effective and efficient, so that students can learn independently.

From the explanation above, the purpose of this research is to develop interactive learning media based on Adobe Animate, test the feasibility of the media, and evaluate its effectiveness in improving mathematics learning outcomes in grade IV SDN Kedungpane 02 Semarang. The development of this learning media aims to create a learning experience that is more fun and inviting and can foster understanding of math concepts more effectively.

▪ METHOD

This research uses the Research and Development (R&D) method with the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). In line with the opinion (Dwitiyanti et al., 2020), the ADDIE model can be implemented in R&D research. The population in this study were all fourthgrade students of SDN Kedungpane 02. However, due to the limited number of classes that were not parallel, the sample selection was carried out using purposive sampling technique, which selected one class as the research subject without an equivalent comparison class. The number of samples in this study consisted of 28 fourth grade students. Interactive Math Media based on Adobe Animate with Problem Based Learning (PBL) model was applied to this class

to measure its effectiveness in improving student learning outcomes on fraction material. Data were collected through learning outcome tests (pretest and posttest), observations, and questionnaires to determine student responses to learning media.

This research uses the Research and Development (R&D) method with the ADDIE development model, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation. This model is used to produce Adobe Animate based Interactive Math learning media applied with the Problem Based Learning (PBL) approach to improve student learning outcomes on fraction material.

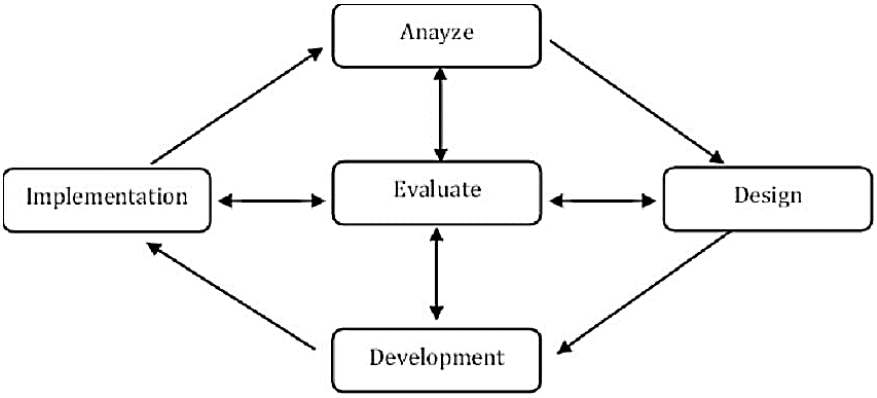

Figure 1. ADDIE development model

Based on Figure 1 of the ADDIE development model, the following is an explanation of the ADDIE model stages. The first stage in the ADDIE model is Analysis. The Analysis stage in the ADDIE model is a very important first step in developing learning media. The main purpose of this stage is to identify student learning needs, understand student characteristics, and analyze the problems faced in the learning process. The identification of student learning needs is done to find out the gap between the current learning conditions and the expected ideal conditions and by paying attention to several aspects such as identifying basic competencies and learning indicators that must be achieved by students in fraction material, identifying parts of fraction material that are most difficult for students to understand and determining the factors that cause learning difficulties, such as media limitations, less interesting learning methods, or lack of student involvement in the learning process, determining whether the media currently used is effective in helping students' understanding and exploring students' preferences for types of learning media, for example whether they are more interested in animation-based and interactive media. Once the data was collected, it was analyzed to understand students' learning needs. The analysis technique used is descriptive analysis where data from observations, interviews and questionnaires are categorized and described to see common patterns in students' learning difficulties. The second stage is Design, which aims to design the structure and elements of learning media before it is developed into the final product. Adobe Animate based interactive learning media design is made by compiling a storyboard to design the flow and appearance of each part of the learning media which includes: home screen, introduction, presentation of material, interactive exercises or quiz, as well as feedback and evaluation. In the development of Adobe Animate based interactive learning media, learning design principles are applied to make the media more effective in improving student understanding. These principles refer to learning design

theory which includes aspects of multimedia, interactivity, and student motivation. Adobe Animate based interactive learning media is designed by adapting the characteristics of elementary school students and fraction materials, namely with an attractive visual approach, interactive animation, simple and easy-to-understand language, as well as elements of gamification and interactivity, this media is expected to be able to improve students' understanding of the concept of fractions more fun and effective. The third stage is Development. Although Adobe Animate offers a variety of features that support the development of interactive learning media, there are some challenges that arise during the development process, including animating mathematical concepts such as fractions requires clear and intuitive visualization, so that students can understand it easily, need to ensure that students can operate the media easily, without feeling confused by navigation or interactions that are too complex. The solution is to use simple design principles, with minimal but effective animation, so as not to overload the system and still appeal to students, Using an intuitive interface, with large navigation buttons, clear icons, and voice guidance that helps students understand how to use the media. The fourth stage is Implementation. Adobe Animate-based interactive learning media is applied to fourth grade students of SDN Kedungpane 02. This media is used as a tool in the teaching and learning process to improve student understanding of fraction material. Its use in the classroom is integrated with the Problem Based Learning (PBL) model, which encourages students to learn through active problem solving. Its use can be done in three main stages, namely: preparation, by ensuring the readiness of the device and integration of the media into the lesson plan; implementation in learning, by utilizing animation, direct interaction, and problem-solving-based exercises; evaluation and reflection, by measuring student understanding and using the media for independent learning. In learning using interactive media based on Adobe Animate, the role of teachers and students is very important to create an effective and enjoyable learning experience. The teacher acts as a facilitator, motivator, director, and evaluator who helps students understand the concept of fractions through media exploration. Meanwhile, students act as active learners, problem solvers, collaborators, and independent learners who explore the material in an interactive and fun way. Furthermore, the fifth stage is Evaluation. Evaluation aims to assess the effectiveness and efficiency of the learning media developed. In this evaluation stage, the effectiveness of Adobe Animate based interactive learning media is assessed through several approaches, namely measurement of learning outcomes through pretests and postests, observation of student involvement during the learning process, user satisfaction surveys through questionnaires for students and teachers, interviews and group discussions to get direct input, and validation tests by media and material experts before the media is tested. The data collected at the evaluation stage are quantitative and qualitative data. Quantitative data in the form of pretest and postets learning outcomes. While qualitative data is in the form of student and teacher response questionnaires, media and material expert validation test sheets. The data were analyzed with statistics for learning outcomes, thematic analysis for student and teacher responses.

Data collection techniques in this study used several methods such as interviews, observations, questionnaires, documentation, and tests. In addition, there are also preliminary data analysis techniques carried out, namely validity and reliability tests. The validity of instruments (questionnaires and tests) is tested to ensure that the instrument actually measures what should be measured such as measuring ability, knowledge, or skills. Instrument validity (questionnaires and tests) can be tested using statistical

methods such as Pearson correlation analysis, regression, or factor analysis with software such as SPSS, AMOS, or SmartPLS. In this study, researchers tested the validity of the test instrument using SPSS. The following are the validity results obtained from the test.

Table 1. Results of calculation of validity of test questions

Category	Question item number
Valid	1.2.4.5.6.7.8.9.11.14.15.18.19.20.26.28.29.30.31.32.33.34.36.38.39.40.44.45.46.47
Invalid	3.10.12.13.16.17.21.22.23.24.25.27.35.37.41.42.43.48.49.50

Based on table 1, the results of the calculation of the validity of the trial questions found that the questions categorized as valid were 30 questions, while the invalid questions were 20 questions. After the validity test, a reliability test must also be carried out. Instrument reliability is tested to ensure that the instrument (test or questionnaire) provides consistent and stable results when used under the same conditions. If it produces high reliability, it shows that the instrument can be used repeatedly with stable and reliable results. Reliability testing is done using SPSS. Data is said to be reliable if the Cronbach's alpha value is > 0.06. Based on reliability testing, the Cronbach's alpha value is 0.871, which means that this value meets the reliability standards.

In addition to validity and reliability tests, there are validation tests by media experts and material experts. The expert validation procedure was carried out by two PGSD UNNES lecturers as media and material validators. For media experts, researchers involved Mr. Dr. Deni Setiawan, S.Sn., M.Hum and material experts by Drs. Yuli Witanto, M.Pd. The selection of media experts and material experts is based on several main criteria, namely: For media experts, the criteria are having an educational background relevant to educational technology, instructional design or multimedia, experienced in developing learning media both digital and non-digital, understanding visual design, interactivity, and usability in learning media and being able to provide evaluations and suggestions related to technical aspects, appearance and readability of the media. While the criteria for material experts are: mastering the scientific field that is the focus of research, namely mathematics subjects, able to analyze and assess the accuracy, depth and relevance of the material to learning objectives, and can provide input to improve the quality of material content to suit the needs of target users. The expert validation instrument (questionnaire or observation sheet) was developed with the following steps: determining the aspects assessed, compiling assessment indicators, determining the assessment scale, testing the clarity and validity of the instrument and compiling the final format using the instrument. Some aspects assessed by experts are aspects of the effectiveness and efficiency of the learning media used, display quality, media suitability for student characteristics, practicality, flexibility and teachers are skilled in using them, aspects of suitability for the objectives to be achieved, media suitability for student characteristics, concept suitability and relevant evaluation, and visual media used to emphasize target information in the text (images to clarify material). Data from the validation results of media experts and material experts were analyzed to assess the quality of the products developed. The analysis process is carried out by steps: first, collecting data obtained from questionnaires or observation sheets that have been filled out by experts; second, calculating the scores given by experts from each aspke assessed; third, determining the validity category whether the product is very valid, valid,

quite valid, invalid. If the results are in the valid or very valid category, the product is considered feasible. Fourth, analyze the suggestions and input used to revise and improve the quality of the media or material; fifth then draw conclusions whether the media or material is suitable for use or needs further improvement. Expert validation scores are calculated and interpreted by calculating the number of scores obtained then divided by the maximum score set by the researcher and then multiplied by one hundred percent. The final score results will be compared with the validity category to determine the level of validity. If the score is in the valid or very valid category, the media or material can be used with little or no revision, while if the score is in the moderately valid or invalid category, it needs improvement before further testing.

Furthermore, the data collection technique in this research consists of five types. The first is interview. Interviews were used by researchers in preliminary studies to find out the problems and information of respondents, so that researchers obtained information related to existing problems. Interviews were conducted with 1 class teacher in a polite and structured atmosphere. The meeting began with greetings and introductions, followed by an explanation of the purpose of the interview. The interviewer asked questions in clear language, while the teacher gave answers based on her experience and views. During the interview, the interviewer listened carefully, noted important points, and occasionally asked additional questions to clarify information. After all questions were answered, the interview was closed with a thank you note to show appreciation for the time and insight given. The questions asked to the interviewees were questions related to the learning process, such as: what curriculum is applied in class IV?, how is the implementation of learning using the curriculum?, what subjects do students find difficult to accept?, in what material do students find it difficult, especially in learning mathematics?, why are these materials and subjects difficult for students to accept?, do teachers always use learning media in delivering material?, if using the media how often do teachers use it and what media is used?, is the media effectively used in the learning process?, does the school provide learning media to support the delivery of material provided by the teacher to students?, does the teacher apply a learning model in learning?, what learning model is used?, what learning resources are used by the teacher as a reference in the course of learning?, have students experienced learning difficulties so far?, what factors cause students to experience learning difficulties?, what is the role of the teacher in dealing with learning difficulties experienced by students?, how do teachers try to make all students take an active role in the learning process?, how is student interest in learning subjects in class IV?, how are student learning outcomes in subjects that are less interested?. Then the interview data was analyzed by transcribing the interviews into text (transcription), then reading and understanding the content thoroughly. After that, relevant information was categorized based on the main themes or topics that emerged. An in-depth analysis was then conducted to find patterns, relationships or meanings in the interviewees' answers. The results were then summarized in a clear and systematic report. Second, observation was conducted by directly observing the condition of the school environment as well as the learning process in class IV that took place at SDN Kedungpane 02 Semarang. In addition to observing the school environment, observations were made by directly observing the behavior, interactions, and responses of the research subjects to the media or learning model. The focus of observation in this study is the use of learning media used during the learning process. Observation data was recorded by the researcher by systematically recording each finding in the observation sheet and then analyzed.

Third, the questionnaire or questionnaire used in this study is a Likert scale. Likert scale questionnaires in this study were used to measure student responses to the learning media developed. This questionnaire is arranged in the form of statements that reflect various aspects, such as ease of use of the media, student involvement, understanding of the material, and pleasure in learning. Likert scale questionnaires are given to fourth grade students in a systematic and easy-to-understand way so that they can answer well. Before the questionnaire is distributed, the researcher or teacher explains the purpose of the questionnaire, which is to find out students' opinions about the learning media they have used. The questionnaire is arranged in printed form or with simple statements and in accordance with the level of understanding of students. Each statement is followed by a Likert scale answer option, such as strongly agree, agree, neutral, disagree, and strongly disagree. Then students are given sufficient time to read each statement and choose the answer that best suits their experience. If any students had difficulties, the teacher or researcher was ready to provide guidance without affecting their answers. The Likert scale questionnaire data was analyzed by scoring each answer, for example, strongly agree = 5 to strongly disagree = 1. After that, the data was collected and processed using tables or statistical software such as Excel or SPSS. Fourth, documentation. Documentation is a record of an event that occurred. The types of documents collected were written documents, pictures, or recordings that supported the research. Written documents such as syllabus, lesson plans, and student grades list. Visual documents are photos of learning activities taking place. Recorded documents such as audio and video recording learning and interviews with teachers. Written documents, pictures, or recordings were analyzed by classifying, interpreting, and drawing conclusions based on the data obtained. Written documents were read and categorized according to research indicators, such as analysis of student grades to see improvements in learning outcomes. Picture documents were observed to identify learning activities, student engagement, or the effectiveness of the media used. Audio/video documents were transcribed or analyzed based on student and teacher interactions, media use, and responses to learning. Fifth, tests. Tests are evaluation instruments used to measure individual student understanding and achievement. The tests given to students in this study were pretest and posttest with multiple choice format. The pretest was given before students used the learning media to measure their initial understanding, while the posttest was conducted after learning to see the improvement of learning outcomes. The multiplechoice test was given to students by the researcher in a structured way. Before the test begins, the researcher or teacher explains the purpose of the test and the rules of the test so that students understand the instructions clearly. Tests can be given in printed or digital form. Students are asked to read each question carefully and choose the most correct answer from several available options. During the test, the researcher supervises to ensure students work independently without interruption. After the specified time is over, the answers are collected to be analyzed to measure students' understanding of the material that has been learned. Multiple-choice test data is analyzed by checking and calculating scores. Student answers are checked and compared with the answer key, then each correct answer is given a score according to the predetermined weight, namely the correct answer is worth one and the wrong answer is worth zero. The data analysis technique used in the test is descriptive statistics, namely to calculate the average, standard deviation, and percentage increase in scores; n-gain score test to measure the level of improvement in student understanding, and paired sample t-tests to see significant differences between pretests and posttests.

One of the learning models that can be combined with interactive learning multimedia is Problem Based Learning (PBL), which is a learning model that is oriented towards problem solving as the core of the learning process (Anggreni et al., 2021). Learning using the Problem Based Learning (PBL) model can create a learning experience that is more interesting and easily understood by students. This model encourages students' active participation in the learning process, as they are directly involved in problem solving. Thus, PBL does not only place students as passive recipients of information, but also as active learners in constructing their own understanding. In its implementation, the Problem Based Learning (PBL) model is implemented in learning by involving students in solving real problems to improve concept understanding which encourages students to think critically and actively in finding solutions. The process stages consist of five steps. First, orienting students to the problem, the teacher introduces a real problem or situation that is relevant to the learning material. This problem is open, challenging, and encourages students to think and find solutions. Second, organizing learners to learn, Students explore problems by asking questions, seeking information from various sources (books, the internet, or discussions), and connecting with existing knowledge. Third, guiding individual and group investigations, students work in groups to analyze problems, exchange ideas, and develop problem-solving strategies. The teacher acts as a facilitator who guides the discussion without providing direct answers. Fourth develop and present work, Students design and develop solutions based on their analysis. They may conduct experiments, create simulations, or compile reports based on their findings. Fifth analyze and evaluate the problem-solving process, Each group presents the solution they have created. The teacher and classmates provide feedback, then reflection is done to assess the effectiveness of the solution and understand the concept more deeply.

The examples of problems used in Problem Based Learning, especially fraction materials are: “Ani and Budi bought one pizza which was divided into 8 pieces. Ani ate 2 parts, and Budi ate 3 parts. How many pieces of pizza have been eaten? How many pieces are left? If they want to divide the remaining pizza fairly, how many parts will each of them get?”. The problem is chosen or designed to be suitable for the learning material and student characteristics by considering, first, the relevant fraction concept, namely this problem involves addition and subtraction operations; second, the familiar and interesting context, namely pizza is a concrete object that children often encounter, so it is easier to understand and the problem is in the form of a story so that students are more interested and motivated to solve it; third, it encourages active problem solving.

▪ RESULT AND DISSCUSSION

Adobe Animate based interactive learning media was developed as a tool in learning fractions for grade IV elementary school students using the Problem Based Learning (PBL) model. This media is designed to improve student understanding through animation, interactive simulations, and problem-based exercises. This interactive learning media based on Adobe Animate is designed so that students not only receive material passively, but also actively interact and solve problems on their own. Adobe Animate based interactive learning media is designed to increase students' involvement in learning fractions in a more active, explorative, and fun way. Here are the ways how this media enhances students' interaction with the learning materials: visualizes the concept of fractions dynamically i.e. interactive animation helps students understand the concept of

fractions more easily than just using text or static images; enhances collaboration and discussion i.e. the media can be used in group learning, where students can discuss and solve problems also with PBL model, students not only memorize the concept of fractions but also learn how to apply it in real life; provide immediate feedback if students answer correctly or incorrectly in the exercise problem, the media will provide an automatic response in the form of sound, sign, or animation, this feedback helps students to understand their mistakes and correct them directly, without having to wait for the teacher's explanation; flexible access and user-friendly, the media can be used on various devices (computers, laptops, tablets and also mobile phones), so that students can learn inside or outside the classroom, easy and intuitive navigation allows students to learn independently without having to always depend on the teacher. So that their understanding of fraction material becomes deeper and longer lasting.

Based on the data and results that have been obtained, this research produces an interactive learning media based on Adobe Animate designed to help grade IV elementary school students in understanding fraction materials. This learning media includes various features, such as cover, instructions for use, learning outcomes and learning objectives, fraction materials, learning videos, and quizzes or practice questions designed to improve student understanding effectively. The following is an interactive learning media display based on Adobe Animate.

Figure 2. Menu page display

Figure 3. Main menu page display

Figure 4. Instructions for use display

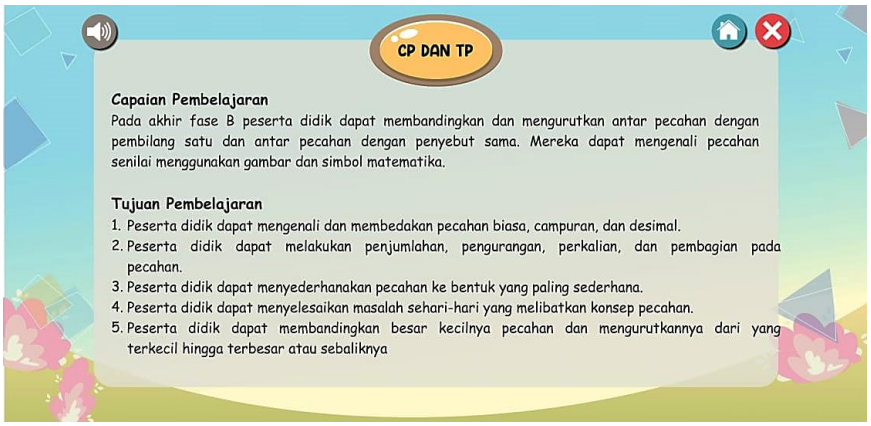

Figure 5. CP and TP display

Figure 6. Material display

Figure 7. Learning video display

Figure 8. Quiz view

After the learning media has been developed, the next step is the validation process by experts. This validation aims to assess the feasibility of the media and the suitability of the material in supporting the learning of mathematics fraction material. If there are aspects that need to be improved, the expert will provide input to improve and perfect the media. This improvement process is carried out so that the learning media can be used optimally in the school environment. The following images before and after revision can be seen in Table 2.

Table 2. Result of design revision from media and material experts

Before Revision	After Revision
	
Material display before revision	Material display after revision

Based on table 2, it is known that there are pictures before and after the learning media is revised. In the validation of material and media experts, there are comments or suggestions given to researchers, namely in the material display section, for each material title box, a number should be given to make it easier for students to study the material in order.

Furthermore, researchers also analyzed student learning outcomes data to find out whether there will be differences and improvements in learning outcomes from the media that will be implemented to students. From the analysis of student learning outcomes, the average pretest score was 75 and the posttest score was 81. From this average, it shows that student learning outcomes have increased. In addition, the standard deviation on the pretest was 6.23 and on the posttest was 4.52. In this study, standard deviation is used to assess the consistency of learning outcomes, as well as to assist in decision making based on data distribution. The smaller the standard deviation, the more homogeneous the data obtained, while a large standard deviation indicates a high variation in the research results.

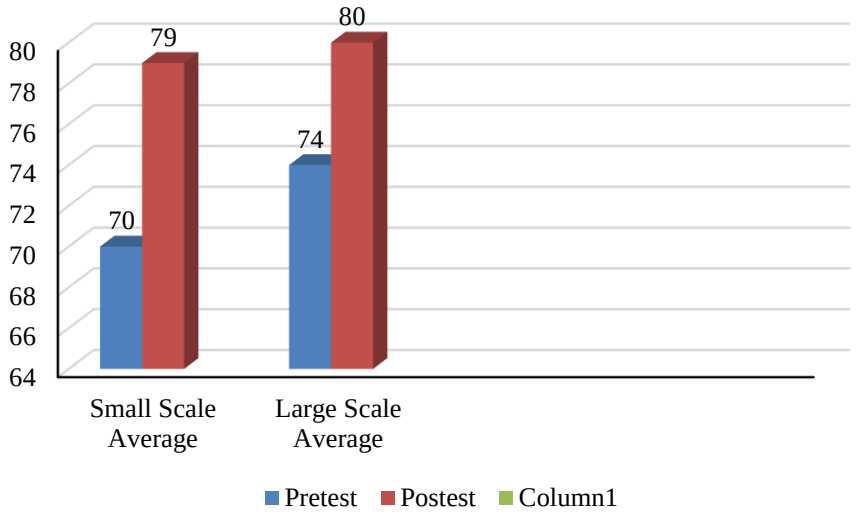

Figure 9. Student learning outcomes

Based on diagram 1 of student learning outcomes, we obtained data on student learning outcomes on a small and large scale with pretest and posttest scores. On a small scale, the pretest score was 70 and the posttest was 74. While on a large scale, the pretest score was 79 and the posttest was 80. So from these results we can see the comparison.

Further analysis of the aspects of fraction learning materials that improved the most after using Adobe Animate interactive learning media showed that students experienced significant improvement in understanding the concept of fractions, especially in recognizing, comparing, and simplifying fractions. In addition, skills in fraction calculation operations, such as addition, subtraction, multiplication and division, also improved as the interactive animation helped visualize the calculation process more concretely. Problem solving skills involving fractions are also developed, as students can see a visual representation of the story problem situation, making it easier for them to find solutions. In addition to cognitive aspects, students' motivation and interest in learning

also improved, as the attractive interactive media made learning more fun and encouraged their active involvement in understanding the concept of fractions more deeply.

At the media validation stage, Adobe Animate-based interactive learning media validation has been carried out by media experts and material experts to assess aspects of product feasibility. This validation process aims to ensure that the learning media meets the predetermined standards. Adobe Animate-based interactive learning media is considered very feasible by material experts and media experts because it fulfills various important aspects in learning, both in terms of material quality and interactive media design. Aspects that are considered very good by media experts consist of 4 aspects with 15 questions. These aspects are: aspects of the effectiveness and efficiency of the learning media used, display quality, media suitability for student characteristics, practicality, flexibility and teachers are skilled in using it. Meanwhile, the aspects that were rated very well by the material experts consisted of 4 aspects with 14 questions. These aspects are: aspects of suitability with the objectives to be achieved, media suitability with student characteristics, concept suitability and relevant evaluation, and visual media used to emphasize target information in text and images to clarify the material.

Based on the results of the media expert assessment consisting of 4 aspects with 15 questions, a score of 55 out of a total score of 60 was obtained. Meanwhile, the material expert assessment consisting of 4 aspects and 14 questions obtained a score of 51 out of a total score of 56. The calculation of these scores is carried out using the percentage formula of product feasibility analysis to determine the feasibility level of the learning media developed. The results of the calculation showed that Adobe Animate-based interactive math media obtained a percentage of 91.66% from media experts and 91.07% from material experts, both of which were categorized with the criteria 'Very Feasible'. The assessment of media experts shows that this learning media has fulfilled all aspects needed in its development. Therefore, Android-based interactive learning media with the Problem Based Learning (PBL) model developed using Adobe Animate software is declared feasible to be tested on grade IV students.

Because the learning media is very feasible to use, of course Adobe Animate interactive learning media is effective in improving students' math learning outcomes with the Problem-Based Learning (PBL) model. This is because the media is able to present concepts visually, dynamically, and interactively. In the PBL model, students learn through solving real problems, which requires a deep understanding of mathematical concepts. Adobe Animate helps by visualizing abstract concepts such as function graphs, geometry, and transformations in the form of animations that are easier to understand. In addition, its interactive features allow students to explore, so they can understand cause-and-effect relationships in math more deeply. This increases student engagement and motivation, as they can actively participate in the learning process. With the simulation and immediate feedback, students are also quicker to identify errors and correct them. The factors that contribute to the effectiveness of Adobe Animate media in improving students' mathematics learning outcomes with the PBL model are relevant animation design, interactivity support, compatibility with the PBL model, teacher involvement, and the ability to use technology by students and teachers. With the combination of interactive media and PBL model, learning mathematics becomes more meaningful, interesting, and effective in improving student learning outcomes.

In using Adobe Animate based interactive math media, digital technology creates a flexible learning environment, allowing students to process information, access various resources, and interact virtually with fellow students and instructors. This is in line with the principle of constructivism theory which emphasizes that learning should be interactive and reflective. In addition, technology also plays a role in presenting more interesting learning media, especially through new innovations that can increase student attention, clarify the delivery of material, and minimize misunderstandings in understanding the concepts taught. Constructivism theory explains that learning is an active process in which students construct their own understanding through experience and interaction. In the context of Adobe Animate based interactive learning media, its effectiveness can be explained as follows: Interactive media allows students to interact directly with learning materials, thus activating them in the learning process, build knowledge, students can build their own knowledge and understanding of learning materials, provide experience, interactive media provides real and relevant learning experiences, thus helping students to understand concepts better, interactive media can help students develop skills such as critical, creative, and logical thinking. The findings of this study "Development of Interactive Media Based on Adobe Animate with Problem Based Learning Model to Improve Learning Outcomes of Fraction Material of Fourth Grade Students of SDN Kedungpane 02 Semarang" shows that integration of interactive media with the Problem Based Learning (PBL) model can improve the learning outcomes of fourth grade math students. math learning outcomes of grade IV students. This finding is in line with other studies that evaluate the effectiveness of interactive learning media and PBL models in learning mathematics. As in the research conducted (Sukmawati et al., 2024): This study examines the use of the Lectora Inspire application as an interactive learning media in learning mathematics for grade IV students. The results show that the use of this interactive media has a significant effect on improving students' math learning outcomes. Another research finding is by (Pendidikan & Sorong, 2025), research that evaluates the use of interactive learning media shows positive results in improving understanding of mathematical concepts. A study found that the use of interactive learning media significantly improved students' understanding of basic math concepts. This improvement was shown through increased participation in classroom activities and positive responses to learning delivered with interactive media. The findings of this study are consistent with the results of other studies showing that both interactive learning media and PBL models are individually effective in improving mathematics learning outcomes. The integration of the two, as done in this study, has the potential to have a more significant impact on students' understanding and learning outcomes in mathematics.

After the experts provided input, researchers revised the learning media to improve product quality. After the improvement process was completed, the learning media was tested on grade IV elementary school students. The trial was practiced in two stages, namely small-scale trials for a small group and large-scale trials for a wider group. This stage aims to evaluate the effectiveness and applicability of learning media before it is used more widely. First, Small Group Test. The small group test involved 6 students of SDN Kedungpane 02 Semarang as respondents. This test aims to evaluate the initial effectiveness of learning media before being implemented on a wider scale. The results obtained include pretest and postest scores which are used to analyze the increase in

student understanding after using the learning media. Second, Large Group Test. The large group test involved 28 students of SDN Kedungpane 02 Semarang as respondents. The trial was conducted with pretest and posttest measurements to analyze the increase in learning outcomes after using the product. The following is a recap of the average pretest and posttest on a small and large scale.

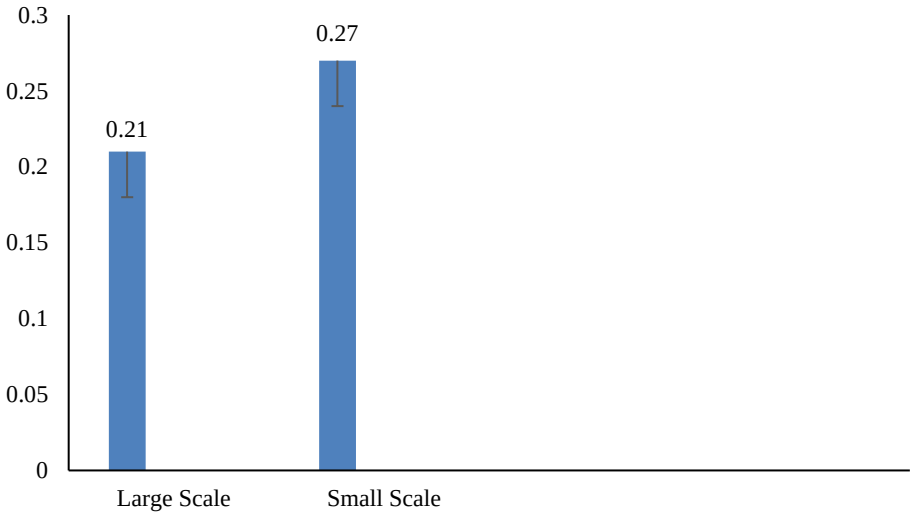

Figure 10. Average improvement (N-gain)

Based on diagram 1, it shows an increase in the average mathematics learning outcomes in small-scale classes, with a result of 0.27. Meanwhile, the large-scale class obtained a result of 0.21. This means that there is an increase in learning outcomes between small scale and large scale using Adobe Animate based interactive media developed by researchers.

The Adobe Animate based interactive learning media developed by researchers is designed to support more visual, dynamic, and interactive learning. This media is used as a tool in delivering material in a more interesting and easy-to-understand way, especially in mathematics subjects with the Problem Based Learning (PBL) model. With an interactive, visual, and exploration-based approach, this media helps students learn more actively and independently. In PBL, this media presents real problem-based scenarios and encourages students to explore and find their own solutions and interactive problem exercises help students understand the concept of fractions more clearly.

Adobe Animate based interactive media is designed to facilitate Problem Based Learning (PBL) and improve students' understanding of fraction concepts through attractive, interactive, and exploration-based visual displays. Adobe Animate based interactive media is designed by considering the principles of PBL learning, namely: problem presentation, skill development, and collaboration. Adobe Animate-based interactive media has several features that support PBL learning and understanding of fraction concepts, namely: interactive animation, simulation, and quiz and evaluation. By using Adobe Animate based interactive media, students can: improve understanding of fraction concepts, develop problem-solving and critical thinking skills, and increase

Figure 2. Demonstration of media explanation by researcher

Figure 3. Demonstration of media use by students

learning motivation by using interactive and fun media. The following are responses from teachers and students after the learning media was implemented.

"Students look more active when learning using this media. They grasp the concept of fractions faster than when using textbooks alone." (Class IV teacher)

"Usually I get bored quickly when learning math, but with this media I get more excited because the use of the media is like playing a game." (Student A)

Based on the responses of students and teachers, it has been proven that the use of Adobe Animate based Interactive Math media is very effective and helps students in learning. Students are very enthusiastic and interested in the use of Adobe Animate interactive learning media. They feel that learning becomes more fun and interactive. Students can actively participate in the learning process by operating the animations and interactions. The benefits felt by students include: Learning is more fun: students feel that learning is no longer boring, Increased motivation: Students are more motivated to learn because of the interaction and animation, Better understanding of concepts: Students can understand concepts better due to visualization and interaction, Improved technology

skills: Students can develop technology skills by using Adobe Animate. Thus, the use of Adobe Animate interactive learning media can improve the quality of learning and make students more motivated and interested in the learning process. The results of this study provide some practical implications in the design and development of mathematics learning media, especially in the application of Adobe Animate based on Problem Based Learning (PBL). The practical implication in this research is related to the learning process in the classroom. This interactive math media based on Adobe Animate can provide convenience in learning fraction materials, provide a new atmosphere in the learning process so that students become active learners, this media also helps teachers in delivering learning materials, increase student interest and motivation, make students active in the learning process because the media is designed to be easily operated by students. Research on the development of interactive math learning media based on Adobe Animate provides various important insights in creating more effective and interesting media. From this research, some key aspects that can be learned and should be considered in developing interactive learning media to be more effective and interesting are: use interactive visualizations to help students understand mathematical concepts better, integrate PBL models to get students more involved in solving real problems, provide immediate and interactive feedback to help students learn from their mistakes, ensure user-friendly design and wide accessibility so that the media can be used by all students, and use technology to personalize learning that allows students to learn according to their pace and style.

Every study has limitations that can affect the validity and generalizability of the results. In this study, some limitations that need to be considered include: limitations of the sample, the research sample may only include students from certain schools, so the results cannot be directly generalized to all grade IV elementary school students in Indonesia, differences in curriculum, school facilities, and socio-economic backgrounds of students in various regions can affect the effectiveness of the developed media; limitations of PBL model implementation, the success of Problem Based Learning (PBL) is highly dependent on the teacher's skills in implementing it. If teachers are not familiar with PBL, its effectiveness may decrease; limitations in measuring effectiveness, the observed improvement in learning outcomes may not only be caused by the interactive media and PBL, but also by other factors such as the teacher's teaching style, classroom conditions, or even students' social interactions, PBL takes longer than conventional methods, which can be a challenge in the learning schedule; external factors that affect learning outcomes, other factors such as student motivation, parental support, access to technology, and availability of devices (computers/gadgets) at home also play a role in improving learning outcomes. Implications for the interpretation of the results of the study should be interpreted in the context of sample limitations, so that before being widely applied, this interactive media should be tested in various school environments with different student characteristics, the effectiveness of this media may vary, depending on teacher readiness, students' access to technology, as well as their learning environment support. It is also undeniable that there are other factors that can affect student learning outcomes including internal and external factors. Internal factors include learning motivation, cognitive ability, interest in math, and learning style. External factors include teacher teaching quality, parental support, access to technology, school environment, and lack of learning time.

The next stage is the Paired Samples T-test to examine the effect of interactive learning media based on Adobe Animate. The analysis is carried out by comparing the results of the pretest and posttest before and after using the learning media. If the sig.(2-tailed) value <0.05, it means that there is an increasing difference between the learning outcomes before and after the use of the media, which indicates that the learning media has a definite effect on improving students' interpretation. Based on the results of the paired samples t-test conducted on 28 samples, there is a significant difference between the pretest and posttest scores. The average pretest score was 77.93 with a standard deviation of 5.83, while the average posttest score was 82.64 with a standard deviation of 4.69. The correlation between pretest and posttest scores is 0.630 with a significance of 0.000, which indicates a significant positive relationship between the two variables. The t-test results showed a t value of -5.374 with a degree of freedom (df) of 27 and a significance of 0.000. This indicates that there is a significant average difference between pretest and posttest scores. The mean difference between the pretest and posttest is -4.7142 with a standard deviation of the difference of 4.64166 and a standard error of the difference of 0.87719. The 95% confidence interval for the mean difference is between -6.51413 and -2.91444. Thus, it can be concluded that there is a significant increase in posttest scores compared to pretest scores. Where the results of the analysis show that the alternate hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected with a significance amount of 0.000, because the significance results obtained are> 0.05, this indicates that the intervention or treatment given has had a positive and significant impact on increasing the value. This research is reinforced by research by (Jisr et al., 2018), the results showed a value of 0.000 <0.05 in the t test, so that an increase in understanding was obtained in students, after being given treatment using the media.

▪ CONCLUSION

The research "Development of Adobe Animate Based Interactive Media with Problem Based Learning Model to Improve Mathematics Learning Outcomes of Grade IV Students of SDN Kedungpane 02 Semarang" aims to produce innovative and effective learning media in improving student learning outcomes. The results showed that the use of Adobe Animate-based interactive media combined with Problem Based Learning (PBL) can have a positive impact on student understanding in learning mathematics. Adobe Animate-based interactive media is able to present mathematical concepts in a visual form that is interesting, dynamic, and easily understood by students. Animation and interactivity in the media help students to be more focused and motivated in learning. In addition, the application of the PBL model allows students to be more active in exploring concepts, analyzing problems, and finding their own solutions, thus increasing their understanding of the material studied. The media development design consists of several menus, namely, cover, instructions for using the media, CP and TP, material, learning videos, and also quizzes. The results of validation by media experts and material experts show that the developed media has good quality in terms of design, content, and interactivity. The developed learning media obtained a percentage score of 91.66% from media experts and 91.07% from material experts, both with very feasible criteria. The assessment of media experts shows that this learning media has fulfilled all aspects needed in its development. Student trials showed an increase in learning outcome scores after using this media, compared to before learning. In addition, students showed

increased engagement, independence, and problem solving, which supports the effectiveness of the PBL model in learning mathematics. Therefore, the use of Adobe Animate as an interactive learning media can be an alternative to increase the effectiveness of learning Mathematics in an academic environment. Nevertheless, the effectiveness of this media is still influenced by several factors, such as the teacher's ability to implement PBL, students' skills in using technology, and limited access to devices in some schools. Therefore, further research is recommended to test this media in more diverse learning environments and develop broader implementation strategies so that the benefits can be felt by more students.

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