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Development of Computer-Based Learning Media on Collision Lesson Using the Context of Traditional Marbles Game

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ABSTRACT

Purpose of the study: This research aims to develop learning media using computer-based collision material in the context of the traditional game of marbles.

Methodology: This research is a Research and Development study using the ADDIE research design. The research was conducted at MA Al-Fatah Palembang using instruments in the form of interviews and questionnaires for data collection. Interviews were conducted with physics subject teachers at MA Al-Fatah Palembang. The questionnaire was given to media expert validators, material expert validators, teachers and students to see the validity and practicality of media use.

Main Findings: The result of this research is a learning media product using computer-based collision material in the context of the traditional game of marbles which meets the valid and practical criteria. The results of media expert validation that have been carried out show percentages of 91,7% with very valid categories. The material expert validation results show a percentage of 92.8% with a very valid category. The results of the limited trial showed that the percentage of assessments from physics subject teachers was 89,2% in the very practical category and students' responses to the use of learning media showed a percentage of 87.3% in the very practical category.

Novelty/Originality of this study: The main novelty of this study lies in utilizing a traditional game as a contextual and engaging framework to teach abstract physics concepts, such as collisions, in a more comprehensible way.

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1. INTRODUCTION

The development of education continues to progress alongside the advancement of time. Initially, people defined education as an effort to mature an immature child. This definition has, of course, experienced development and expansion in meaning. After centuries of evolution, scholars and philosophers have continuously explored the meaning of education [1]. The meaning of education has gradually expanded from a traditional interpretation, as described above, to a transitional one. It is termed a "transitional meaning" because, in this context, educators—or in this case, parents and teachers—have begun to recognize that children have the right to direct their own life goals. In setting these life goals, children must be equipped with knowledge [2].

Education plays a crucial role in a country's development. Quality education can drive a nation's progress, while poor education quality renders the country unable to compete with others [3]. Therefore, education is an essential tool that a country must optimize to achieve a better civilization. The educational process allows for reciprocal interactions between teachers and students, as well as with the learning environment. This interaction is referred to as a learning activity [4]. Unlike learning, "learning activity" has a more complex meaning, as it involves the interaction of several elements in the learning process. According to Dryden, learning is a behavioral process that engages all the senses, resulting in creativity in problem-solving with diverse and non-monotonous approaches [5].

To fulfill the learning process, certain elements are needed to support its occurrence. These elements include teachers, students, teaching materials, learning resources, and learning media [6]. Each of these plays a crucial role in the learning process. For instance, learning media serve as tools used to convey messages from the sender (teacher) to the receiver (students), stimulating students to engage effectively in the learning process and achieve the learning objectives, or more broadly, the objectives of education itself [7].

In another context, the modern era has introduced humanity to a life shaped by technology. Technology is essentially meant to assist humans in various aspects of life, including computer technology [8]. The use of computers has steadily expanded across many areas of human activity, one of which is in the learning process. One application of computers in education is their use as learning media [9]. Although computers operate strictly according to given instructions, computer-based learning is not entirely monotonous [10]. Learning with computers can be combined with traditional games to enhance students' enthusiasm and interest in learning, while also indirectly introducing and preserving these traditional games [11].

One of the challenges faced by educators in the modern era is integrating technological advancements into the creation of learning media [12]. Technology can be leveraged to its fullest to improve the quality of learning [13]. In the context of physics education, learning media play a crucial role for educators, as many physics topics are concept-based and require media as tools to help students grasp these concepts more easily [14]. From the students' perspective, physics is often seen as a challenging subject, leading many to feel intimidated even before starting the learning process [15]. Engaging learning media are expected to shift students' perspectives toward physics. In this study, the researcher aims to develop computer-based learning media using Adobe Flash CS6 for physics collision topics in grade 10.

A study conducted by Sumarni et al. (2018) titled "Development of Physics Learning Media Based on Macromedia Flash Pro CS6 for Grade 10 at SMAN 115 Jakarta" stated that physics learning media based on Macromedia Flash Pro CS6 positively impacted students' learning engagement and influenced their learning outcomes. This suggests that physics learning media created with Macromedia Flash Pro CS6 is effective for use in the learning process with students, particularly for grade 10 students at SMAN 115 Jakarta [16].

Before developing this learning media, the researcher conducted a series of activities to assess the needs of teachers, especially students, regarding the availability of computer-based physics learning media. Based on interviews with a physics teacher at MA Al-Fatah Palembang, it was found that during her time teaching physics at MA Al-Fatah Palembang, she mainly used textbooks and student worksheets as learning media, particularly for grade 10 and 11 students. According to her, using learning media such as PowerPoint often results in the teacher appearing more active than the students, while the curriculum demands that students be more active than the teacher. Additionally, the limited availability of usable media was another reason she was not particularly inclined to use other types of learning media.

From the perspective of student needs, unengaging learning methods have resulted in poor responses from students towards physics lessons. Based on a questionnaire distributed to grade 10 MIA I and MIA II students at MA Al-Fatah Palembang, it was found that 93.3% of respondents stated that physics was a subject that was difficult to understand. Their reasons for finding physics difficult were varied, ranging from too many calculations, the large number of formulas to memorize, to complex language in the textbooks. The questionnaire also revealed that, out of 30 students as respondents, 18 stated that the topic of collisions was among the most difficult to understand. When completing the questionnaire, each student could select more than one topic or chapter they found challenging. This research is also based on the results of the student needs analysis, in which all of them were familiar with the traditional game of marbles, and 96.6% of the students had played it. However, 80% of the students did not know which physics concepts were involved in the game of marbles. While 20% of students claimed to know, they were unable to explain the concept correctly.

Based on the description above, it is deemed necessary to conduct research to determine the outcomes of developing computer-based learning media for the topic of collisions, with the context of the traditional marble game. The use of the traditional marble game context is intended to help students better understand the concept of collisions, which is commonly encountered and applicable in everyday life. Previous research, such as that conducted by Layyin (2023), which developed flash-based learning media for the topic of angles, shows that the use of interactive media can enhance conceptual understanding [17]. This aligns with the current research, which connects technology-based learning media with an increase in physics learning motivation. Therefore, this research

is expected to contribute to the development of learning media that are more relevant to students' everyday contexts, as well as support the achievement of the core competencies expected in the curriculum.

2. RESEARCH METHOD

The type of research applied in this study is Research and Development (R&D), also known as research and development. This study uses the ADDIE development model as the research design, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation [18]. The ADDIE model was chosen by the researcher due to its simplicity in implementation while still being systematic. One of its advantages is that the model includes an evaluation step during the development stage, allowing for errors to be minimized and shortcomings to be addressed [19].

This research was conducted at MA Al-Fatah Palembang during the odd semester of the 2023/2024 academic year. The sample for this study consisted of 3 physics teachers and 10 grade 10 students from the Mathematics and Natural Sciences department. Data collection in this study was carried out using interviews and questionnaires with qualitative data types. Interviews were conducted with a physics teacher at MA Al-Fatah Palembang to understand the current state and the needs of physics learning at the school. The questionnaire was distributed to gather information about students' learning needs during the needs analysis phase. Additionally, the questionnaire was also distributed to subject matter experts and media experts to gather feedback on the feasibility of the developed product. Subsequently, the questionnaire will be given to physics teachers and students as a response to the use of the developed media.

After the completion of the questionnaires by subject matter experts, media experts, and the responses from teachers and students, the obtained data will go through an analysis stage. Data analysis is conducted to assess the overall feasibility of the data gathered from the questionnaires, where respondents provide ratings on various aspects using a Likert scale. The criteria for the Likert scale are as follows [20]:

Table 1. Criteria for the Likert Scale

Criteria	Score
Very Good	5
Good	4
Quite Good	3
Bad	2
Very Bad	1

After tabulation, the next step is to calculate the validity percentage. The result can be processed using the following formula.

$$\text{Percentage} = \frac{x}{\Sigma x} \text{ x } 100\%$$

Description:
x = Total score obtained
Σx = Maximal score

After obtaining the percentage results, the researcher then performs a conversion using the validity criteria as shown in the following Table 2 [21].

Table 2. Product Validity Analysis Criteria

Interval	Kriteria
80 < x < 100	Very Valid
60 < x < 80	Valid
40 < x < 60	Quite Valid
20 < x < 40	Invalid
0 < x < 20	Very Invalid

To assess the practicality of the media from the results of the media trial with teachers and students, it is calculated using the following formula.

$$\text{Percentage} = \frac{x}{\Sigma x} \text{ x } 100\%$$

Description:
x = Total score obtained
Σx = Maximal score

After obtaining the percentage results, the researcher then performs a conversion using the practicality criteria as shown in the following Table 3 [22].

Table 3. Product Practicality Analysis Criteria

Interval	Kriteria
80 < x < 100	Very Practical
60 < x < 80	Practical
40 < x < 60	Quite Practical
20 < x < 40	Impractical
0 < x < 20	Very Impractical

3. RESULTS AND DISCUSSION

1. Analysis Stage

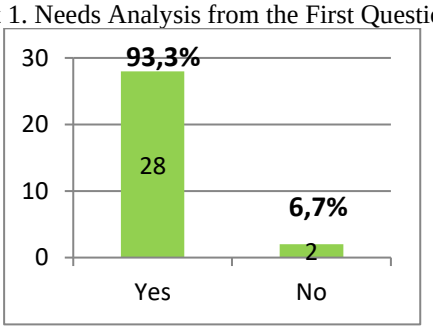
The needs analysis was conducted through two methods: interviewing the teacher and distributing questionnaires to students. The results of the interview with the physics teacher can be seen in Table 4.

Table 4. Results of the Physics Teacher Interview

No.	Questions	Response
1	What media or teaching materials do you use when teaching?	Books and student worksheets
2	What method do you use when teaching?	Discussion and lecture methods
3	What learning media are you familiar with that can be used in the teaching process?	There is a virtual lab (Phet). I have used it when teaching 12^{th} grade.
4	Have you previously utilized learning media in the teaching and learning process?	Only occasionally.
5	What is your opinion about the learning habits of the students?	Most of them are only enthusiastic at the beginning of the lesson (they get bored quickly).
6	How would you assess the learning abilities of the students?	Their abilities can be considered average. The most recent results from the CBT exam show that around 25-30% of the students scored above the minimum passing grade, which can be considered mid to high level.
7	Regarding facilities like projectors and computer labs, does the school have them?	Yes, but it cannot be used frequently because it may cause a power outage.
8	In your opinion, how do you feel about using animation media in the teaching process?	This is good, but in my opinion, the use of media should make the students more active rather than the teacher.

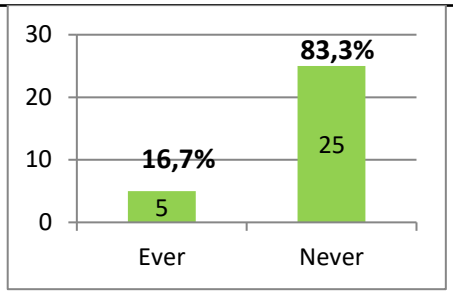
The results of the student needs analysis were obtained from the responses provided by the students to the questionnaires that were distributed. The questionnaire consisted of eight questions. The first needs analysis question was "Physics is a difficult subject." The distribution of the students' responses to the first needs analysis question can be seen in the following chart 1.

Chart 1. Needs Analysis from the First Question



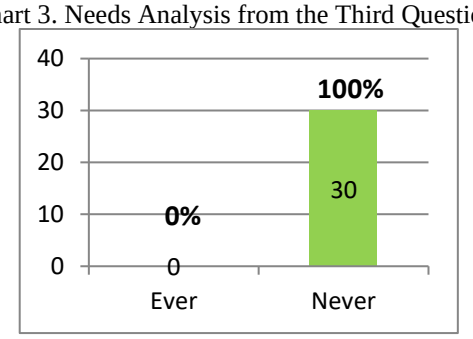
The second question asks whether or not the physics teacher at MA Al-Fatah Palembang has ever used a computer or laptop in the learning process. The distribution of student responses to this question can be seen in Chart 2 below.

Chart 2. Needs Analysis from the Second Question



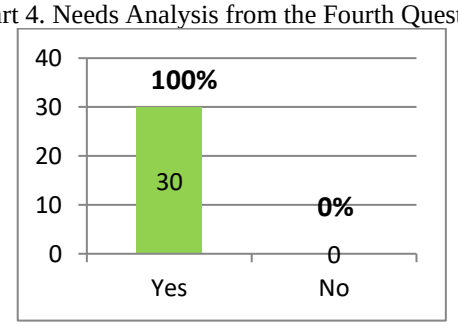
The third question is about whether or not the physics teacher at MA Al-Fatah Palembang has ever used animation media in the learning process. The results of student responses to this question, based on the distributed questionnaire, are as follows.

Chart 3. Needs Analysis from the Third Question



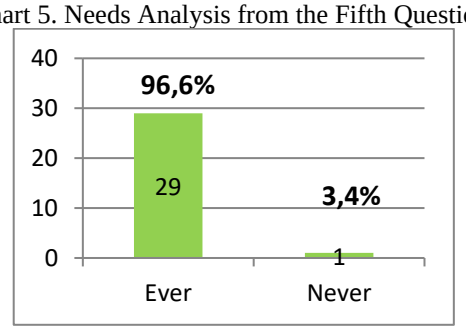
The next question is about students' knowledge of the traditional marbles game. This question was given to assess students' initial understanding of the physics concepts involved in the traditional marbles game. The fourth question asked was, “Are you familiar with the traditional marbles game?” The results of the student questionnaire for the fourth question can be seen in Chart 4 below.

Chart 4. Needs Analysis from the Fourth Question



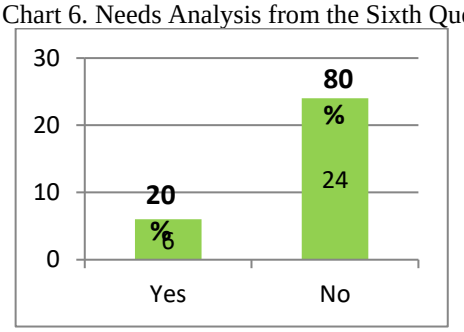
The fifth question asked whether the respondents had ever played the traditional marbles game. The distribution of student responses from the questionnaire can be seen in Chart 5 below.

Chart 5. Needs Analysis from the Fifth Question



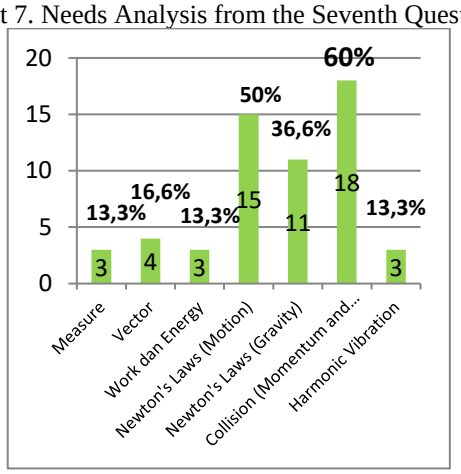
The sixth question is about students' understanding of the physics concepts involved in the traditional marbles game. The question asked was, “Are you aware of the physics concepts involved in the traditional marbles game?” The results of student responses from the distributed questionnaire can be seen in Chart 6 below.

Chart 6. Needs Analysis from the Sixth Question



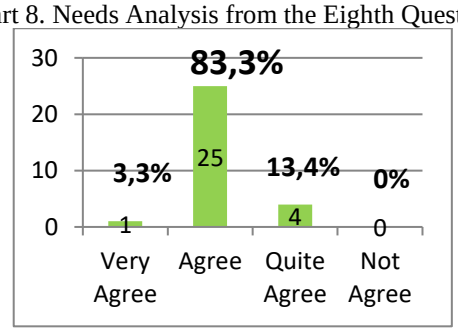
The next question is about the 10th-grade physics lesson that is considered difficult by 10th-grade science students at MA Al-Fatah Palembang. For this question, respondents were allowed to select more than one option. The distribution of responses from the student questionnaire is as follows.

Chart 7. Needs Analysis from the Seventh Question



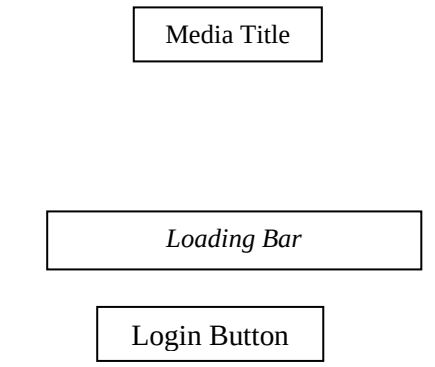
The eighth question is about students' opinions regarding the development of computer-based learning media in the context of the traditional marbles game. The students' responses to this question can be seen in Chart 8 below.

Chart 8. Needs Analysis from the Eighth Question

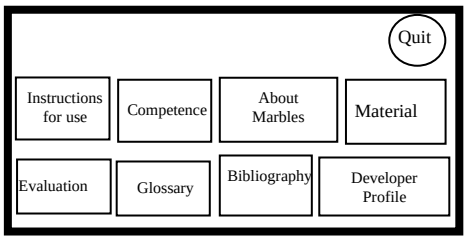


2. Design Stage

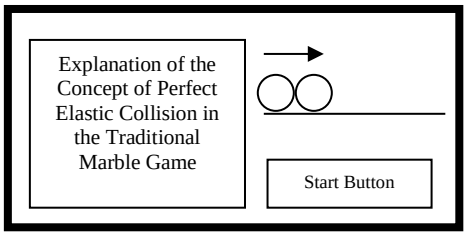
This stage aims to design the learning media that will be created in the next stage (development stage). In this stage, the design of the computer-based learning media for the topic of collisions, in the context of the traditional marble game, is created using Adobe Flash CS6 software with ActionScript 2.0.



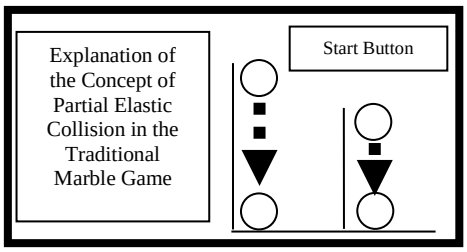
Picture 1. Initial Design of Learning Media



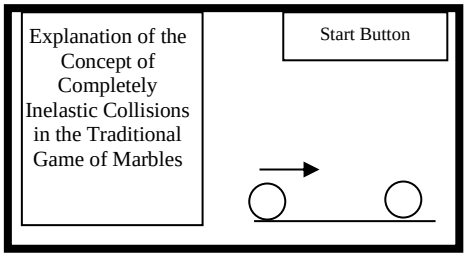
Picture 2. Design of the Main Menu Interface of Learning Media



Picture 3. Design of the Perfect Elastic Collision Animation



Picture 4. Design of the Partially Elastic Collision Animation



Picture 5. Design of the Totally Inelastic Collision Animation

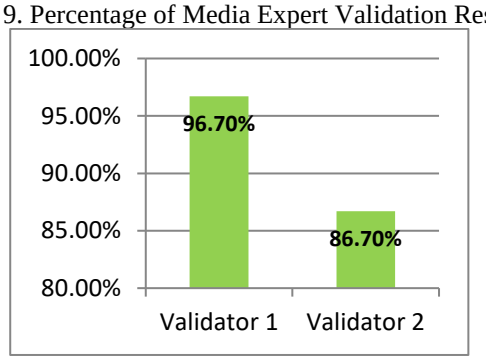
3. Development Stage

At this stage, computer-based learning media on the topic of collisions with the context of the traditional marble game has been developed using Adobe Flash CS6 software.

Picture 6. Main Menu Interface

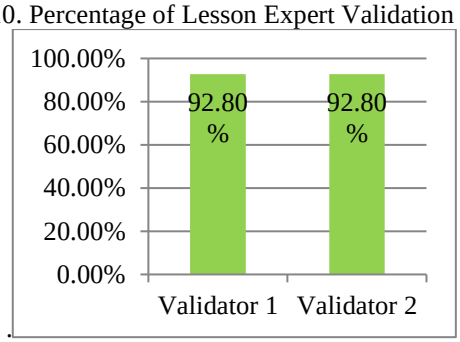
The produced media has also undergone a validation process by two media expert validators and two subject matter expert validators. The percentage results of the validation by the first and second media expert validators are presented in the following chart 9.

Chart 9. Percentage of Media Expert Validation Results



The percentage of validation results by the first and second subject lesson expert validators is presented in the following chart 10.

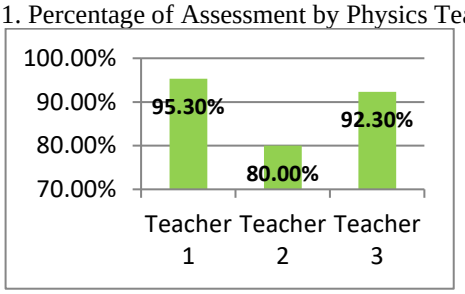
Chart 10. Percentage of Lesson Expert Validation Results



4. Implementation Stage

At this stage, a limited-scale trial was conducted, where the researcher sought assistance from 3 physics teachers and 10 students as respondents. The results of the trial with the 3 physics teachers yielded a practicality percentage as shown in the following chart 11.

Chart 11. Percentage of Assessment by Physics Teachers



The students' responses to the use of the media were obtained from questionnaires distributed to the students. Based on the questionnaire, the total evaluation score was 65.5 out of a maximum of 70, with an average score of 4.36 out of 5. When calculated as a percentage, it results in:

$$\text{Percentage} = \frac{65,5}{70}\ x\ 100\% = 87,3\%$$

5. Evaluation Stage

In this study, the evaluation conducted includes two types, formative evaluation and summative evaluation. Formative evaluation is the evaluation conducted at each stage that has been outlined earlier [23]. Formative evaluation is used in this study because it aligns with the researcher's need to make revisions and improvements at each stage to ensure the learning media produced has minimal errors.

On the other hand, summative evaluation is conducted to assess the practicality of using the media by looking at the students' learning outcomes after using the learning media [24]. Since this study is not aimed at comparing students' learning outcomes before and after using the learning media, the summative evaluation conducted is in the form of a post-test.

The development of computer-based learning media on the topic of collisions, within the context of the traditional marble game, was developed using the ADDIE development model. This development model is based on an effective and efficient systems approach, where each stage is interactive, allowing the model to generate evaluation results at each stage that are useful for progressing to the next stage of development [25].

The first stage is the analysis stage. In this stage, the researcher determines the foundational elements of the study. The researcher conducts a needs analysis to gather students' opinions and needs regarding the availability of physics learning media. Additionally, the researcher performs a competency analysis to ensure the learning media aligns with core competencies, basic competencies, and learning objectives as required by the curriculum. The researcher also conducts a material analysis to identify which physics topics students find challenging to understand through verbal explanations alone. The use of learning media, especially animation, will help students observe and understand physics phenomena that occur in a relatively short time [26]. Furthermore, the researcher analyzes the characteristics of the students through observations and interviews with physics teachers. This analysis aims to understand students' learning interests in physics, allowing the researcher to design media that can accommodate and motivate students during the learning process.

The results obtained in the needs analysis stage show that 93.3% of students consider physics to be a difficult subject to understand. Students cited various reasons for their difficulties in understanding physics, such as the large number of formulas to memorize, excessive calculations, and so on. This finding is consistent with a study by Novita Amelia Sari (2021), where 70.4% of students expressed that physics is difficult to understand [27]. Similar results were also found by Alifudin Khumaidi and Imam Sucahyo (2018), where 73% of students said that physics was a difficult subject to understand [28]. The percentage obtained in this study is higher, suggesting that physics is truly considered difficult by the respondents compared to those in previous studies.

The second stage is the design stage. In this stage, the researcher chooses to use ActionScript 2.0 as the programming language for the Adobe Flash CS6 software to create the learning media. ActionScript 2.0 was selected because it is simpler compared to ActionScript 3.0. This is similar to a study conducted by Novita Amelia Sari (2020), which found that ActionScript 2.0 in Adobe Flash CS6 is easier to understand than ActionScript 3.0 [29]. However, from a technological standpoint, ActionScript 3.0 is recommended over its predecessor, ActionScript 2.0. A study by Fatur Rahman (2018) using ActionScript 3.0 to create Adobe Flash CS6-based learning media found that ActionScript 3.0 allows media to link to trusted websites or journals, referred to as the e-reference feature. This feature is quite interesting, though it requires an internet connection, which is a drawback of ActionScript 3.0 [30].

The third stage is the development stage. In this stage, the researcher begins to develop the learning media, which will then be applied to the next stage. The development of the computer-based learning media on collisions with the context of the traditional marble game took approximately 80 hours. After the media was developed, the researcher conducted a validation process to assess the validity of the media. After several revisions based on validator feedback, the learning media was deemed valid and ready to be applied in the learning process, after which the researcher proceeded to the next stage of the study.

The fourth stage is the implementation stage. In this stage, three physics teachers and 10 students from the XI MIA class of MA Al-Fatah Palembang were asked to experience using the developed learning media. Afterward, each respondent was asked to fill out a questionnaire regarding their response to the use of the media. The purpose of this questionnaire was to assess the practicality of the learning media when applied in the field.

The final stage in the media development process is the evaluation stage. Based on the evaluation results from students on the questions they answered, it was found that only 50% of the total respondents achieved scores above the passing grade scores. In response, the researcher interviewed a student who scored below the passing grade scores. Additionally, the researcher evaluated the learning process during the study. Based on these findings,

the low scores were attributed to several factors, such as limited time to use the learning media. This was due to the limited number of computers available during the trial, forcing students to take turns using the media.

Regarding the students' performance, the researcher categorized students into three cognitive ability groups based on their evaluation scores. The highest score achieved by a student in the sample was 80. This student can be considered to have high cognitive ability. Based on 10 questions, this student answered 8 correctly. The students' performance indicated that, in general, they had an understanding of collision concepts and problem-solving steps. However, there were some questions where the steps were not fully explained, although the students managed to answer them correctly. Additionally, there were some calculation errors made by students when solving the problems.

4. CONCLUSION

Based on the results of the conducted research, it can be concluded that the media validation performed by two media expert validators showed an average percentage of 91.7%, while the material validation performed by two material expert validators showed an average percentage of 92.8%. This indicates that the developed learning media meet the criteria of being highly valid. These findings align with the study by Layyin and Haqiqi (2023), which stated that technology-based learning media, such as Adobe Flash, can enhance the validity and effectiveness of learning materials [31]. Furthermore, physics teachers provided positive feedback on this learning media, with an average evaluation percentage of 89.2%. Meanwhile, the students' responses to the use of the media showed a percentage of 87.3%. This indicates that the learning media received positive responses from both teachers and students, thus meeting the criteria of being highly practical. These findings are supported by previous research, such as that by Utami et al. (2023), which revealed that interactive media based on everyday contexts can increase students interest and motivation in learning [32]. This research has significant impacts. In the short term, this learning media can be directly used to support the understanding of collision concepts in the classroom, helping students comprehend materials applicable to daily life, such as through the context of traditional marble games. In the long term, the use of such technology-based media has the potential to encourage more contextual and engaging physics learning innovations, ultimately improving the overall quality of physics education. However, this research has several limitations, including being conducted on a small scale in one school, which limits the generalization of results to various learning contexts. Moreover, this study focused only on media validation and initial responses without measuring the long-term impact on improving students' learning outcomes. Further research is recommended to include trials with larger samples and evaluate the effectiveness of the media on learning outcomes over the long term.

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