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Development of virtual reality material: Archimedes' Law (VIRMA) in high school physics subjects to improve student learning outcomes

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ABSTRACT

The development of this virtual reality (VR) with an artificial environment consisting of scenes and 3D objects is expected to be a problem solution from a low conceptual understanding of Archimedes' Law material. This study aims to make physics learning media with virtual reality on Archimedes' Law (VIRMA) material. The purpose of his research is to describe the validity of making virtual reality learning media on material: Archimedes' Law (VIRMA), to tell the effectiveness of making virtual reality learning media on material: Archimedes' Law (VIRMA) based on learning outcomes and student response questionnaires. The type of research used in this research is development research according to the ADDIE model with one group pre-test post-test research design. The result showed that the development of virtual reality media in Archimedes' Law (VIRMA) material is very valid, with a percentage value of 85.9%. Using virtual reality media on material: Archimedes' Law can provide hands-on learning experiences, facilitate a deeper understanding of abstract concepts, and improve student learning outcomes with n-gain in the medium category 0,67. In addition, the response questionnaire showed that 93.7% of students agreed that virtual reality media was enjoyable and effective in helping to understand Archimedes' Law. Using the virtual reality media on the material is recommended: Archimedes' Law, which can increase student involvement, stimulate student interest in learning physics, and improve student learning outcomes.

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INTRODUCTION

The millennial generation is now entering the era of the industrial revolution 4.0 and the age of society 5.0. In this era, humans are considered to have never known life without technology. In the Society 5.0 era, people can solve various problems by utilizing multiple technologies that emerged in the Industrial Revolution 4.0, such as Big Data, Artificial Intelligence, and the Internet of Things, such as the virtual world and the metaverse (Saragih, 2022). The existence of the era of Society 5.0 creates the availability of education more comprehensive, flexible, and innovative. This causes the use of technology in education to continue, such as virtual classrooms and even has the

potential to utilize robots in the learning process. Even so, according to the Ministry of Education and Culture in ditpsd.kemdikbud.go. There is a teacher role that cannot be replaced by technology, namely the emotional bond between teacher and student, direct interaction during class learning, character building, and exemplary teacher (Laila & Hendriyanto, 2021).

The role of the teacher in education in the Society 5.0 era is crucial in building students' character, soft skills, and hard skills. According to Risdianto (2019), students' skills in the 21st century are 4C (Critical Thinking, Creativity, Communication, and Collaboration). Learning methods and media are needed to achieve these essential learning activities skills. Learning media helps deliver material effectively and can increase student understanding, motivation, and interest in learning (Suryani, 2016). Indonesia is a country where people are active in using smartphones. This can be seen from the people who access the internet on an average of 34 sites per day, and 63 million are Facebook users (Sulistyowati & Rachman, 2017). So do not be surprised if almost every child knows and is even an expert in using laptops and smartphones because digital-based learning can be an exciting learning medium for students.

The quick development of education shows that learning methods and media in schools need to be developed following the integration of technology into the learning process. Online experiment simulations, e-learning, and online classrooms can be accessed anywhere and anytime (Sulaiman et al., 2020). Using three 3-dimensional (3D) media is one of the student's demands that learning is interactive, innovative, and more concrete (Dewi, 2020). One of the 3D learning media is virtual reality. Virtual reality (VR) is a technology that uses computer technology to create immersive simulated environments. VR is increasingly used in education and in recent years to develop skills through interactive learning environments (ILE) with VR implementation. Physics education is one area where VR has been used to improve the visual representation of educational content and stimulate the cognitive process of learning with interactive experiences (Geng et al., 2022; Zatarain-Cabada et al., 2023).

They are learning media as one of the supports to reduce student learning barriers. One of the learning barriers is in physics lessons. In learning Physics, students experience obstacles in solving problems because the physics questions given by the teacher directly use mathematical equations without the need for analysis, and students are required to memorize formulas as used in other problems (Azizah et al., 2015). In addition, the results of previous research mention that examples of students' physics learning barriers are the lack of quality teaching staff, inadequate learning media and practicum tools, lots of subjects with dense syllabuses, and unfavorable family, school, or community environmental conditions will also have an effect (Daun et al., 2020). This is the results of research conducted by Dewi & Anggaryani (2020) & Hafi & Supardiyono (2018), which explains that physics material is challenging to understand because the teacher conveys it with direct explanations using the media of textbooks, power points, and practice questions that only contain formulas.

Obstacles in learning physics cause students' difficulty in counting, difficulty solving and analyzing problems on questions, difficulty understanding material concepts, difficulty using physics equations, including difficulty interpreting symbols and units (Azizah et al., 2015; Daun et al., 2020; Haqiqi & Sa'adah, 2018). According to research by Azizah et al., (2015), the difficulty of learning physics for students can be seen from 26% on Temperature and Heat material, 21% on Static Fluid material, 17% on Elasticity and Hooke's Law material, 25% on Optical material, and 11% on Kinematic material.

Archimedes' Law is a sub-material of Static Fluids in Physics lessons. Several studies regarding mastery of the concept of Archimedes' Law material show that there are still many misconceptions and students' lack of understanding of Archimedes' Law (Anjelin et al., 2021; Lestari et al., 2017; Rohmayanti et al., 2020; Widodo et al., 2018). In addition, students' initial obstacles to Archimedes' Law material include not being able to determine the volume of objects that sink, the density of things that are in the fluid, and not understanding the conditions of sinking, floating, and floating when objects are placed in the liquid (Lestari et al., 2017). The results of other studies also show that students' mastery of this material is relatively low, especially when

determining the equations of Archimedes' Law, causing difficulties in mathematical calculations (Widodo et al., 2018).

Based on research on the use of virtual reality media in education, there has yet to be any development on Archimedes' law material at the high school level. In addition, students' understanding of this material still needs to be improved. The description above-inspired researchers to make physics learning media with virtual reality on material: Archimedes' Law (VIRMA). This research aims to test the feasibility or validity of virtual reality learning media on the material Archimedes' Law (VIRMA). The second is to describe the effectiveness of virtual reality learning media on material: Archimedes' Law (VIRMA) based on the pre-test and post-test scores and increased learning outcomes from n-gain. Third, to describe the effectiveness of virtual reality learning media on material: Archimedes' Law (VIRMA) based on student response questionnaires.

METHOD

The type of research used in developing virtual reality learning media is development research according to the "ADDIE" model (Analysis, Design, Develop, Implement, Evaluate) (Branch, 2009). The flow of virtual reality media development that will be used is shown in Figure 1.

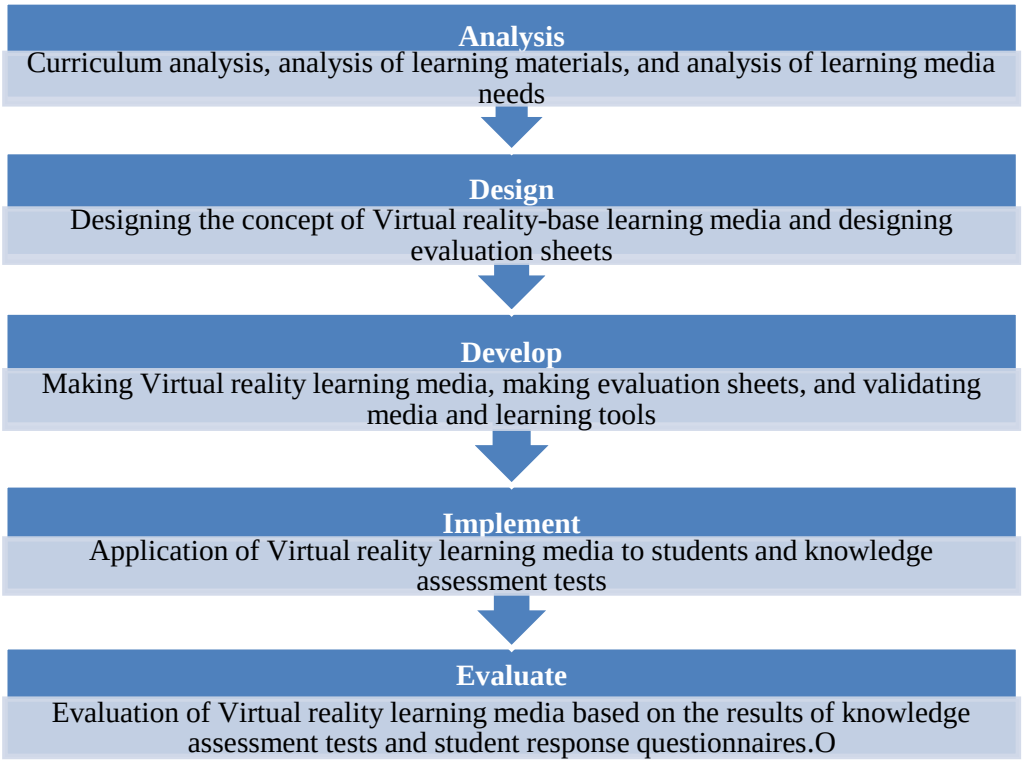

Figure 1. The Flow of Virtual Reality Media Development

This research was conducted at SMAN 3 Ponorogo and the Department of Physics, Universitas Negeri Surabaya, in the 2022/2023 academic year. This research was applied to class XI students at SMAN 3 Ponorogo using a limited test on students from class XI. The subject of this study was the development of virtual reality on material Archimedes' Law (VIRMA); validation was carried out by two lecturers from the Physics Department at Universitas Negeri Surabaya and one Physics teacher from SMAN 3 Ponorogo.

The research design used was a one-group pre-test and post-test design. This design can be described in Formula 1.

$$O_1 \text{ X } O_2 \quad (1)$$

Description:
O_1 = Pre-test
O_2 = Pro-test (after being given treatment)
X = Treatment

The research procedure gives a pre-test to determine the student's initial knowledge, and then the learning treatment uses virtual reality-based media on Archimedes' Law material. After that, the students were given a response questionnaire and a post-test to determine the increase in learning outcomes. The thing tested is the difference between O2 and O1. If there is a difference where O2 is more significant than O1, then the VIRMA media positively improves student learning outcomes. If O2 is smaller than O1, the n has a negative impact (Sugiyono, 2009).

This study only consisted of one group that was given the treatment. The population in this study were all students of class XI SMA Negeri 3 Ponorogo, which consisted of twelve classes. In this study, the sampling method used is probability sampling. The physics lesson schedule was in class XI IPA 3 SMA Negeri 3 Ponorogo during the research. The researcher conducted research in that class with 34 students sampled.

The research instruments for obtaining data were validation sheets, knowledge or understanding test sheets, and student response questionnaire sheets. The validation sheet is an instrument given to the validator to validate virtual reality media on the material: Archimedes' Law (VIRMA) media products that researchers have developed. Meanwhile, there are pre-test and post-test forms of knowledge or comprehension test sheets to determine increased learning outcomes after virtual reality media treatment. Validation used a "Likert Scale". According to Riduwan (2007), to determine the percentage validity of learning media, the assessment scores of all validators are calculated using the following Formula 2.

$$P = \frac{K}{n} \, x \, 100\% \quad (2)$$

Description:
P = Percentage of assessment
K= Sum of all scores obtained
n = Maximum number of scores

Analysis of students' knowledge or understanding tests using a minimum passing score for physics subjects is 70. Furthermore, pre-test and post-test scores are used to determine the results of increased student learning using "n-gain" equation in Formula 3 (Hake, 1998). Increasing student score based on "n-gain" scores can be categorized in Table 1.

$$(g) = \frac{\%\,(G)}{\%\,(G)_{max}} = \frac{\left(\%(S_f)\right) - \left(\%(S_i)\right)}{(100\% - \%(S_i))} \quad (3)$$

Description:
(g) = Increase of Student score
(S_i) = Pre-test score
(S_t) = Post-test score

Table 1. Gain Score Category

Gain score (g)	**Categories**
$more\ excellent(g) > 0{,}7$	High
$0{,}3 < (g) \leq 0{,}7$	Medium
$(g) < 0{,}3$	Low

An increase in student learning outcomes is seen from the close in $(\boldsymbol{g})$ reaches the medium or high category. Furthermore, for the analysis of student response questionnaires using the Guttman Scale. Students must complete a questionnaire with "Yes" or "No" answers. The percentage value of the response questionnaire is obtained from Formula 4.

$$P = \frac{F}{n} x\ 100\% \quad (4)$$

Description:
P = Percentage of all answers from the response questionnaire
F = Number of positive replies from respondents
n = Number of all respondents

Assessment of virtual reality learning media based on validation results, understanding test scores, and student response questionnaires is declared valid and effective if the percentage is ≥ 61% or in the excellent/effective category.

RESULTS AND DISCUSSION

Results

This section discusses the results of each stage of developing virtual reality-based learning media on Archimedes' Law material carried out with the "ADDIE" model.

Analysis

First is an analysis of the Curriculum. The educational curriculum used as a reference in this research is the Revised 2013 Curriculum (K-13 Revision). The 2013 curriculum implements a learning center for students; it is hoped that it will encourage students to have the ability to observe, ask questions, communicate, and reason actively, creatively, and innovatively. The expected student competencies in the 2013 Curriculum include attitude, skill, and knowledge competencies (Nurhasanah et al., 2021). So, in learning physics with the 2013 curriculum, students must be more active and creative in discovering natural phenomena around them and solving problems in these phenomena. Observations of natural wonders in the learning process of the 2013 curriculum are often faced with limited student experience and the surrounding environment. In abstract material, it is difficult for students to find examples of natural phenomena around them, so the learning process must be distinct from elements of learning media to achieve the desired competencies.

Second is an analysis of Learning materials; the material to make virtual reality learning media is static fluid, especially in the Archimedes Law sub-material. At this stage of material analysis, the researcher conducted a study of the Basic Competency (KD) of physics in static fluid material contained in the "Regulation of the Minister of Education and Culture Number 37 of 2018", with the following essential competencies: "3.3 *Menerapkan hukum-hukum fluid statik dalam kehidupan sehari-hari*". Based on KD 3.3, students are expected to be able to identify the application of Archimedes' Law in everyday life, develop ideas and solve problems related to Archimedes' Law in everyday life, identify the variables that affect the amount of buoyant force, and be able to analyze the phenomena of floating, drifting and sinking.

However, in practice, many students still need to gain a higher understanding and mastery of the concept of Archimedes' Law, causing the achievement indicators of KD 3.3 to be partially achieved by students. As in the research of Lestari et al., (2017), study results explain that students cannot apply Archimedes' Law in determining the volume of objects that have fallen and cannot identify the state of things that float, float, or sink when immersed in a fluid. To optimize the achievement of essential competencies, it is necessary to use suitable learning media. Not only through practicum tools but innovative learning media at the learning orientation stage can help students understand the concept of Archimedes' Law and its application in everyday life in their limited surroundings.

Third is an analysis of Learning Media. Learning media analysis was carried out by analyzing previous research regarding the use of virtual reality media, which was researched by Dewi (2020). The development of Revolution 4.0 causes students to want innovative learning activities, can attract interest in learning, and lead to 3-dimensional (3D)-based media. The study results from this research show that virtual reality as a learning media has the advantage of providing visualization of abstract and difficult-to-explain material. In addition, 3D media based on virtual reality effectively increases student learning outcomes and interest.

However, the availability of virtual reality learning media still needs to be expanded to certain materials and fields of knowledge. Hence, it needs to be developed and tested at various levels of schools and other areas of expertise. Based on the facts and demands on fundamental competency analysis, material analysis, and media analysis, this has encouraged researchers to develop virtual reality learning media on Archimedes' Law material.

Design

In this section, the planning and design of virtual reality learning media is carried out. At the media planning stage, the researcher determines the software and concepts used. Next, the researcher compiles a virtual reality script in which material from Archimedes' Law will be presented and an overview of what student activities they must achieve in the virtual reality world. For designing virtual reality learning media, researchers choose the following platforms or software. Frame VR platform, accessed on the link https://learn.framevr.io/, is used to design 360 views and layout of 3D objects. The first step is to develop a virtual environment (scene) that will be used as the location and flow of material delivery to students. The second step is to create and compile material for Archimedes' Law. In developing VIRMA media, the authors use the Frame VR platform because there is no need to download or install separate programs for VR creators and users so that students can participate directly in the browser via laptops, mobile phones, and VR headsets. In Frame VR, students are players, and there are 3D avatars for each user, so it is an immersive environment, a social presence, and interaction with other users.

In addition, Frame VR is used as a learning medium because it enables teachers and students in the same virtual environment and during the learning process to upload various content during the learning process, such as photos and videos, PDFs, whiteboards, shared screens, files, 3D models, etc. For a continuous learning experience, Frame VR can be used as an effective and sustainable learning medium because it is adaptive; students can also access and interact with Frame VR before and after class (Lee & Hwang, 2022).

In research conducted in Korea, the results also show that e-learning with virtual reality using the Frame VR platform, students feel class in a virtual environment such as face-to-face classes, students in a virtual environment can organize authentic knowledge and build an interactive learning community with other players (Hwang et al., 2023) . In addition, avatars or players in Frame VR help students be more active and foster a sense of connection that is very different when using Zoom or other media conferences (Jeong et al., 2022). Besides that, the researcher uses Filmora software to create, edit, and combine videos regarding Archimedes' Law material, which is then presented on Frame VR. Researchers also used Sketchfab. Sketchfab is a platform for visualizing and sharing content for 3D creators. This platform is used to create and find 3D objects needed to support the visuals and virtual reality concepts that have been designed.

In addition to designing virtual reality learning media, researchers also developed a guidebook for using VIRMA learning media, which contains features on Frame VR, virtual reality scene images, and activities that players in VIRMA learning media must carry out. This guide will help users, especially beginners who have never used the VR medium before, to make things easier.

Development

The development section is the stage of making VIRMA learning media per the media design using the platform and software selected to create the required scene and material. The results of creating virtual reality learning media on Archimedes' Law material is also used as a learning video that can be accessed on YouTube with the link address

https://youtu.be/xE3HxApZ6GY. The visualization of virtual reality on Material: Archimedes' Law (VIRMA) is in Figure 2.

Figure 2. Visualization of VIRMA Learning Media

Furthermore, the VIRMA learning media made is submitted to the validator to validate the feasibility of the press based on audiovisual aspects, aspects of media operation, and aspects of material content—recapitulation of VIRMA learning media assessment in Table 2.

Table 2. Score Validation of VIRMA Learning Media

No.	Assessment Aspects	Score from Validator			Percentage and Criteria
		Physics lecturer	Physics media lecturer	Physics Teacher	
1	Display aspects and media concepts	26	27	25	86,7% (Very Valid)
2	Audio aspects	5	5	3	86,7% (Very Valid)
3	Media processing aspects	12	13	12	82.2% (Very Valid)
4	The suitability of physics learning materials	24	23	19	88% (Very Valid)
	Average				**85.9% (Very Valid)**

The results of Table 2, the recapitulation of the validator's assessment show that the percentage of validity of the VIRMA learning media is 85.9%. Hence, it is very valid and suitable as a learning medium to support the physics learning process on Archimedes' Law material. Furthermore, the researcher also made a student response questionnaire and a knowledge or understanding test instrument consisting of pre-tests and post-tests for evaluation sheets. Furthermore, validation of knowledge tests related to content and construction feasibility aspects. Based on the assessment of three validators, the percentage of validity of the evaluation sheet in the form of knowledge test questions is 85.2%. The validation results for student response questionnaires obtained a fact of 88.9%. The overall validation percentage results show that both instruments are valid and suitable for use.

Implementation

The application of VIRMA learning media uses one group pre-test and post-test design. The procedure is that students will be given a pre-test as an initial test before being treated using VIRMA learning media to know the initial abilities of students and then treated with virtual reality media. Furthermore, students are given a post-test to determine their final ability after being treated with VIRMA media. Knowledge assessment using the pre-test and post-test covers the cognitive domains C1 to C6 with ten questions in multiple choices. The results of implementing VIRMA learning media can be seen based on the pre-test and post-test values in Table 3.

Table 3. The Results of Pre-test and Post-test Scores

Respondent	Pre-test	Post-test	Description	Respondent	Pre-test	Post-test	Description
1	30	90	Pass	18	30	90	Pass
2	20	70	Pass	19	40	70	Pass
3	30	70	Pass	20	20	70	Pass
4	40	90	Pass	21	40	90	Pass
5	20	40	Failed	22	40	90	Pass
6	40	90	Pass	23	10	60	Failed
7	10	70	Pass	24	30	80	Pass
8	20	90	Pass	25	40	70	Pass
9	30	70	Pass	26	50	100	Pass
10	20	70	Pass	27	40	90	Pass
11	40	70	Pass	28	30	70	Pass
12	30	80	Pass	29	20	80	Pass
13	10	80	Pass	30	20	80	Pass
14	10	70	Pass	31	30	60	Failed
15	50	80	Pass	32	40	80	Pass
16	40	100	Pass	33	40	70	Pass
17	10	30	Failed	34	30	70	Pass
Average of pre-test score					**29.4**		
Average of post-test score					**75.9**		

Based on Table 3, it is known that none of the students' pre-test scores met the minimum score of completeness. It is also known that the post-test scores of each student have increased after being given the learning treatment with VIRMA learning media. Apart from that, it can be seen that as many as 30 students have passed the minimum score in physics subjects ≥ 70, and the average pre-test of students gets a score of 29.4 while the average post-test has increased with a score of 75.9.

Evaluation

Evaluation is used to assess the effectiveness of using virtual reality learning media in the material Archimedes' Law based on the results of the student reaction questionnaire. Recapitulation of Questionnaire Results Responses for using VIRMA media are mentioned in Table 4. Based on

Table 4, the student response questionnaire results obtained an average percentage of 97.3%, which means perfect criteria.

Table 4. The Results of the Student Reaction Questionnaire

No.	Statement	Percentage (%)	
		Yes	No
1.	This virtual reality learning media is easy to operate and functions well	97	3
2.	Object illustrations and videos in virtual reality learning media can help to understand Archimedes' Law material	100	-
3.	The material presented on virtual reality learning media is easy to understand	100	-
4.	Learning media with virtual reality is attractive in terms of appearance and concept of presenting the material	100	-
5.	Archimedes' Law material in virtual reality learning media is compatible with the teacher's explanation	100	-
6.	The illustrations through this virtual reality learning media can increase my motivation to study physics	97	3
7.	The virtual reality learning medium has helped my learning process become more interactive and fun	97	3
8.	This virtual reality learning media aroused my curiosity.	97	3
9.	Using virtual reality-based learning media has kept up with current technological developments	100	-
10.	This virtual reality learning media is flexible and can be used in various software	85	15
	Average	**97,3**	**2,7**

Discussion

Research on the development of virtual reality learning media on the material: Archimedes' Law (VIRMA) is to create valid and effective learning media to improve learning outcomes and students' learning motivation in physics learning activities.

Appropriate based on the validity of VIRMA learning media

The average score of VIRMA learning media includes four aspects: display aspect and media concepts, audio aspects, media processing aspects, and the suitable f Physics material. The result of each category can be drawn in Figure 3.

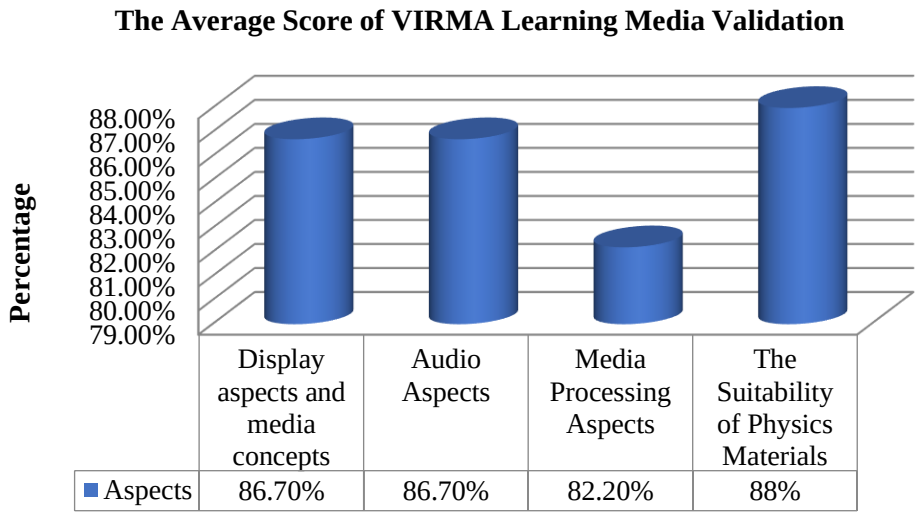

Figure 3. The Average Score of VIRMA Learning Media Validation

Based on Figure 3 recapitulation of the validation of virtual reality learning media on Archimedes' Law, it was found that the learning media created had an average percentage of 85.9% in the very valid category. Of the aspects assessed in the validation of the VIRMA learning media, the first is the visual aspect, which gets a percentage of 86.7%, which means the layout of the material, the selection of colors or fonts, and the concept of VIRMA media presentation has been declared very valid and have the opportunity to be developed according to technological advances. Except for audio aspects such as intonation and audio clarity, learning is also excellent, with a percentage of 86.7%.

Second, based on media work such as software selection for developing VIRMA learning media, the media's flexibility, and ease of operation, the average percentage of media validity is 82.2%. So that VIRMA learning media can be declared feasible from the aspect of media work. Third, based on the material aspects of Archimedes' Law and the effectiveness of the media to make physics learning interactive and support independent learning, an average percentage of 88 is obtained. This shows that the VIRMA learning media is by the concept of Archimedes' Law and is in a very valid and feasible category to use.

The effectiveness of VIRMA media based on improving student learning outcomes

The effectiveness of the media is based on the increase in student learning outcomes seen from the pre-test and post-test evaluations. The determining indicator for the success of VIRMA learning media is that students' post-test scores can pass a minimum score of ≥ 70, which can be drawn in Figure 4.

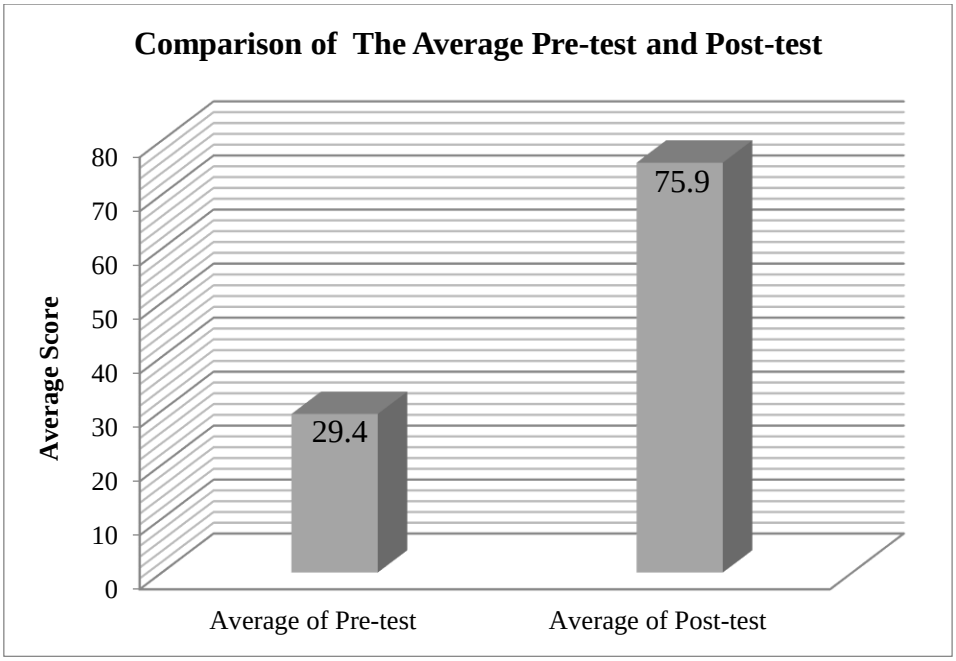

Figure 4. Comparison of The Average Pre-test and Post-test

Based on Figure 4, the post-test scores showed an increase of 60.96% from the students' pre-test scores. It is known that the post-test scores of each student have increased after being treated with VIRMA learning. The following Figure 5 is a graph of the number of students passing the minimum score.

Based on Figure 5, the percentage of students who pass the minimum score is calculated using Formula 5.

$$\%\ Pass\ rate = \frac{The\ number\ of\ students\ who\ passed\ the\ test}{The\ total\ number\ of\ students}\ x\ 100\% \qquad (5)$$

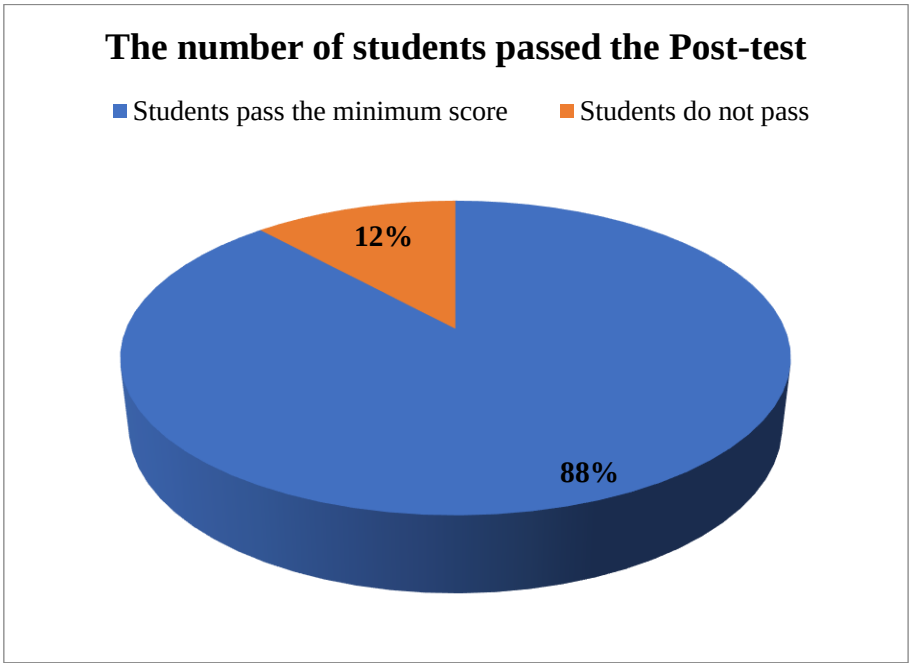

Figure 5. The number of Students Passing the Post-test

The percentage of students who pass the minimum score is 88%. This is also explained in the results of research conducted by Dewi (2020), which shows that after being treated with 3D media, the development of students who pass the minimum score did not get a percentage of 100%. This result indicates that learning activities do not occur optimally if the media entirely replaces the teacher's role. However, this percentage still meets the effective virtual reality learning media criteria.

Furthermore, the N-gain equation will calculate the increase in eating learning outcomes. The results of the N-gain recapitulation are mentioned in Table 5.

Table 5. Student n-gain Scores

Criteria	Number of Students	Average n-gain score (g)
High	15	
Medium	17	0.67 (Medium)
Low	2	

The increase in learning outcomes based on Table 5 is a normalized n-gain of 0.67 in the moderate category. Based on the results of students who pass the minimum score and n-gain calculations in Table 5, VIRMA learning media's development positively impacts improving and completing student learning outcomes. This shows that VIRMA learning media can help the process of learning Physics activities well.

The results of the research on the effect of virtual reality Media are also supported by the analysis of Abdillah et al., (2018), which shows that the test data show significant differences in improving students' analytical abilities in the aspects of distinguishing, attributing, and organizing and in the use of virtual reality media in experimental classes in natural sciences subjects.

The effectiveness of VIRMA learning media based on student response

After the learning treatment with VIRMA media, students will be given a response questionnaire to assess the effectiveness of the developed VIRMA learning media. In this student response questionnaire are ten statements, as in Table 4 the reaction to VIRMA learning media can be drawn in Figure 6.

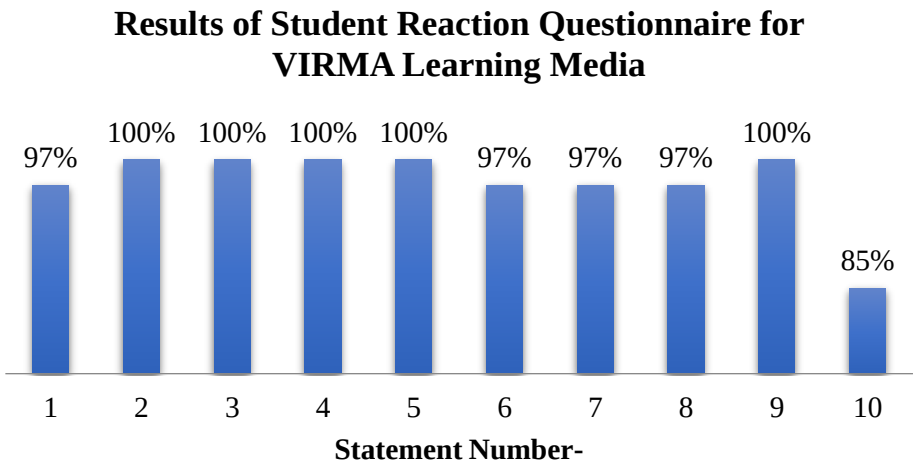

Figure 6. Results of Student Reaction to VIRMA Learning Media

Based on Figure 6, the first statement regarding the media's function and ease of operation gets a percentage of 97%. Not all students agree that VIRMA media is easy to operate because students who have never used virtual reality are surprised and confused by the functions of the features in Frame VR. In addition, research also shows that in VR, students feel dizzy over time because when moving between scenes and material, there is a sudden change in appearance before their eyes (Devianti & Anggaryani, 2022; Pirker et al., 2017). In the second to fifth statements, the percentage is 100%, which means all students agree that the illustrations of objects in the VIRMA learning media are attractive and concept. The material presented is easy to understand and identical to the teacher's explanation. The sixth to eighth statements about illustrations on media that can increase learning motivation, make learning more interactive and increase curiosity get a percentage of 97%.

In the ninth statement, all students agree that virtual reality learning media follows current technological developments. However, the tenth statement about VIRMA learning media, which is flexible to be used in various devices, only gets a percentage of 85%. This is because some student devices are incompatible, and the network speed could be better. So, they could have gained a better experience when operating VIRMA media. Although most students agree that virtual reality media is flexible and helps improve their learning, some think it is a complicated technology. According to them, this is due to several aspects: requiring a fast internet connection, less understanding of new technology, and equipment or gadget performance that does not support VR (Olivas Castellanos et al., 2022). The recapitulation of student responses obtained an average percentage of response questionnaires of 97.3%. The ratio shows perfect criteria. Based on this, learning media assessment is declared effective if it gets a value of ≥ 61%, so applying VIRMA media is practical for physics learning activities.

Student response questionnaires show that media concepts and attractive 3D object illustrations on VIRMA media receive positive reactions from students and can increase the percentage of students who pass the minimum score. The VIRMA learning media displays the application of Archimedes' law in life and the working principles of Archimedes' Law in technology. The artificial environment designed in virtual reality aims to facilitate learning that cannot be done by direct observation around the limited student environment. This is because the virtual reality environment can bring a learning environment that is considered impossible for direct observation by students into an artificial environment that can be accessed safely and from anywhere. With a learning virtual reality environment that requires facilities that are too expensive to be accessible or experiments that are dangerous for students, it becomes possible to provide students with artificial scenes that adapt to the natural environment (Allcoat & von Mühlenen, 2018).

Several studies show that the rapid development of technology makes it difficult for education to keep abreast of the latest advances. Even though the world of education has difficulty keeping up with technological developments, researchers and practitioners have contributed to increasing knowledge and experience (Campos et al., 2022; Lege & Bonner, 2020). This research can be a practical contribution to the world of education to continue to develop and adapt to using technology as part of innovative learning media.

CONCLUSION

Based on the description of the problem formulation, research objectives, and research data, it can be concluded that the development of virtual reality media in the material Archimedes' Law (VIRMA) is very valid with a percentage value of 85.9%. Then, VIRMA learning media effectively improves student learning outcomes with n-gain in the medium category of 0.67. At the same time, the percentage of class learning completeness shows that 88% of students passed the minimum score. It means the development of VIRMA learning media can positively impact the improvement and completeness of student learning outcomes. VIRMA learning media is also effective according to the results of student responses obtained an average percentage of questionnaire results of 97.3% with an outstanding category.

An internet network speed of 15-25 Mbps is recommended when running VIRMA learning media for a better user experience. Overall, using VR on material Archimedes' Law can enhance student engagement, provide hands-on learning experiences, and facilitate a deeper understanding of abstract concepts. It offers a unique and immersive approach to teaching and learning physics. Then, it must be developed on other physics materials requiring visualization and concrete implementation to make learning more interactive, exciting, and fun.

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