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# Development of Virtual Reality Hydroelectric (VIRRIC) for teaching students about renewable energy

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## Abstract

Understanding abstract physics theories, such as energy, can be challenging for students. Teachers also face the difficulty of meeting learning objectives within limited classroom time. The purpose of this research is to develop physics learning media to teach high school students about renewable energy. The learning media is presented as virtual reality, focusing on the energy conversion process in hydroelectric power plants. The goal is for students to apply their understanding of energy conversion concepts in hydroelectric power plants as one type of renewable energy source. The research process follows the ADDIE model, focusing on the analysis, design, and development stages. Data is collected through validation sheets completed by media experts, which provide valuable suggestions for revisions. The data was analyzed using descriptive statistical methods. It is known that at this level of education, the cognitive level required for understanding renewable energy material is C4 according to the revised Bloom's taxonomy. At the design stage, storyboards are used to frame the media development process, comprising a problem orientation scene and an exploration scene. After development, the VIRRIC media was validated based on visual aspects, interest, usefulness, accuracy, legitimacy, and structure. The final media expert validation score for the VIRRIC media is 0.87, categorized as highly valid. The lowest score was in the visual aspect, which was 0.77. This was due to some text information in the media being difficult to read. The text is observable when not using a gyro device, but becomes difficult to read when observed using a gyro device. Based on these results, the VIRRIC media is deemed suitable for testing in learning after making improvements.

**Keywords**: learning media; renewable energy; virtual reality

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## INTRODUCTION

Renewable energy is a source of energy that can be naturally replenished and used continuously. It is important to educate students about renewable energy to achieve educational goals for sustainable development (Jauhariyah et al., 2021). Due to its significance, the topic of renewable energy is included in the national education curriculum for phase E physics subjects. According to Afriyanti et al. (2020), Indonesia's renewable energy consumption has been inadequate. The average consumption from 2010 to 2018 was only 6.05 million tonnes of oil equivalent. This insufficiency is ascribed to the low level of public awareness concerning the significance of renewable energy. Faize and Akhtar (2020) propose that an effective approach to raising awareness about renewable energy is through its integration into the learning process for students.

An observation of the current situation indicates that students possess a limited comprehension of energy conversion principles. According to the 2019 National Examination results, only 38.79% of students demonstrated a correct understanding of the energy concept. This suggests that there is still room for improvement in students' comprehension of energy. One of the reasons for this may be the abstract nature of physics concepts, which require a solid understanding (Hamidun, et al., 2022). Additionally, teachers face the challenge of meeting learning targets within limited classroom time (Suhartini, 2023).

Utilizing educational technology can enhance student engagement, addressing various learning styles while supporting visual, auditory, and kinesthetic preferences (Abdullah et al., 2021). However, according to UNESCO (2023), the application of technology in science learning is low, namely only 11%. Regrettably, the underutilization of advanced technologies in the education sector persists, despite significant technological advancements. The Fourth Industrial Revolution's technologies like Big Data, AI, IoT, and Metaverse are expected to tackle educational challenges in the era of Society 5.0 (Saragih, 2022), with virtual reality metaverse being a promising option.

The integration of virtual reality into educational settings offers a promising approach to aid students in grasping both theoretical and practical learning materials. Empirical evidence indicates noteworthy disparities in students' analytical proficiencies, particularly in the realms of distinguishing, organizing, and attributing information, when utilizing virtual reality as opposed to those who do not (Abdillah, et al., 2018). Although not surpassing the efficacy of direct, real-world learning experiences, virtual reality surpasses other digital learning modalities, such as video demonstrations. Furthermore, compared to observing simulations on a two-dimensional screen, virtual reality demonstrates a more substantial positive impact by enabling student interaction and sensory stimulation (Chernikova et al., 2020).

There is previous research that developed similar media. Setyawan (2023) recommends teachers be more creative in presenting learning content such as using VR. Prillyanti (2023) also developed VR media in physics learning which obtained results in the form of students being more actively involved in the learning process and gaining new learning experiences. Virtual three-dimensional spaces provide students with immersive experiences involving visual, audio, and movement stimuli. This innovative technology enables access to objects that students may not have the opportunity to interact with in a traditional classroom setting, such as intricate hydroelectric power plants. Research was conducted to develop virtual reality-based learning media named Virtual Reality Hydroelectric (VIRRIC) to teach students about renewable energy. The developed VIRRIC was validated through expert assessment to gather feedback. This feedback was used to enhance the media so that it could be tested in a classroom.

## METHODS

This type of research is research and development (RnD) using the ADDIE model. Research and Development has the aim of producing and testing a product (Sugiyono, 2013). The ADDIE model consists of 5 stages, namely Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). This research is limited to the development stage because the research aims to develop learning media and test it based on assessments and trials by validators. The design of this research are shown in Figure 1.

During the analysis stage, an evaluation of the learning outcomes in physics subjects related to renewable energy was conducted. The findings of this analysis were supported by an examination of the students' characteristics who will be participating in the VIRRIC media trial in the next phase of this research. The results of this analysis will serve as a reference for the design stage, specifically in setting the specifications and creating a storyboard for the development of the product.

The next stage is development, which is divided into media and user guide development. Media development refers to the storyboard designed in the previous stage. The software used is MilleaLab Creator version 1.3.9.5, accessed using the Windows 11 operating system with i3-115G4 processor and 8 GB of RAM. The resulting product was then validated by two media experts and a physics teacher who has used virtual reality media.

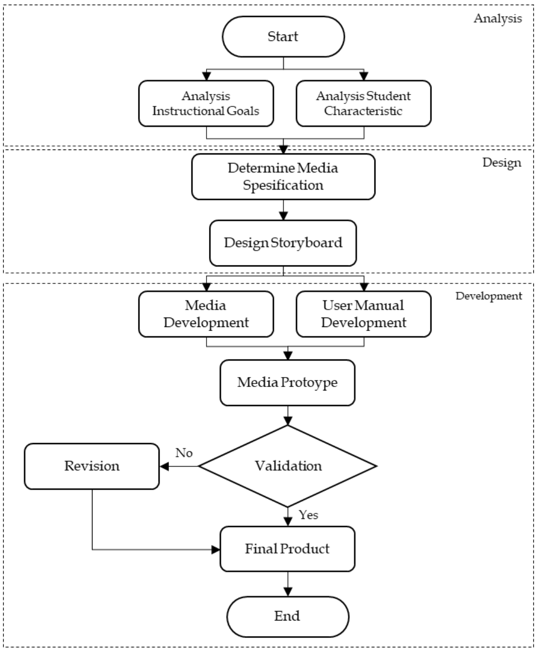



**Figure 1.** Research Design Diagram

Media validation tools encompass visual appeal, interest, usefulness, accuracy, legitimacy, and structure. Media validity is evaluated using a numerical rating scale on a validation sheet (Arikunto 2010). The assessment scale employs a 4-point Likert scale without a middle value to minimize bias (Mulyatiningsih 2012).

**Table 1**. Likert Rating Scale

| Category | Score |
|---|---|
| Strongly agree | 4 |
| Agree | 3 |
| Disagree | 2 |
| Strongly disagree | 1 |

After obtaining the validation results, they will be processed through descriptive statistical analysis, culminating in the calculation of the final score using equation (1). In order for the media to be deemed valid and appropriate for use, the final score must meet or exceed 66%, as indicated in table 2.

$$P(\%) = \frac{\Sigma x}{\Sigma x_{ideal}} \times 100\% \quad (1)$$

**Table 2**. Interpretation of Validity Categories

| Interval | Category |
|---|---|
| 80% - 100% | Very valid |
| 66% - 79% | Valid |
| 40% - 65% | Less Valid |
| 0 – 39% | Invalid |

# RESULTS AND DISCUSSION

## Analysis Stage

The results of the analysis indicate that the topic of renewable energy is part of the independent curriculum phase E, which is equivalent to class X in high school. The specific learning objectives include students being aware of global issues and being capable of contributing to solutions. One of the issues highlighted is related to energy, and students are expected to comprehend the scientific process in applying technology to the field of renewable energy. One example of technological application in renewable energy is hydroelectric power generation. Based on the requirements of this curriculum, it can serve as the foundation for developing a virtual reality hydroelectric (VIRRIC) as a learning media.

During this stage, we also confirmed with physics teachers about the characteristics of students who would be taught using VIRRIC media in additional research. According to the physics teachers, students have different learning styles. Male students tend to have kinesthetic and visual learning styles, while female students tend to have auditory and visual learning styles. Additionally, students have access to smartphones and the internet in the classroom. However, these resources have not been optimally utilized, leading to decreased focus on learning. These student characteristics support the development of virtual reality hydroelectric (VIRRIC) as a learning media.

## Design Stage

During the planning stage, a storyboard for the Virtual Reality Hydroelectric (VIRRIC) media, along with the product specifications, will be developed. The VIRRIC media is designed to be accessed using VR cardboard goggles. Therefore, a smartphone with a minimum of 2 GB RAM, 1 GB storage memory, and supported gyroscope and accelerometer sensors, running on the Android operating system, is required. The designed storyboard can be found in table 3.

**Table 3**. Storyboard of Virtual Reality Hydroelectric (VIRRIC)

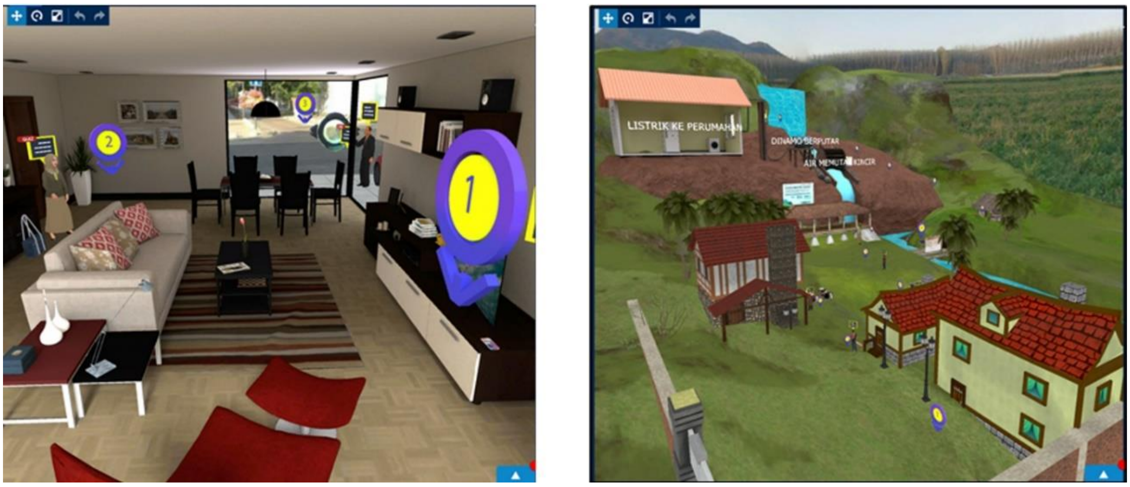
| Scene 1 | Scene 2 |
|---|---|
| • Find and troubleshoot electrical issues | • Discover the differences in the origins of conventional electrical energy compared to renewable energy |
| • Learn about the sources of electrical energy | • Obtain information about energy conversion in hydropower |
| • Complete a quiz before proceeding to scene 2 | • More detailed information on kinetic and potential energy |
| | • More depth on the efficiency and power of hydropower |

## Development Stage

The development stage is divided into 3 more detailed stages. This stage includes the production stage, validation stage, and revision stage. Each stage is sequential and interconnected.

### Production

The media production process is carried out by researchers independently using MilleaLab Creator software. The production process was carried out in stages from scene 1 and continued to scene 2 by referring to the storyboard. The obstacle experienced when producing VIRRIC media was determining 3D assets that matched the storyboard. 3D assets need to be adjusted to proportional position and size.




(a) (b)

**Figure 2.** Production Result (a) Scene 1: Problem Orientation (b) Scene 2: Exploration

The production results can be seen in Figure 2 which contains footage of the production results from scene 1, and scene 2. The results of VIRRIC media production were tested independently by researchers before being validated by experts. At this stage, a user manual has also been developed

### Validation

The validation stage aims to determine the suitability of the product in the form of VIRRIC media based on expert assessment. The validation results can be seen in table 4 which contains the assessment results for each aspect and the final scores of all validators.

**Table 4**. Validation Result of Virtual Reality Hydroelectric (VIRRIC)

| No. | Aspect | Score V1 | V2 | V3 | Mean | Category |
|---|---|---|---|---|---|---|
| 1. | Visual | 0,75 | 0,81 | 0,75 | 0,77 | Valid |
| 2. | Interest | 0,94 | 0,94 | 0,88 | 0,92 | Very Valid |
| 3. | Useful | 0,94 | 0,81 | 0,88 | 0,88 | Very Valid |
| 4. | Accurate | 0,75 | 0,88 | 0,75 | 0,79 | Valid |
| 5. | Legitimate | 0,94 | 1,00 | 0,88 | 0,94 | Very Valid |
| 6. | Structured | 0,94 | 0,94 | 0,88 | 0,92 | Very Valid |
| | | | | **Final Score** | **0,87** | **Very Valid** |
| | | | | **(%)** | **87%** | |

Based on the results of the assessment by 3 experts in Table 4, overall VIRRIC media was declared very valid or very feasible with a final score of 87%. This score is greater than the minimum threshold that has been previously determined for the media to be declared suitable for testing. The highest assessment is on the legitimacy aspect with an average value of 0.94. Meanwhile, the lowest assessment was on the visual aspect with an average value of 0.77. The results of this assessment are due to the existence of several parts of the media that need to be revised. These revisions will be discussed in the next sub-chapter.

**Revision**

After receiving an assessment and review from the validator, the next step is to carry out revisions according to the directions and suggestions obtained. These revisions must be made before media and other research equipment are tested. The sections that need revision and follow-up actions are listed in table 5.

**Table 5**. Validation Result of Virtual Reality Hydroelectric (VIRRIC)

| Improvement Suggestions | Revised Results |
|---|---|
| Clarify the shape and position of the standpoint so that it is easier for users to find<br><br>(Before) | The shape of the standpoint cannot be changed but has been enlarged to make it easier to see and find. At each standpoint, there are also directions to go to the next standpoint<br><br>(After) |
| Review physics content related to energy, kinetic energy, potential energy, and electrical energy conversion before being tested in the learning process | The physics content mentioned has been reviewed and is by the material in the applicable curriculum. |
| Some texts in the media cannot be read clearly when observed using VR goggles<br><br>(Before) | The text was enlarged and a reading trial was carried out using VR independently. The text size has been aesthetically proportional and also readable<br><br>(After) |
| Pop-up info is too far from the standpoint so it's hard to read | The pop-up information has been brought closer to each standpoint at a proportional distance and remains legible. |

| Improvement Suggestions | Revised Results |
|---|---|
|  (Before) |  (After) |
| The background music is too loud so it is a little annoying when exploring the virtual world | The background music has been reduced in volume and will automatically stop while playing a video in the media |

## Discussion

According to the criteria stated by Arikunto (2018), a media is declared valid if it obtains an assessment result of ≥ 66%. The media validation results in Table 4 show that VIRRIC media received a validation assessment of 87% so it can be categorized as very valid. Therefore, VIRRIC media generally covers all visual, interest, useful, accurate, legitimate, and structured aspects and can be declared suitable for testing in the learning process. The lowest assessment score was on the visual aspect, namely 0.77. In fact, according to Kristanto (2016), the main characteristic of 3-dimensional learning media such as virtual reality is that its visual can be observed from any direction. This low assessment of the visual aspect is caused by several things which are discussed below.

The visual aspect cannot be separated from the development of a media. The appearance aspect assesses how the media looks when observed using the sense of sight. The appearance that is assessed is not only beauty or aesthetics but also includes the readability of the text and the proportional size of images and other visual objects.

The results of the validator's assessment of the visual aspects of VIRRIC media obtained an average score of 77%. Based on this score, the visual aspect of VIRRIC media is included in the valid category. Based on the validator's assessment, things that need to be considered in developing virtual reality learning media are related to text readability. The three validators stated that the text in the media was not readable. This is because reading text using VR glasses is more difficult than reading regular text. The eyes need to adjust their focus or accommodate to read the text. The findings concur with Agusty (2021) research, underscoring the imperative of emphasizing the visual appeal and readability of media content. The follow-up to this is to enlarge and bring the object in the form of text closer to the standpoint. After revisions were made to the media, the text was easier to read when using VR glasses.

## CONCLUSION

Based on the results of this research, virtual reality hydroelectric media (VIRRIC) was declared suitable for testing in the learning process. The final validation score was 0.87 which can be categorized as very valid. Several important points that need to be considered in the process of developing virtual reality media are the readability of text that contains information related to learning material. Therefore, it is necessary to pay attention to the plan for implementing media in the classroom, whether using VR glasses or using an LCD projector. If you use VR glasses, you must ensure that the text, objects, and other information contained in the media can be understood clearly. The recommendation for further research is to conduct a trial of VIRRIC media in the classroom to determine student responses and their effectiveness.

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