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Designing Educational Games for Teaching Hydro-Electric Power Stations in Elementary School Curriculum

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Abstract

Introducing the concept of renewable energy to elementary school students is very important, one of which is to enhance their learning motivation. In enhancing learning motivation, it is necessary to have enjoyable, interactive, and easy-to-use learning media so that elementary school students feel happy while studying a subject. In this study, we present a novel approach to teaching elementary school students about hydro-electric power stations through the development of an android-based game. The game is designed to gamify the learning process, engaging students in an interactive and immersive experience that facilitates understanding of complex concepts related to hydro-electric power generation. Our focus lies in elucidating the manufacturing, construction, operational procedures, and supplementary information pertinent to hydro-electric power stations within a format accessible to elementary students. By harnessing the capabilities of Unity 3D software and incorporating assets from Obi Fluid, we have crafted an engaging and educational gaming application tailored to the unique learning needs of young learners. This research contributes to the growing body of literature on educational game design and underscores the potential of gamified approaches in enhancing STEM education at the elementary level. Furthermore, it lays the groundwork for future studies exploring the effectiveness of similar interventions in diverse educational contexts.

Keywords: elementary curriculum, game design, hydro-electric power

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INTRODUCTION

Introducing the concept of renewable energy to elementary school students is important to do (Wagner et al., 2024). Because, in addition to fostering a sense of concern for the environment, introducing the concept of renewable energy can enhance students' understanding of future challenges and provide solutions to address environmental conditions in the times to come (Pambudi et al., 2024). The learning approach implemented at this time is considered appropriate because students will find it very easy to grasp the concepts of renewable energy when combined with the right teaching models and learning media (Delgado-Sanchez & Lillo-Bravo, 2021). One of them is through an approach using Game-Based Learning. Game-Based Learning is an effective pedagogical approach to enhance student engagement in the process of introducing concepts of renewable energy (Zubair et al., 2024). By combining concepts of renewable energy with the interactive elements of Game-Based Learning, students can actively and directly participate in enjoyable games while still learning about renewable energy concepts (Marrero-Trujillo et al., 2023). Game-Based Learning makes education easily accessible and enjoyable for students, encouraging them to actively participate, experiment, explore, and apply simulated environments in their daily lives, thereby strengthening their understanding of renewable energy concepts (Aly et al., 2024). In addition, Game-Based Learning can also enhance critical thinking skills and problem-solving abilities by completing challenges or missions present in the game (Hsu & Wu, 2023).

Hydroelectric power plants play an important part in the global energy landscape (Ullah et al., 2024), offering a sustainable source of electricity generation while minimizing the environmental effects of fossil fuel burning. Understanding the concepts and functioning of hydroelectric power plants is critical not just for addressing energy issues, but also for increasing environmental literacy and encouraging sustainable development (Briones-Hidrovo et al., 2021). Therefore, incorporating innovative approaches into the elementary curriculum can be an effective way to engage and motivate students in learning about hydroelectric power stations (Hong & Lin, 2019).

Teaching complicated scientific ideas such as hydroelectric power generation to primary school children is difficult in typical educational environments . Conventional techniques frequently rely on static textbooks and passive learning strategies, which may fail to engage young learners and limit their understanding of abstract scientific ideas. The use of technology in elementary level, particularly instructional games, presents a viable answer to these issues (Guan et al., 2022). Using the interactive and immersive aspect of gaming, instructors may turn abstract concepts into concrete experiences that pique students' attention and enable deeper learning (Zhao et al., 2022). Gamified techniques have been found to improve student motivation, engagement, and information retention in a variety of educational contexts, including science, technology, engineering, and mathematics (STEM) (Muliyati et al., 2021).

Research in the field of educational game design for elementary students has shown that incorporating game-based learning into the curriculum can lead to improved learning outcomes (Leonardou et al., 2020). By integrating elements of gameplay, such as challenges, rewards, and interactivity, educators can effectively engage young students and enhance their understanding of

complex subjects like hydroelectric power generation (Takbiri et al., 2023). Studies have demonstrated that educational games not only increase student motivation and engagement but also promote better retention of information (Chao-Fernández et al., 2020).

Furthermore, the use of educational games provides opportunities for interactive and experiential learning (Dabbous et al., 2023), allowing students to explore and experiment with concepts in a hands-on manner. This active involvement can lead to a deeper understanding of the principles behind hydroelectric power stations (Noda et al., 2020). Incorporating game-based learning into the elementary curriculum for teaching about hydroelectric power plants has the potential to make the learning process more enjoyable and effective for students (Videnovik et al., 2023). Additionally, it aligns with the global trend of integrating technology into education to enhance learning outcomes and prepare students for the digital age. By utilizing educational games, students can learn about hydroelectric power stations in a dynamic and interactive manner.

This project aims to bridge this gap by creating an android-based game that is especially adapted to basic curricular requirements, with an emphasis on teaching hydroelectric power station fundamentals. By creating an interesting and dynamic gaming experience, we hope to improve primary students' comprehension of hydroelectricity generating processes while also instilling a feeling of environmental care and sustainability. This game will feature interactive challenges and puzzles that simulate the operation of a hydroelectric power station. Through the use of engaging gameplay and interactive visualizations, students will be able to explore and understand the various components of hydroelectric power generation, including dam construction, water flow, turbine operation, and electricity generation.

METHOD

The development of the android-based game for teaching hydro-electric power station concepts followed a systematic and iterative design process. The methodology encompassed several key stages, including concept development, prototyping, implementation, testing, and refinement. The game was designed using Unity 3D, a popular game development platform known for its versatility and robust features. Unity 3D provides a user-friendly interface and comprehensive tools for creating immersive gaming experiences across various platforms, including Android. Additionally, the game utilized assets from Obi Fluid, a physics-based fluid simulation plugin for Unity. The inclusion of fluid dynamics in the game design aimed to enhance realism and interactivity, particularly in simulating water flow and hydro-electric power generation processes. The target audience for the game comprised elementary school students, typically ranging from grades 3 to 6. Consideration was given to the cognitive abilities, learning preferences, and developmental stages of this demographic to ensure that the game design aligned with their educational needs and interests.

RESULTS AND DISCUSSION

The result of design android-based game for gamified approach to teaching hydro-electric power station (PLTA) is an application of How PLTA Works. The games made consisted of 4 levels (Figure 1), namely Introduction, How the dam works, Energy conversion, and Closing. each level has a different question which will be used as a condition to advance to the next level. The user must get a score of three stars shown in figure 2, if the user did not get a three stars, then the user must repeat that level.

Figure 1. The main page of games

Figure 2. The score of three stars

The level 1 (Introduction) with background scene in front page of PLTA, user will be introduced by 3 character, Ansar, Rudi, and Shinta. Character Ansar shown in Figures 3. Character Rudi shown in Figure 4. The last character is Shinta shown in Figure 5. Ansar and Shinta are student from elementary school. Rudi is an employee of PLTA.

Figure 3. Character Ansar

Figure 4. Character Rudi

Figure 5. Character Shinta

The level 2 (How the dam work) with background scene in a place that will become a dam shown in Figure 6, user will be given a three questions. The user invited by Rudy to move the crane shown in Figure 7 and then Rudy explain the function of the crane. The function of the crane is to lift the gate cover.

Figure 6. The background scene of Level 2 a place that will become a dam

Figure 7. The user invited by Rudy to move the crane

The level 3 (Energy conversion) with the background scene in the engine room of PLTA shown in Figure 8. The user will be given a three questions and explained how the mechanical energy turns into electricity. Also in this level, Shinta asking to Rudy about the rotor and stator work shown in Figure 9. Then, Ansar asking to user about how the relation between diameter and power generated Figure 10.

Figure 8. The background scene of Level 3 engine room of PLTA

Figure 9. Shinta asking about the rotor and stator work

Figure 10. Ansar asking about the diameter and power generated

The final level, level 4 (Closing) with the background scene is the main PLTA building consists of many transformers shown in Figure 11. The user will be given a three questions and explained about the function of transformer in PLTA. The function of transformer is regulate that electricity flowing into homes is in accordance with the rules set by State Electricity Company (PLN)

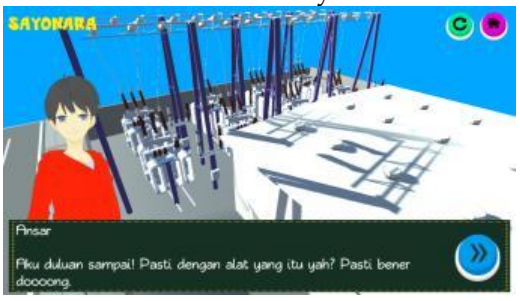

Figure 11. The background scene of Level 4 main building of PLTA

This application can be exported into desktop or smartphone applications, because the application made with Unity, so it is easy to export into desktop and smartphone applications. By combining game-based learning with the concept of education, it can significantly enhance students' understanding of renewable energy concepts. Until now, students may have only learned about

renewable energy concepts using printed books or limited resources. However, with a game-based learning approach, students will gain a different atmosphere or learning experience. Students can clearly see the shape of solar panels, understand how they work or the principles behind solar panels, and recognize other concepts in different ways. This finding can enhance the effectiveness of student learning.

CONCLUSION

The research and development using a 4D Thiagarajan model. The result of this study is an application of How PLTA Works. The application developed for design android-based game for gamified approach to teaching hydro-electric power station (PLTA). The application with four level can help students to know how PLTA works. Game-based learning is an effective approach to enhance student engagement and deepen their knowledge, even on topics that may be challenging, but can be easily accessed through games in an enjoyable way. This approach also trains students to learn a concept based on their learning experiences, thereby improving their critical thinking and problem-solving skills.

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