

Virtual Reality-Based Game Learning on Animal Reproduction for Elementary School Level

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Keywords:	Abstract
<p>virtual reality;</p> <p>game-based learning;</p> <p>animal reproduction;</p> <p>teaching materials</p>	<p>The transition from Industrial era 4.0 to Society era 5.0 brings significant changes to education in Indonesia. However, technology use in elementary schools is limited, particularly in biology education, which involves observational processes. To address this, researchers developed a virtual reality-based game for teaching animal reproduction at the elementary level. The research focuses on developing and validating the virtual reality-based game learning media, using the ADDIE model. Data was collected through observations, interviews, questionnaires, and validation. Experts validated the media, and practicality tests were conducted on 5 students at Elementary school 2 Gunungsari, Boyolali. The results showed a validity level of 77.3% and a practicality level of 79.99%, indicating that the virtual reality-based game can enhance students' understanding and provide an engaging learning experience.</p>

INTRODUCTION

Background of the Study

The shift from Industrial era 4.0 to Society era 5.0 has led to a significant paradigm change in education in Indonesia, resulting in the adaptation of all educational processes to the advancements in information and digital technology. This transformation is particularly evident in the learning process at schools, driving changes in the entire education system in Indonesia. According to Kamal et al. (2020), research, the current era's shift is accompanied by changes in the education system that must equip learners with 21st-century skills. Changes in various components of education to align with the

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modern era can be observed in the quality of education, the adopted curriculum, infrastructure, and more.

The important role of technology is its utilization in the learning process, especially in elementary schools. However, currently, elementary schools, particularly in the Boyolali area, are not fully maximizing the benefits of technology in various aspects. The facts discovered by researchers in the field concerning the learning process are as follows: (a) The delivery of materials is not optimal due to the difficulty in presenting real or concrete objects related to the subject matter; (b) Some materials are not effectively conveyed because the teaching media or learning materials used do not adequately cater to the characteristics of the learners; (c) The utilization of technology is not fully optimized in facilitating the learning styles of the students. These findings highlight the need for better integration and utilization of technology in the educational process, particularly in elementary schools, to enhance the effectiveness and efficiency of learning.

The facts mentioned above seem to impose an obligation on educators to use learning media carefully and appropriately to assist participants during learning activities. Utilizing technological advancements to support teaching is essential, while students are encouraged to actively engage in solving problems they encounter. Although learning activities may proceed smoothly with students actively participating, the learning resources available to students are limited to teachers and textbooks alone, leading to less effective outcomes. Passive learning occurs during these activities, and the subject matter may be challenging to comprehend when basic concepts are not adequately fulfilled due to teachers primarily relying on lecture-style teaching and textbooks.

Previous studies have shown that elementary school children still require real and tangible objects to stimulate their intellectual abilities (Desstya, 2016). Nuriansyah, (2016), also states that the delivery of subject matter is limited to lecturing, without actively involving students, resulting in inadequate understanding of concepts related to the material. Elementary school students perceive the subject of Science as challenging to grasp. According to Imanuel, (2015), this perception is mainly due to the fact that the basic concepts of Science are not connected to their daily lives during the learning process. Praptiningtyas, (2020) indicates that difficulty in understanding the subject of animal reproduction arises from students' limited experiences and the use of inadequate media by teachers, which does not align with the principles of Science that emphasize observation. Dwiasmoro, (2017) also suggests that students encounter difficulty in understanding the subject of animal reproduction because they do not directly observe the reproductive process and the media used by teachers are inadequate, often limited to using chalkboards and textbooks for explanations. Based on the aforementioned opinions regarding the challenges in learning the subject of animal reproduction, it can be concluded that students face difficulties in understanding the topic due to the lack of direct observation and observation, ineffective use of teaching media by teachers, and monotonous and uninteresting teaching methods. Ideally, an effective science learning activity involves observation, experimentation, and appropriate media usage, enabling students to comprehend concepts better (Nuriansyah, 2016). Suryadi, (2019) also highlights that effective learning activities involve using teaching media suitable for students' learning styles. With the easy accessibility of information and learning resources through the development of information and digital technology in Society era 5.0, students can take advantage of these tools as valuable sources of knowledge.

Based on the issues discussed, it can be concluded that challenging subject matter requires adequate learning media for educators to effectively convey the material. Utilizing appropriate and student-centered learning media can enhance learning outcomes and motivate students, as highlighted by Suryadi, (2019). The development of learning media should not only incorporate visual elements but also include audio components. Technology-based learning media available today, such as YouTube, PowerPoint, augmented reality, virtual reality, and others, can support educational advancements and align with Society era 5.0 (Sunarni & Budiarto, 2014).

Based on the opinions of Praptiningtyas, (2020) and Dwiasmoro, (2017) regarding the difficulties in learning the subject of animal reproduction, virtual reality can be considered as a solution for teaching this topic. Virtual reality is content displayed through head-mounted goggles that enable users to interact with three-dimensional impressions realistically, supported by audiovisual elements (Au & Lee, 2017; Buttussi & Chittaro, 2017; Maghool et al., 2018). In line with Widhayanti & Abduh, (2021), audiovisual media holds great potential in facilitating learning activities and enhancing student learning retention. Frøland et al., (2020) also state that virtual reality is a learning tool suitable for both direct and e-learning methods, and elements of gamification can be incorporated into virtual reality experiences.

Virtual reality media operates based on three principles: immersion, interaction, and narrative, which engage users to experience a realistic impression (Freina & Ott, 2015; Parisi, 2015). Several advantages of virtual reality in the field of education include the ability to interact with content that is difficult to access or physically visit (Garcia et al., 2023; Kamińska et al., 2019; Sinambela et al., 2018), the inclusion of audio and visual elements in virtual reality content (Supriadi & Hignasari, 2019), and the provision of realistic visuals (Tarmizi et al., 2020). However, virtual reality also comes with certain limitations, such as the potential for difficulties in distinguishing between the virtual and real world if used excessively (Tarmizi et al., 2020). Moreover, the development of virtual reality technology in the field of education in Indonesia is relatively limited (Andyani et al., 2022), and accessing virtual reality content creation applications can be challenging (Iswanto et al., 2022). Similar findings were evident in previous studies, such as Hidayati & Ramansyah, (2018) research on virtual reality-based teaching materials for the theme of energy. The advantages of this approach include visualizing science subjects, student-centered learning, active student participation, accessibility of learning materials for students at home, and the ability of virtual reality teaching materials to illustrate abstract concepts in science subjects with engaging visuals. Conversely, a study conducted by Darajat et al. (2022) on developing virtual reality media for the solar system found limitations in terms of less engaging audio content not suitable for elementary school students, less detailed material presentation, and unrelated animations. These findings highlight the potential and challenges of using virtual reality in education, emphasizing the importance of addressing limitations and optimizing its advantages for an effective and engaging learning experience.

Based on the advantages and limitations mentioned earlier, the researchers strive to develop a virtual reality-based game media for teaching animal reproduction in science (IPA) subjects. Educational games are one effective way to provide an engaging and active learning environment for students (Putri & Muzakki, 2019). According to Winarni et al. (2020), educational games can enhance students' knowledge in an effective and enjoyable learning process. Piaget's theory suggests that students' cognitive development improves when they actively participate in learning activities (Ibda, 2015; Yeh et al., 2018). In a study by Iswanto et al. (2022), virtual reality-based games were found to help develop problem-solving skills, strategic thinking, and comprehensive abilities that have real-life applications. Virtual reality is a technology capable of addressing real-world problems and scenarios. In the field of education, virtual reality is highly recommended as a significant technological breakthrough with great potential to facilitate learning activities (Schütz et al., 2023; Supriadi & Hignasari, 2019). One of the benefits of using virtual reality is its potential to enhance student learning retention (Chou, 2017; Zhou et al., 2018). Virtual reality media not only incorporates visual elements but also includes audio components. The development of a virtual reality-based game media for teaching animal reproduction aims to capitalize on the benefits of technology-enhanced learning, encouraging active student participation and providing an enjoyable and effective learning experience. By immersing students in a virtual environment and engaging them through interactive gameplay, the media aims to foster better understanding, retention, and application of the subject matter.

The research on developing a virtual reality-based game media for teaching animal reproduction in science aims to achieve a final product that is suitable for use as an effective learning tool, particularly for the subject of animal reproduction, and caters to various learning styles of the students. In the line Fauda in Hartini et al. (2018), the validation of the product's goal is to assess the appropriateness of the developed product, ensuring it is worthy of being tested if it meets the criteria of validity or high validity and is also practical in its application. Therefore, this research aims to describe the development and prototype of the virtual reality-based game learning media specifically for the topic of animal reproduction at the elementary school level, ensuring that it fulfills the criteria of validity and practicality.

Problem of The Study

Based on the background that has been outlined above, there are several issues in the context of education in Indonesia that are the focus of the research, as follows:

1. Insufficient utilization of technology in learning: despite the shift towards the era of society 5.0 marked by the development of information and digital technology, there are still challenges in maximizing the use of technology in elementary school learning processes. this leads to a lack of technology utilization to enhance interactivity and attractiveness in learning (Danuri, 2019).
2. Limitations of learning media that do not facilitate student characteristics: during the learning process, there are problems related to the use of learning media that do not align with the learning styles and characteristics of students. The inadequate use of suitable media can result in a decrease in conceptual understanding (Suryadi, 2019).
3. Difficulties in Understanding the Animal Reproduction Material: The material on animal reproduction is perceived as challenging for students to grasp. One of the reasons is the lack of direct observation and supportive experiences to understand the subject matter (Dwiasmoro, 2017).
4. Lack of active student engagement in learning: the prevalent lecture-style delivery of material by teachers causes students to be passive in the learning process. Active involvement of students in the learning process becomes less optimal (Hartini et al., 2018).
5. Limited infrastructure: there are limitations in accessing adequate technology and learning media in some regions, such as in Boyolali.
6. The necessity for teachers to adjust teaching methods: the transition to the society 5.0 era demands educators to be more meticulous and precise in selecting teaching methods that can keep up with the times and utilize technology effectively.

To address these issues, the research aims to develop Virtual Reality (VR)-based learning media in the form of a game for the animal reproduction material. The use of VR technology is expected to enhance interactivity, student engagement, and improve conceptual understanding in the learning process

Research's State of the Art

The researchers examined several relevant studies similar to their own research. Nuriansyah, (2016), discussed the ideal conditions for conducting science learning activities by using observation, experiments, and appropriate media to help students better understand concepts. Similarly, Suryadi (2019), stated that effective learning activities use media that align with students' learning styles. The use of suitable and engaging learning media can enhance learning outcomes and motivate students. Sunarni & Budiarto, (2014) identified technology-based learning media that can support educational progress in the era of society 5.0, such as Winarni h as YouTube, PowerPoint, augmented reality, virtual reality, and others. Frøland et al. (2020) stated that virtual reality is a learning tool that can be used for both direct and e-learning, and game elements can be incorporated into virtual reality. According

to Hamari et al., (2016), educational games can broaden students' knowledge in an effective and enjoyable learning environment. Iswanto et al., (2022) found that virtual reality-based games can aid in the development of problem-solving skills, strategic thinking, and comprehensive understanding, applicable to real-life situations. Virtual reality is a technology capable of addressing real-world issues and experiences. Au & Lee, (2017) and Supriadi & Hignasari, (2019) suggested that virtual reality holds significant potential in facilitating educational activities and is considered a promising technology in the field of education.

Gap Study & Objective

Based on the previous explanation, there are several issues in the learning process at the elementary schools in the Boyolali area related to the utilization of technology and learning media. One of the identified problems is the lack of technology integration in the learning process and the limited availability of adequate learning media. Additionally, there are difficulties in understanding the topic of animal reproduction due to limited direct experiences, inadequate media used, and unengaging teaching methods. This research aims to describe the development and prototype of a virtual reality-based game learning media for the topic of animal reproduction in elementary schools that meets valid and practical criteria. Through the development and testing of virtual reality learning media, this study seeks to provide innovative and effective solutions to enhance the quality of learning in elementary schools, particularly in the subject of animal reproduction.

METHOD

Type and Design

The research conducted by the researcher is a type of development research, also known as Research and Development (R&D). This study falls under the category of Educational R&D, focusing on developing software in the form of a Virtual Reality-based educational game media for teaching Science subject, specifically on the topic of Animal Reproduction. Development research encompasses various models, and one of them is the ADDIE Development Model (Rayanto & Sugiati, 2020). The ADDIE Model is a type of Research and Development (R&D) model consisting of five stages as follows: analysis, design, development, implementation, and evaluation (Rayanto & Sugiati, 2020). The study employs the ADDIE model due to its systematic and instructional nature, involving evaluation in each development process to minimize errors.

Data and Data Sources

This research utilizes data from two sources, namely primary data and secondary data. Primary data is obtained directly through various techniques such as observation, interviews, questionnaires, and discussions with the teachers of elementary school 2 Gunungsari, Boyolali, and the students, as well as validation from media and subject matter experts. Secondary data, on the other hand, is obtained from indirect sources, in various forms, and can be collected from other individuals to obtain relevant data. Secondary data includes journal articles, books, library materials, previous research, and other relevant sources.

Data Collection Technique

The data collection techniques used in this research include observation, interviews, validation, and questionnaires. The researchers used research instruments in the form of Virtual Reality (VR) game-based media for the topic of animal reproduction, which consists of validation sheets, observation sheets, questionnaires, and interview sheets (Rayanto & Sugiati, 2020). Interviews and observations were conducted with 4th-grade students and teachers at elementary school 2 Gunungsari, Boyolali. The questionnaires provided statements related to the needs of students and

teachers. The validation sheets involved scoring statements related to the presented media. These techniques were employed to assess the practicality and validity of the Virtual Reality (VR) game-based media used in the Science subject, specifically on the topic of animal reproduction.

Data Analysis

The data analysis technique used by the researcher is quantitative descriptive and qualitative descriptive techniques. The stages of data analysis technique used to analyze validation and practicality data were modified from Setiawati et al., (2017).

The formula for validity used is as follows:

$$V_m = \frac{T_a}{T_{max}} \times 100\%$$

Explanation:

- V_m : Validation score percentage
- T_a : Total obtained score
- T_{max} : Maximum possible total score

There are criteria that the researcher used as a reference for the validity of the developed product, which can be seen in Table 1.

Table 1. Criteria for the validity of learning media

Intervals	Category
$85,00\% < V_1 \leq 100\%$	very valid
$70,00\% < V_1 \leq 85,00\%$	valid
$50,00\% < V_1 \leq 70,00\%$	less valid
$01,00\% < V_1 \leq 50,00\%$	invalid

Source : Setiawati et al., (2017)

The formula used for the analysis of practicality data is as follows:

$$V_k = \frac{T_a}{T_{max}} \times 100\%$$

Explanation:

- V_k : Percentage of practitioner validation sheet score
- T_a : Total obtained score
- T_{max} : Maximum possible total score

There are criteria that the researcher used as a reference for the practicality of the developed product, which can be seen in Table 2.

Table 2. Criteria for the practicality of learning media

Intervals	Category
$85,00\% < V_1 \leq 100\%$	very practical
$70,00\% < V_1 \leq 85,00\%$	practical
$50,00\% < V_1 \leq 70,00\%$	less practical
$01,00\% < V_1 \leq 50,00\%$	does not practical

Source : Setiawati et al., (2017)

RESULTS

Prototype Product

Development of instructional media with a prototype of virtual reality-based games on the topic of animal reproduction for elementary school students in Phase B was designed and developed

according to the results of observations, interviews, and the analysis of the needs of students and teachers. The observations, interviews, and analysis of the needs of students and teachers in learning science at elementary school 2 Gunungsari can be considered quite good and effective. Teachers have utilized digital technology advancements by using videos and PowerPoint presentations that align with the subject matter. However, there are several challenges in teaching science, particularly on the topic of animal reproduction. Some of the challenges faced by teachers are: adapting to the era of society 5.0 and the independent curriculum; students' lack of engagement in learning due to unappealing media; difficulty in presenting concrete media that aligns with the subject matter. Based on the analysis of students' needs through observations and interviews, it was found that students prefer when teachers use real or tangible media when explaining the subject matter. They also show more enthusiasm when learning through interactive games. Moreover, students find it easier to understand the material when using gadgets as learning aids. However, there are school regulations that prohibit students from bringing gadgets to school.

The design of the developed product is based on the analysis of problems and the needs of students and teachers conducted by the researcher, resulting in a suitable design for a virtual reality-based game media on the topic of animal reproduction. The prototype product can be seen in Figure 1. This media can only be accessed on devices with a minimum specification of a Hexa-core 4x 1.4 GHz processor or higher, Android Lollipop or higher for the operating system, at least 2 GB of RAM, at least 500 MB of storage, Adreno 510 or higher for the graphics card, and a gyroscope or accelerometer sensor, which can be seen in the device settings under the phone section.

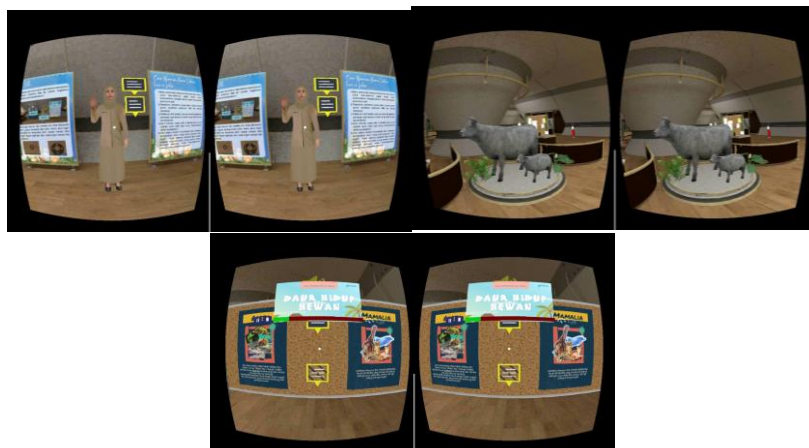


Figure 1. Screenshot of game-based virtual reality media

Based on Figure 1, provides an overview of the virtual reality-based game product, accessible through the MilleaLab application, which requires the code jyBlcz or the link <https://millealab.page.link/NWc99jtLmgnSkq679> to enter the provided class. The virtual reality-based game product consists of 11 steps, including instructions on how to use the media and the game, video explanations, animations of animals related to the topic, animations of teachers and students to guide the next steps, and a word puzzle game related to the material.

Feasibility and Practicality of the Product

The developed product will be tested with expert media and subject matter validators to determine its suitability for implementation with students or practitioners. The validation data for this research was obtained through validation tests conducted by Validator A and Validator AD, who are

experts in media and subject matter, as shown in Table 3. The feedback and notes provided by these experts are used to support the development process of the virtual reality-based game media for teaching animal reproduction at the elementary school level. The validation process involves assessing various aspects, such as graphics, language, content suitability, contextual assessment, and overall validity. Validator A and Validator AD's input and comments are crucial in refining the media to ensure its effectiveness and appropriateness in facilitating learning. Once the validation process is completed and any necessary revisions are made based on the feedback, the virtual reality-based game media can be further implemented and tested with a small group of students to evaluate its practicality and user-friendliness in an actual educational setting.

Table 3. Validation results by media and subject matter experts

Aspect Criteria	Percentage (%)	Criteria
media		
graphics	80	valid
language	78	valid
material		
content feasibility	82	valid
language feasibility	77,14	valid
presentation	76,66	valid
contextual assessment	70	valid
average (%)	77,3	valid

Based on the validation results in Table 3, the media obtained a validation result of 80% for the graphics aspect and 78% for the language aspect. This means that in terms of graphics, the appearance, font selection, illustrations, audio, video, and color balance in the virtual reality media are already good. However, there are some minor revisions or notes provided by Validator A regarding the font size being too small and the presentation of the game not being in line with the developer application facilities.

The next stage of the research, the researcher conducted an implementation test of the revised product based on the input from expert validators in media and material within a small-scale or small group setting. The data on practicality obtained from the implementation test conducted on a small scale or with a small group, specifically involving students in phase B, will serve as a benchmark to determine whether the developed media is practical for use or not. Widiyahti et al., (2015) revealed that a product with practicality characteristics means that it is easy to use by users and can be accessed or utilized anytime and anywhere. The results of the implementation test can be seen in table 4. There were 5 students from elementary school 2 Gunungsari, Boyolali, who participated in the product testing, all of whom were in phase B with different academic abilities and technology knowledge, including high, medium, and low academic abilities based on teacher assessments. Student 1 had high academic achievement, students 2 and 3 had moderate or average academic performance, and students 4 and 5 had below-average academic performance.

Table 4. Results of practicality assessment by students

Participant	Percentage (%)	Criteria
1	81,66	practical
2	78,33	practical
3	80	practical
4	83,33	practical
5	76,66	practical

average (%)	79,99	practical
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The aspects assessed in the product trial are ease of use, attractiveness, and efficiency (Nasution, 2016). The practicality test results in Table 4, conducted with 5 students trying to use the game-based virtual reality media, obtained an average score of 79.99%, in line with the practicality criteria in Table 2. The practicality test results indicate that it is practical to use as a learning media for the topic of animal reproduction in science. This means that the presentation of the material is good and systematic, making it easy to understand. Accessing the application using the link is relatively straightforward, the language used in the media is simple, concise, and clear, and the games provided are easy to play, which helps improve the students' understanding of the subject and keeps them focused. The students' suggestion is not to use background music in the game-based virtual reality media as it can distract practitioners from learning.

DISCUSSIONS

Prototype Product

The game-based virtual reality product consists of 11 steps, including rules and procedures for using the media and game, explanatory videos, animal animations related to the subject matter, animations of teachers and students guiding the next steps, and a word puzzle game that is relevant to the material. The presentation of the media is tailored to the results of the needs analysis. An engaging media is one that has captivating elements, such as animations that suit the characteristics of the students, visually appealing animations to facilitate observation, simple and clear language, and an interesting game that helps improve concentration and problem-solving skills. However, the game in the media can only be played once with one account.

Consistent with previous research stating that elementary school-age children still require tangible objects or media to help develop their intellectual abilities (Desstya, 2016). Monita & Ikhsan, (2020), argue that presenting material that aligns with the students' characteristics can emphasize understanding related to core material explanations using easy-to-understand, simple, clear, communicative language, suitable for the students' characteristics. Similarly, Saputri et al., (2018) stated that presenting material using visual elements such as illustrations, 3D objects, and relevant animations can motivate and encourage students to learn more about the subject matter.

Based on these points, game-based virtual reality media can be considered a tool that facilitates students and teachers in explaining, observing, and understanding the material, accessible anytime and anywhere (Kusuma et al., 2018). This aligns with Prastowo's in Akmal & Saputra, (2020) that with accessible media or learning materials that students can access independently and at their own pace, students can choose material according to their preferences and engage in active learning activities.

Feasibility and Practicality of the Product

Based on the validation results presented in Table 3, the game-based virtual reality media received a validation score of 80% for the graphics aspect and 78% for the language aspect. This indicates that the visual elements, font selection, illustrations, audio, video, and color balance in the virtual reality media are already of good quality, but there are some minor revisions suggested by Validator A, particularly concerning the font size being too small and the presentation of the game not aligning with the developer application facilities. Hasan et al. (2021), supported the idea that engaging elements such as real examples, illustrations, and appealing colors can capture students' attention and make them more comfortable with the learning process.

Regarding the language aspect, the media scored 78% with the language presented in audio, images, and videos being considered good, despite some revisions needed for the explanation of the

material displayed in images. The presentation provided by the researcher is deemed suitable for children's characteristics, attracting their attention and encouraging active learning, although some revisions were suggested by the validator. Monita & Ikhsan, (2020), argued that presenting material in line with students' characteristics can enhance understanding through language that is easy to understand, communicative, and tailored to their characteristics. Saputri et al. (2018), also mentioned that a creative and engaging presentation can arouse students' curiosity.

Regarding the material validation, it obtained a score of 82% for content feasibility, 77.14% for language feasibility, 76.66% for presentation, and 70% for contextual assessment. Validator A and AD provided some feedback, suggesting clearer material in images presented concisely and clearly to maintain the teacher's role, and increasing real-life examples related to the material. Hasan et al., (2021) also supported the idea of presenting language concisely with a simple, clear, and effective core, making it easier for students to understand the material.

According to Table 1, the overall average validation score for the game-based virtual reality media was 77.3%, indicating that it meets the criteria for learning media validity. The material presentation aligns with learning objectives and teacher-provided insights from interviews and observations, using illustrations, videos, animations, and games related to the material, stimulating students' curiosity, motivation, and easy understanding of the content. This aligns with Saputri et al. (2018), statement that visual elements like illustrations, 3D objects, and animations can motivate students to explore the material's content further.

Based on the validation results presented in Table 4, the game-based virtual reality media achieved an average score of 79.99% for usability, attractiveness, and efficiency, in line with the practicality criteria mentioned in Table 2. This indicates that the media is practical for use as a learning tool for the topic of animal reproduction in science. The presentation of the material is well-structured, making it easy for students to understand. Accessing the application through a link is straightforward, and the language used in the media is simple, clear, and effective. The game presented in the media is easy to play and helps enhance students' understanding of the subject matter, keeping them focused during the learning process. Previous research also supports the idea that technology-based games can support learning activities, motivate students, and add positive elements to the learning environment (Jayanti et al., 2021; Villena-Taranilla et al., 2022). Game-based education has been found to increase students' knowledge and provide an effective and enjoyable learning experience (Winarni et al., 2020).

The response from students during the trial of the game-based virtual reality media can be seen from the average practicality test score of nearly 80% in Table 4. This indicates that the media is suitable for students to use as a learning tool that can be accessed independently and anywhere, without limitations of time and space. This aligns with Prastowo's statement in Akmal & Saputra, (2020) that accessible media or learning materials allow students to choose materials according to their preferences and engage actively in the learning process at their own pace (Sülter et al., 2022; Wang et al., 2023). Feedback and suggestions from practitioners during the implementation test provide valuable insights for the researcher. One suggestion is to avoid using background music in the game-based virtual reality media, as it can distract practitioners during learning sessions.

Moving to the final stage of the research, the evaluation phase will be conducted to assess the strengths and weaknesses of the game-based virtual reality media for the topic of animal reproduction in science. The strengths include its independent accessibility through gadgets, its presentation with illustrations and written, audio, and video explanations to help students understand the material, and its motivational aspect due to the inclusion of interactive games. However, the weaknesses include the requirement of internet connection for using virtual reality-based games, the limitation of one-time play for the game, and the limited accessibility of the media to specific gadgets with specified minimum processor and system requirements. Overall, the game-based virtual reality media shows promise as a practical and engaging learning tool for the subject of animal reproduction in science,

with areas for improvement to address the identified weaknesses and provide a seamless learning experience for students.

CONCLUSION

Based on this development research, the researcher concludes that a product has been produced in the form of a virtual reality-based game media on the topic of animal reproduction for elementary school students, which is valid and practical to be used as a learning media. The level of validity of the developed virtual reality-based game media is 77.3% with a valid criterion, and the level of practicality is 79.99% with a practical criterion. The strengths of the virtual reality-based game media on the topic of animal reproduction are its ability to be used independently anytime and anywhere through gadgets, the media presented with illustrations and explanations in written, audio, and video formats to help students understand the material, the material can be accessed repeatedly except for the game, and the media can motivate students to learn due to the inclusion of the game. However, its weaknesses include the need for internet connectivity when using the virtual reality-based game media, so students must ensure that their network is in good condition. The game can only be played once by one user, and the application for using the media cannot be accessed on all gadgets because it requires a minimum specification of a Hexa-core 4x 1.4 GHz processor or higher. In conclusion, the virtual reality-based game media on the topic of animal reproduction can be considered an effective and suitable product for use as a learning media to support science education in elementary school Phase B. Despite having some weaknesses, its potential strengths can provide a more engaging and interactive learning experience for students. Furthermore, this media needs to be further tested on a larger scale and involve more students to obtain more representative results

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