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Research Article

The Feasibility of Enhancing Environmental Awareness using Virtual Reality 3D in the Primary Education

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Technology development promotes different learning strategies for varying levels of education. This technology provides opportunities for more engaging learning and encourages motivation to understand concepts and values. This research focuses on the development of 3D virtual reality (VR), which explains the living environment, especially animals, in the original habitat in the context of elementary school learning. This VR application is called Zoo-VR, which can be used in various learning models to achieve learning competencies. Zoo-VR includes 30 types of animals with their original sounds and explanations in audio and text form. The animals move freely in their habitat according to natural conditions. Users can move from one place to another, approach particular objects, and run virtual menus using programs installed on Oculus. The feasibility of Zoo-VR is reviewed from the perception of teachers and students after using it. The snowball effect interview model measured the perceptions of teachers and students. The teacher's experience is observed in four aspects of the experience: conformity with the subject matter, feasible learning models, competencies, and the adequacy of menus in the application. The student experience is observed in five aspects: immersion, interest, the comfort of the tool, intention to share, and practicality of existing features. This experience gives the basis for a broader analyzing the use of Zoo-VR both in and outside the classroom. The results of the review and observation explain that Zoo-VR is feasible to apply to real learning situations. The challenge of Zoo-VR is integrating this application with learning objectives on various subjects. However, the result from the limited number of participants cannot be applied to generalize comprehensively. Studies on the application of Zoo-VR to actual learning conditions need to be carried out to reveal the real potential of VR.

1. Introduction

Society has taken advantage of the development of technological innovations, including smartphones that can also provide access to virtual reality (VR) and augmented reality [1]. VR is widely applied to various interests of society, such as in the fields of health [2, 3], science [4, 5], engineering [6], and education [7, 8]. This technology also strengthens education that integrates technology in learning. VR is a rapidly developing technology used in learning [9]. Exploration in research related to VR is carried out on various aspects in the implementation of learning, the achievement of understanding, the improvement of various competencies, and the impact on psychology and health. With these research findings, VR studies remain relevant and essential in learning. The use of VR has grown due to the benefits not gained from conventional learning. VR contributes to education because in addition to making activities cheaper [10], it provides a hands-on experience of being involved in environments or situations that are difficult to replicate.

VR is an artificial environment that projects the user into a 3D-generated space [11]. VR is increasingly used in education because it provides opportunities in various aspects, such as being able to present phenomena that are impossible for students to encounter in everyday life because of various things, can be used anywhere, and are cheaper from an economic point of view [1, 10]. For example, students in the tropics can make observations of animals living in polar regions. Nevertheless, it is not an easy thing to provide a virtual learning experience from the technical aspects of VR development [12].

The high degree of immersion in VR is believed to encourage a higher sense of social presence [2, 13] due to subjective sensations in virtual environments. Social presence in VR is also known as the presence of spaces. Spatial presence is the feeling that one is in a virtual world that is important in one's consciousness [13]. However, some research has also shown that higher attendance rates do not necessarily lead to better learning outcomes. In the VR research, it was found that gender is not an affecting factor in VR-assisted learning [14]. However, VR-assisted learning has a high degree of interaction between users and the media, so the potential for improved learning outcomes is better [15] by doing hands-on activities [16, 17]. These results can be the basis for collaborative learning using VR. Various factors can be considered to improve learning achievement. The teacher needs to apply the principles of instructional design relevant to the material, students, and competencies by creatively utilizing VR as a medium [18].

On the other hand, there are higher expectations of primary school learning. Learning is encouraged to be able to provide a learning experience that builds a broader range of learning by presenting learning materials or resources that encourage higher thinking skills. This shift in learning leads to providing a contextual learning environment through varied learning experiences. The obstacle faced in the provision of this learning environment is in the provision of certain natural phenomena that do not exist in the student's place of residence. An example is presenting elephants' life in tropical regions to students in subtropical regions. This limitation is an opportunity to take advantage of VR, which is believed to provide a good level of immersion. This study aims to explain the feasibility level of 3D VR with environmental content, especially animals in the original environment, in the context of elementary school learning. The results of this VR study are the basis for teachers to develop various learning strategies with specific models that suit the needs of certain subjects.

2. Method

2.1. Participants. This research used a qualitative method, with a sample of eight people (two low-grade students, two low-grade students, two high-grade students, and two high-grade students). Students have been selected by their teachers to take part in the Zoo-VR trial. There are no specific criteria in this selection (randomly). All students have never used VR in their various activities before, so it can be considered that all the students who participated in this study have relatively the same previous experience. Two teachers participate who have been certified in the profession, assuming they have sufficient competence to provide opinions on using Zoo-VR in good learning. The initials are WHT and PRD, all females. Table 1 shows the student participant's gender and school level.

Table 1: Student participant.

No.	Initial	Gender	Grade	
			(1st–3rd)	(4th–6th)
1	VAB	Male	1	
2	DKN	Male	1	
3	FAD	Female		1
4	MAK	Female		1

2.2. Procedure. Both teachers and students are given an explanation in advance about how to use Zoo-VR. There are no initial interventions related to those inside Zoo-VR. Participants were then allowed to use Zoo-VR alternately and export content within 10 min. During the use of Zoo-VR, market was observed from the side of gestures and speech. After finishing their trying, they were interviewed in several predetermined aspects. After the interview, they are not allowed to meet other participants to avoid another impact. This stage applies to both teachers and students. Figure 1 shows the step of qualitative data collection.

2.3. Measures. The perception of teachers and students is measured qualitatively by two approaches: observation and interviews. The interview was used as a snowball effect interview model. Interviews are conducted using open-ended questions that are interrelated with the answers to the previous questions. The teacher's experience is seen in four aspects of the experience: conformity with the subject matter, learning models that can be applied, competencies (knowledge, attitude, skills) that can be developed, and the adequacy of menus in the application. The student experience is observed in five aspects: immersion, interest (want to try again), the comfort of the tool, intention to share, and expediency of existing features.

2.4. Materials

2.4.1. Zoo-VR. The simulation was built with a dress-up from the Ministry of Research, Technology and Higher Education through the Research Grant Program. The experience built through Zoo-VR is that users can use the full potential of a virtual space featuring a relatively spacious landscape against the backdrop of mountains, a clear sky atmosphere, large trees, shrubs, rocks, and paths leading to various animal habitats. There are 30 animal properties of various types (mammals/aves/reptiles, carnivores/herbivores) (see Figure 2 for the landscape and Figure 3 for the animal sample). The rate for users' movement in the virtual space is tried not to be fast so that elementary school students can feel the atmosphere. The left controller grip (in the form of a red laser in the virtual space) can be used to travel according to the path. Besides that, it can also be used to approach certain animals. When approached at a certain distance, the animal will be heard in different sounds according to its original state.

Each animal property is available as narration presented in the form of sounds and textboards. This textboard describes the location of the habitat in which region it is located, its food, and its physical characteristics. Table 2 shows examples of narratives for zebras that have been translated into English from Indonesian.

A signage can be activated in each animal habitat to issue a full explanation of the animal. The right controller grip

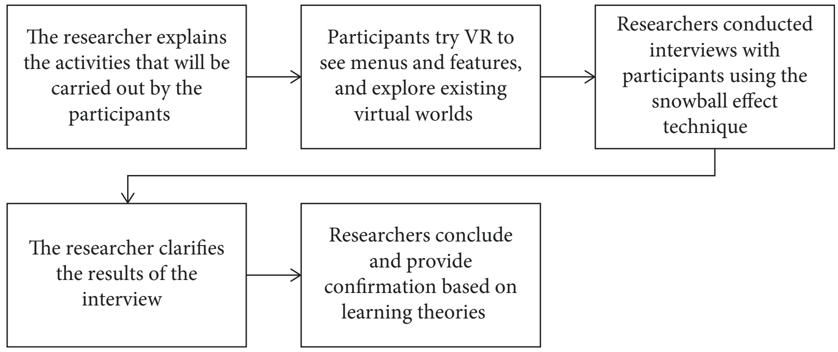

Figure 1: The data collecting procedure.

Figure 2: The landscape in the virtual environment. The number indicates the habitat of a particular animal.

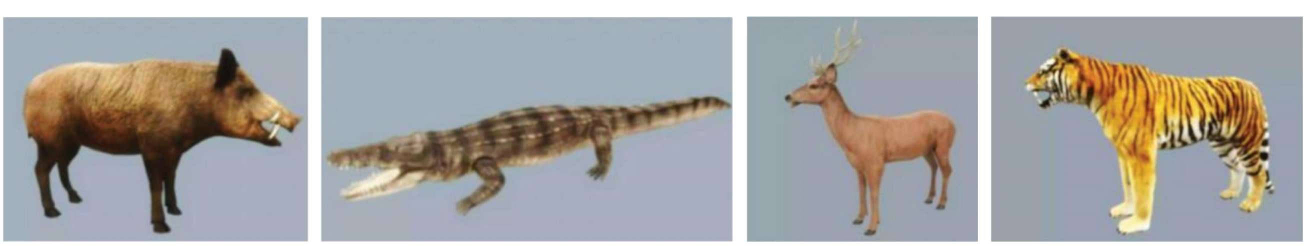

Figure 3: Samples of the animal property.

(white when active) is used to activate the menu in the virtual space. No landscape map is available for maximizing exploration space in application in learning. The Zoo-VR features can be used in various learning strategies according to the teacher's creativity. Figure 4 shows an example of a zebra habitat.

2.5. Informed Consent. The research was conducted with partner schools based on the official agreement of the two parties and explained this research plan and its impact on the participants. The researcher explained the inclusion and exclusion criteria to the principal in selecting the sample. As a representative of the school, the principal has the authority to determine participants (teachers, students) with criteria that have been determined by the researcher (low grade and high grade, male and female; the selected teacher is certified as a professional teacher). Furthermore, through the school, the researcher communicated the selected students to their

Table 2: Sample of zebra zone and its narration (left laser for moving, right laser for activating the board).

Number of property	Animal name	Narration (in the Indonesian language)
23	Zebra	Zebras are animals that are also often referred to as horses. Zebras belong to animals that are endemic to African origin. Zebras live a lot in grasslands, from grasslands that do not have trees to grasslands on the edge of forests. Zebras live much in East Africa, up to South Africa. This animal has a distinctive body pattern, which is black and white striped; and so on.

Figure 4: Zebra habitat, signage, and narrative.

parents to obtain permission as research participants. The school also explained to parents the timing of data collection outside school hours and the benefits and impact of using VR on students. The researchers asked teachers who became the participants for their willingness and explained the benefits and effects of this research. At this stage, this research has met the ethical requirements of research.

3. Result

VR was designed to be as attractive as possible without complicating, to create a sense of closeness and control through its immersive display that puts the user into a simulated environment that looks and feels to a certain extent like the real world. Under the method in this study, teachers and students were allowed to use Zoo-VR and carry out various activities in the virtual world using the available features and menus. Visually observation can be observed by the response of the teacher or student from other faces and body language apart from the spontaneous expression of words. Figure 5 indicates the situation when the teacher or student tries Zoo-VR.

3.1. Teacher Perception. The perception of teachers and students is measured qualitatively by two approaches: observation and interviews. The interview was used as a snowball effect interview model. Interviews are conducted using open-ended questions that are interrelated with the answers to the previous questions. Both teachers stated that Zoo-VR has the potential to apply to a variety of subjects.

> BHT stated:
>
> *VR ini dapat dipakai untuk pengenalan hewan dan tumbuhan pada siswa kelas rendah. Pada kelas atas dapat dipakai untuk pengenalan ekosistem. Termasuk juga cara berkembang biak, habitatnya, dan rantai makanan. Bahasa Indonesia juga bisa untuk kegiatan menceritakan kembali dan membuat kalimat menjadi cerita.*
>
> (This VR can be used for the introduction of animals and plants in low-grade students. In the upper-grade students, it can be used for the introduction of ecosystems. This includes how to breed, its habitat, and the food chain. Indonesian can also be used for retelling activities and making sentences into stories.)

Several learning models can be applied by utilizing Zoo-VR. Both teachers identified five issues related to learning models or strategies: thematic approach, space mapping, problem-based learning, inquiry learning, and project-based learning.

> PRD stated:
>
> *Dengan projek-based learning, siswa dapat mengamati hewan-hewan, membuat miniatur lokasi atau menggambarkan ekosisitem. Dapat juga dipandu dengan LKPD untuk berdiskusi.*
>
> With project-based learning, students can observe animals, create miniature locations, or depict ecosystems. It can also be guided by worksheet to discuss.

> BHT stated:
>
> *Kalau dengan discovery learning, siswa bisa diminta mengamati hewan tertentu dari dekat. Melihat bentuk fisiknya seperti jumlah kaki, bentuk badan. Selain itu juga dapat diminta mengamati bagaimana cara mereka bergerak. Suaranya seperti apa. Kalau mereka bisa melengkapi pengetahuannya dengan membaca tulisan dan mendengarkan suara penjelasan.*

FIGURE 5: Teachers and students who try Zoo-VR.

(With discovery learning, students can be asked to observe certain animals up-close. They are looking at his physical shapes, such as the number of legs and body shapes. In addition, it can also be asked to observe how they move. What kind of voice? If they can supplement their knowledge by reading writings and listening to the voice of explanations.)

Both teachers explained that several competencies could be developed using Zoo-VR, which is integrated with the learning model. Some competencies that can be improved are higher-order thinking skills, spatial abilities, and conceptual understanding.

BHT stated:

Banyak kinerja belajar yang dapat dikembangkan. Itu dapat disesuaikan dengan model pembelajarannya. Untuk kelas rendah bisa dengan membandingkan ukuran hewan. Mana yang lebih besar? Ayam atau Buaya? Atau apa persamaan antara ayam dan burung? Ini kan sudah HOTs

Many learning performances can be developed. It can be adapted to its learning model. Low grades can be by comparing the size of the animal. Which is bigger? Chicken or Crocodile? Or what are the similarities between chickens and birds? It is already HOTs (Ed. Higher order thinking skills).

The existing menu is to move around and activate the explanation of a particular animal. On the controller grip, several buttons can be activated. However, only a few are active in the Zoo-VR application, considering reducing operational complexity.

PRD stated:

Pas coba tadi sempat salah pencet tombol. Mungkin karena ada beberapa ya? Tapi ini sudah bagus. Kalau banyak tombol malah susah buat anak SD.

(When I tried it earlier, I pressed the wrong button. Maybe it is because there are some? However, this is already good. If there are many buttons, it is even difficult for elementary school children.)

3.2. Student Perceptions. The student experience is observed in five aspects: immersion, interest, the comfort of the tool, intention to share, and the expediency of existing features. Immersion describes the feeling of being present when in a virtual space. The experience in the virtual space is perceived as an authentic experience. After using Oculus and experiencing the journey in the virtual space, students, both male and female at all levels, stated there was a feeling of visiting the vast zoo with its various animals.

> VAB and MAK stated:
>
> *Seperti kebun binatang beneran.*
>
> (Like in a real zoo.)

During engaging in research, students are allowed only to try once (10 min). From observation, there was an expression of the students wanting to use and try again. They feel that they have not traced enough of the existing animals. This condition is an indication that Zoo-VR is promoting interest.

> DKN stated:
>
> *Cuma sebentar mainnya. Kalau boleh mau coba lagi. Tadi belum sempat jalan yang ke ujung. Baru lima hewan yang sempat dilihat. Tulisan juga gak sempat kebaca tuntas.*
>
> (It is just a short play. I want to try again. I have not had time to walk to the end. Only five animals have been seen. The writing also did not have time to be read thoroughly.)

The convenience of the tool in observation and interviews tends to be no complaints. Students can move requests in the virtual space using the left and right sticks. The speed of movement is already in line with expectations. However, from the observation, it can be seen that the size of the Oculus is too big for the student's head. During the duration of the trial, the student does not feel exhausted supporting the apparatus.

> DKN stated:
>
> *Ketika bergerak menggunakan laser, pada awalnya tidak tahu caranya. Ternyata mudah hanya dengan geser stik maju atau mundur kekiri atau ke kanan. Ini cukup mudah.*
>
> (When moving using a laser, I do not know how at first. It was accessible by sliding the stick forward or backward to the top or right. It is pretty straightforward.)

When asked whether they want to tell Zoo-VR to their friends, all students tend to have a desire to tell Zoo-VR to friends both at school and at home.

> FAD stated:
>
> *Sepertinya baru sekolah kita yang nyoba ginian. Aku mau cerita ke temanku di rumah biar pingin coba juga. Asyik banget.*
>
> (It seems that it is just our school that is trying to get like this. I want to tell my friend at home, so I want to try it too. It is enjoyable.)

Existing features are selected to support interaction while in the virtual space. In line with the teacher, students also perceive that the menu in the application is sufficient.

> DKN stated:
>
> *Saya bisa menjalankan aplikasi ini dengan menu yang ada. Tidak sulit. Bisa lihat tulisan dan penjelasan dengan laser pada tulisan hewan.*
>
> (I can run this app with the existing menu. It is not difficult. I can see the writing and explanation when I shoot a laser at the animal text.)

4. Discussion

Piaget explained that learning is an interaction between assimilation and accommodation activities. The assimilation principle describes the process of combining new information on a concept with existing information or ideas [19]. By exploring the existing landscapes in VR, students gain further details on the life of various types of animals in their habitats that will improve or increase the knowledge they already have. Accommodation is a process of modifying a pre-existing concept so that it becomes broader and more profound. Both of these processes affect the development of students' thinking [20]. The principle of social interaction developed by Vygotsky as part of the theory of social constructivism explains that interactions between students, directly or indirectly, will affect the understanding of the concepts they already have. In learning, integrating VR with other activities that allow student interaction will encourage the development of ways of thinking.

Students' learning experience will turn into playing with technology while learning so it is key to enhance their experience. VR technology provides many opportunities in education for different aspects of interest [1]. Zoo-VR provides flexibility to be applied to various subject matters in natural and social science fields. Environmental issues are issues that can be discussed in a multidisciplinary manner. These conveniences have become a necessity in the learning process. Especially for twenty-first century students, as digital natives, the generation has different characteristics such as eagering fast access to information, preferring games and visual/graphic elements over long texts, having parallel cognitive structures, and performing multiple tasks simultaneously [21]. Content on Zoo-VR that covers various aspects (animals, plants, mountains, sky, and rocks) provides opportunities to discuss many environmental topics. A vast landscape with various characters can be raised through learning strategies with various learning models. For example, discovery learning can be applied by looking at existing content to characterize animals or landscape conditions. In addition, problem-based learning can be applied to solve environmental issues related to animals' way of life in their environment. The concept of the food chain can be included in this study. This explanation is in line with the statement that discovery learning is a learning theory that expects students to be able to organize themselves to obtain new knowledge delivered indirectly by the teacher so that students will get used to thinking critically about a problem [20, 22].

A virtual experience can also be carried out as a game in a virtual space that allows for various activities. The game in many educational research studies shows the potential for improving learning outcomes [18]. Integrating learning objectives, learning activities, and media is essential when developing VR that focuses on education [23]. Differences or similarities in various aspects of animals can be explored to encourage competency improvement, especially in higher-order thinking skills. Integrating individual and group activities using Zoo-VR can be used to build other skills such as collaboration and communication skills. Activities like this can be developed in virtual observations that, in some research, this way can improve learning outcomes [5]. Other studies confirm that using VR can improve students' different competencies and skills [8]. In this VR development, the principles of assimilation and accommodation are used to provide diverse learning experiences to students [20]. The animals provided come from different regions of the world, different ways of eating, and other characteristics. This strategy is applied as applying the principles of assimilation and accommodation.

For elementary school students, the menu on the application is appropriate. The feature restrictions on the Oculus used make Zoo-VR less complex in its use by students. Moving in a virtual space using a virtual laser helps the user feel the immersion process. Placing animal properties that can be observed in a 360-degree manner also encourages a more exciting exploration process. The student's experience of moving in a virtual space in multiple directions is perceived as a good immersion experience. This activity can be an opportunity for hands-on activities to internationalize better skills. VR was developed so that users can more quickly get information that is difficult to get in the real world. Through virtual reality, users will have the feeling that they are in a virtual world and interact with that world. It can be used to provide real experiences. There is a student's satisfaction to feel various situations that are not easily encountered in actual conditions. In harmony with the teacher's perception, the existing features do not make it difficult for students. When students use VR, they will enter into an atmosphere like in the real world. VR allows students to be completely immersed in the virtual model. So that they will get a different experience when learning. The menu is not too much, making it easier for students to browse the content on Zoo-VR [16, 17, 24].

Interest can be seen in the desire of students to try to repeat the use of Zoo-VR. The aspect that is felt to be driving interest is insufficient time available for full landscape exploration. In addition to interest in animals that have not yet been explored, students are also interested in an in-depth exploration of certain animals in animal visuals (by approaching property) and repeating animal explanatory narratives from textboards and audio. Using interest theory, this situation can be a prediction that students who use VR media in learning will tend to have higher interest and motivation than those who do not use this media. Nevertheless, it is worth considering that the increase in interest and motivation cannot always increase the achievement of higher learning if it is explained using the cognitive theory of multimedia learning [8, 25]. More structured material tends to be more effective at gaining understanding. Thus, when teachers use Zoo-VR in learning, it is necessary to manage a structured learning strategy when exploring virtual spaces [25].

Students' enjoyment level after experiencing virtual activities encourages positive perceptions related to Zoo-VR, so they tend to recommend this application to their friends. VR enjoyment is influenced by a sense of spatial presence, interactivity, and realism [13]. This attitude is perfect from the social learning theory that students will learn from other students' successes and failures and react to specific events. The results of other studies show that the use of VR in learning can improve learning outcomes because between students, there is a process of sharing experiences [26]. Students' experiences when using VR and perceived positively will encourage other students to try to acquire the same experience. Some determinant factors of VR enjoyment are spatial presence, interactions, and realism [13, 21]. Learning is more than just consuming information; constructive learning activities must be integrated inside or outside the virtual world to form meaningful learning [23]. Appropriate learning strategies do not reduce students' positive affective attitudes in VR-assisted learning.

Convenience in using the tool is essential for more prolonged use. This aspect is related to the psychological and ergonomic aspects of health that will develop. During the study, no complaints were found in the use of 10 min. These results need to be followed up on ergonomic studies to see how long students can survive using Zoo-VR and its impact on psychology. A high level of comfort encourages better learning outcomes [10]. The high interaction between students and Zoo-VR contributes to increased comfort when operating it. From the results of these interviews, students were very interested in using virtual reality. The application attracts students to learn, understand the issue, and has a new perspective on learning. These results align with other research findings that high-interaction levels in VR improve students' work performance [15]. Studies on VR-based game players found that there is a possibility of psychic and health problems [11, 27] that may arise, so research on the use of VR in education needs to be studied to determine its impact.

The consideration of psychological and ergonomic aspects of health can be integrated into problem-based learning. This model can be used to encourage critical thinking skills [7]. In the learning stages, students face problems, for example, comparing different animal characteristics from various aspects. Students are allowed to experience being in a virtual world using VR. Students are free to explore existing places and observe animals. After playing by exploring the landscape, students are invited to share their experiences. Teachers can ask questions (as scaffolding) so that students' experiences can be revealed and immediately integrated with the concept of knowledge that has been possessed according to constructivist principles [28, 29].

The learning experience of exploring the landscape with various kinds of animals makes students happy. This feeling was expressed by students who tried VR. Animals that come from multiple places that are not in the student's home area cause curiosity. Media that is still new for students encourages a sense of fun because they get new experiences to learn about animals in their natural habitat. Students can see animal behavior (silent, walking, running), sound, physical characteristics (proportional, color, unique features, etc.), the atmosphere in which they live, and explanations (understanding, habitat, food). With this strategy, students can conduct exploration (observation, discovery) on the observed animals. The various aspects observed lead to interest and motivation. The principle of constructivist learning can explain this situation. Students experience the activities themselves and gain new knowledge from what they are doing. Besides that, active students gain independent learning experience and hands-on experience. In the application of learning, teachers can assist in achieving new knowledge according to the competencies developed, such as by reasoning and comparing various animals. The concept of scaffolding can explain this strategy [28]. The teacher challenges the acquisition of new knowledge slightly higher than the knowledge possessed by students.

The problem-based learning model is one of the most relevant learning models applied today because this learning model directly connects problems in the classroom with those in the real world [12]. From interviews with teachers, this application has the potential to be applied to various learning models, one of which is problem-based learning. The stages with this model are:

(i) Orient, the students on the problem. Before using VR, the teacher explains the learning objectives, such as guiding what to observe for each animal
(ii) Students are given the freedom to choose where they will move in cyberspace while observing animals
(iii) After students have explored and observed, the teacher facilitates students to discuss with other friends (can be with various group learning strategies) that focus on understanding the characteristics of animals (comparing sizes, ways of moving, food, physical characteristics)
(iv) Students study in groups to discuss the results of the activities
(v) One of the students representing the group explains the group's findings to all students

Many studies of VR for elementary schools confirm that VR is effective in various aspects [30–32]. These potential successes can be explained by learning theories. Perceptive constructivist learning sees it necessary to provide students with opportunities to discover new knowledge based on learning experiences or previous knowledge [9, 33, 34]. The provision of a learning environment that allows students to discover new knowledge will promote on self-regulation [35] and better self-efficacy [36] as the results of research on VR confirm these results [17, 33, 37, 38]. VR may apply to various subjects in an integrative way. The same VR can trigger various problem-solving from different perspectives. In this way, VR is more productive for multiple issues. This condition can be achieved with different school policies in the utilization of VR and providing collaborative learning that allows different competencies to be grown [39]. In this study, the number of participants was still limited, so pedagogical impacts could not be observed. Future research is needed to reveal the real potential of VR in learning. Although it is believed that the level of VR acceptance in learning is good [40], several determinants of learning can be included in the study to obtain a more comprehensive picture of Zoo-VR-assisted learning that is in line with the VR literature review on the basic science [41]. In addition, studies involving different contexts (subjects, problems) can be carried out with larger sample sizes and at different levels of education. So that, the results are not limited to the perception of teachers or students, but the impact of Zoo-VR-assisted learning. It is also necessary to research the teacher's side regarding their creativity in designing learning relevant to current needs that VR assists. Achieving competencies such as critical thinking skills, creativity, communication, and collaboration are teachers' challenges while designing learning.

5. Conclusion

The results of other studies related to the use of technology in learning explain the opportunity to improve learning performance. This research clarifies the opportunities for using virtual reality for learning in elementary schools. Not precisely the subjects that overshadow this VR utilization that is an opportunity for utilization in various subjects. Teachers and students have a positive perspective on using VR for learning in terms of material mastery and increasing competence and thinking skills. From the experience of students, it is known that there are opportunities for this VR to encourage a deeper understanding, higher motivation, and better thinking skills. The integration of the use of VR in specific learning models allows for the achievement of better learning performance in various aspects. In this study, the number of participants was limited, so the level of generalization on empirical and pedagogical aspects was not yet comprehensive. Studies on the application of VR in actual learning conditions can reveal the real potential of VR in supporting learning. Determinant variables in learning can be studied when VR is included in the study.

Data Availability

The participants' response data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Dwi Sulisworo conceived the study; Vera Yuli Erviana and Bambang Robiin curated the data and did the formal analysis; Dwi Sulisworo helped with funding acquisition; Vera Yuli Erviana, Yovi Sepriansyah, and Achmad Soleh investigated the study; Bambang Robiin and Achmad Soleh designed the application; Dwi Sulisworo, Vera Yuli Erviana, and Bambang Robiin prepared with methodology; Dwi Sulisworo provided the resources and supervised the study; Bambang Robiin and Vera Yuli Erviana validated the study; Yovi Sepriansyah and Achmad Soleh helped with visualization; Vera Yuli Erviana and Bambang Robiin wrote the original draft of the manuscript; Dwi Sulisworo reviewed and edited the manuscript.

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