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ENVIRONMENTAL LEARNING THROUGH THE DEVELOPMENT OF VIRTUAL REALITY-BASED COMPOSTING MODULES IN ELEMENTARY SCHOOLS

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ABSTRACT

This study aims to develop a Virtual Reality (VR)-based composting learning module to foster environmental awareness among elementary school students and overcome the limitations of conventional learning, which is theoretical in nature. This study uses the Research and Development (R&D) method with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The research subjects are fifth-grade students at SDIT Wildan Mukholladun. Validation results indicate that the developed module is highly suitable for use, with a percentage of 97.65%, meaning the media can be used without revision. The module is considered practical by both teachers and students and easy to use in learning activities, with an average percentage of 80% for both groups. Effectiveness testing through comparison of pretest and posttest scores shows an improvement in students' understanding, with effectiveness ratings in the moderate category. This was determined based on the N-Gain Score calculation, which showed a value of 0.303 for the small class and 0.301 for the large class. The module was deemed capable of providing an immersive and contextual learning experience, as well as supporting the cultivation of an environmentally conscious attitude among elementary school students.

Keyword: Environmental awareness, Compost, Module, Virtual Reality

INTRODUCTION

Environmental learning is an approach to learning that aims to provide students with an understanding of science concepts through real-life experiences and by utilizing the environment as a learning resource (Saputra et al., 2024). Environmental learning is provided to students from elementary school onwards. Based on the current education curriculum, namely the Merdeka Curriculum, environmental learning, which was previously integrated into the science subject in the 2013 Curriculum, has now undergone changes because the subject has been combined with the social studies subject, thus changing its name to IPAS (Natural and Social Sciences). According to Ahmad (2024), the merger of science and social studies subjects at the elementary school level is based on the fact that elementary school-aged children tend to view everything as a whole and interconnected. The stage of thinking of elementary school-aged

children, which is still at the concrete, comprehensive, and holistic stage but not yet deep, is also a reason for the merger of science and social studies subjects.

At the elementary school level, IPAS is taught to students through a phased system: in Phase A (grades 1 and 2), IPAS is integrated with other subjects, while in Phase B (grades 3 and 4) and Phase C (grades 5 and 6), IPAS stands alone as a separate subject. IPAS encompasses two elements: science and social studies, meaning that this subject covers the relationships or interactions between living and non-living things in the universe, as well as the interactions between humans as individual beings and as social beings with their environment (Oktariani et al., 2024). The content of the IPAS subject is a combination of basic concepts from natural sciences and social sciences. Among the many topics covered in the IPAS subject, one of the topics taught to elementary school students is the creation of compost as a form of environmental conservation behavior.

IPAS learning through composting is an implementation of an environmental learning approach conducted through exploration and hands-on activities. This learning approach is considered more meaningful because students gain real-world experience related to environmental issues. Through this learning activity, students are not only invited to understand the composting process but are also taught skills in maintaining a good environment. By providing material on composting, it is hoped that values of care, responsibility, and love for the environment will be instilled in students, especially at the elementary school level, as a foundation for them to develop sustainable environmentally friendly behavior.

Based on observations conducted at SDIT Wildan Mukholladun, it was found that IPAS learning related to composting material is still delivered theoretically through lectures and textbooks, without any direct practical activities by students. As a result, learning becomes less optimal because composting material essentially requires understanding gained through direct experience. Additionally, without practice, learning becomes less meaningful because students have not truly understood the composting process in reality.

The demands of the modern era, which rely heavily on technology in all fields, have also necessitated that education adapt and integrate technology into the learning process. This is because technology in education offers numerous benefits, particularly in terms of effectiveness and efficiency, and can also help students understand the material more easily and improve their skills (Suyuti et al., 2023). Additionally, the use of technology during the learning process, such as in the current implementation of the Merdeka Curriculum, can provide students with greater motivation and understanding (Handayani et al., 2023). Technology can support the learning process in elementary schools, particularly in subjects like IPAS. Learning that emphasizes interaction with the environment is facilitated by the use of technology because of the ease of

access to various information and learning resources online without space and time limitations (Menhard, 2024).

Based on the observation results, it was found that the availability of technology, both in schools, such as LCD projectors, and owned by students, such as smartphones, is adequate. With this technology, it should be possible to support more interactive learning and provide a more realistic experience, especially for material involving the steps of composting. The most common integration of technology in learning at schools is through the use of learning media. Therefore, there is a need for the development of digital learning media that can bridge the gap between the limitations of direct practice and a more realistic learning experience for students.

This research produced a Virtual Reality-based composting learning module to foster environmental awareness among elementary school students. The novelty lies in the integration of VR in IPAS learning on decomposers, combined with organic waste management practices through composting, designed to provide an immersive and meaningful learning experience to cultivate environmental awareness from an early age. This module is expected to enrich understanding of waste management, instill an environmentally conscious attitude, and sharpen 21st-century skills (critical thinking, collaboration, and technological literacy). Additionally, this module serves as an innovative alternative in the implementation of the Merdeka Curriculum for decomposer material in Grade 5 and strengthens the Pancasila Student Profile Project (P5) on the theme of "Sustainable Lifestyle."

LITERATURE REVIEW

According to Ahmad (2024), the merger of science and social studies subjects at the elementary school level is motivated by the fact that elementary school children tend to view everything as a whole and interrelated unit. The thinking stage of elementary school children who are still at the stage of concrete, comprehensive, and holistic thinking but not in depth, is also the reason for the merger of science and social studies subjects.

Science includes two elements, namely science and social, which means that this subject includes the relationship or interaction between living and non-living things in the universe, as well as the interaction between humans as individual beings and social beings and their environment (Oktariani et al., 2024). The material contained in the science subject is a combination of basic concepts from natural science and social science.

Compost is organic (natural) material that has undergone decomposition and is processed into natural fertilizer that is rich in nutrients so that it can be used to improve soil fertility (Ashari, 2024). Making compost is also an effort to reduce the amount of organic waste

in the environment. Science learning with composting is an implementation of an environmental learning approach carried out through exploration activities and direct practice. This learning approach is considered more meaningful because students will get real experience in the field related to environmental problems.

Technology in education provides various benefits, especially in terms of effectiveness and efficiency, and can also make it easier for students to understand the material and improve their skills (Suyuti et al., 2023). In addition, the use of technology during the learning process such as currently implementing the Merdeka Curriculum, can provide more motivation and understanding for students (Handayani et al., 2023). Technology can support the learning process in elementary schools, one of which is in the science subject (Menhard, 2024).

Learning media is an important factor in the learning process that functions as an intermediary in delivering material so that it can be accepted and understood by students so that the selection of media must be careful so that the desired learning objectives can be achieved (Wulandari et al., 2023). Of the several types of learning media as stated by Diana et al. (2022) namely concrete media, visual media, audio-visual media, natural environment, and multimedia media, the most popular with students is audio-visual media that can project images and sound (Rindawati et al., 2022).

Virtual Reality (VR) is a technology that allows users to interact in a digital world that resembles the real world (Wulandari et al., 2022). VR technology is a learning innovation that has the potential to increase student learning motivation which is expected to make learning more interesting and immersive, so that learning objectives can be achieved more effectively (Hartawan & Suryati, 2025). With the use of VR in science learning on composting material, students can witness every stage of composting, even though they do not do it directly. Of course, this will increase student understanding and involvement in learning because it feels more contextual and fun.

METODOLOGY

This type of research is research and development (Research and Development) which aims to produce a learning product in the form of a valid, practical, and effective Virtual Reality-based compost learning module to instill environmental awareness in elementary school students. The development model used is the ADDIE model, which consists of five main stages, namely Analysis, Design, Development, Implementation, and Evaluation (Anafi et al., 2021). Each stage in this model is carried out systematically to ensure the quality of the product being developed.

Analysis

At this stage, analysis or identification of problems and needs is carried out. The aim is to obtain information related to student needs and obstacles faced in the science learning process on the material regarding ecosystems and the role of living things in making compost. The information is obtained through observation activities, interviews, distributing questionnaires, and documentation.

Design

The design stage (design or planning) focuses on planning the design of a Virtual Reality-based compost module. In this study, the design was carried out using the MilleaLab platform. The activities carried out at the design stage include: 1) compiling a concept map of the learning flow using a Virtual Reality-based compost module, 2) preparing a module storyboard, 3) preparing a Virtual Reality media storyboard, and 4) making instruments.

Development

At the development stage, the designed product begins to be made. Researchers can integrate various elements if necessary. At the development stage, a validation process is carried out by three experts, namely teaching material experts, media experts, and material experts.

Validation by teaching material experts aims to assess aspects of the feasibility of the material, presentation, language and grammar, and visuals of the Virtual Reality media being developed. The validation instruments by teaching material experts are as follows.

Table 1. Validation Instrument by Teaching Materials Experts

Aspect	Indicator	Score
a) Material Eligibility	1. Materials are in accordance with learning achievements 2. Materials are in accordance with the level of student development	
b) Presentation	1. Presentation of interesting materials can foster environmental awareness and encourage students' curiosity 2. There are activities or exercises that actively involve students	
c) Language and Grammar	1. Sentences used are easy to understand and effective 2. Terms used are in accordance with the level of students	
d) Visual	1. Attractive visual design 2. The appearance of colors, letters, and layouts facilitate readability	

Next, there is validation by media experts who assess aspects of media completeness, media use in the learning process, media practicality, and media appearance. The validation instruments by media experts are as follows.

Tabel 2. Validation Instrument by Media Expert Aspect Indicator Score

Aspect	Indicator	Score
Completeness of Media	1. There is a media identity 2. There is a developer identity 3. There are instructions for use	
Media in the Learning Process	1. Media can be used in groups or individually 2. Media can increase student activity in the learning process	
Practicality of Media	1. Media makes it easy to understand the material 2. Media can be used easily 3. Media is safe to use 4. Durability of media that can be used for a relatively long time	
Appearance	1. Suitability of element selection 2. Attractive design 3. Clarity of content in expressing meaning	

Finally, there is validation by material experts whose aspects are the suitability of the content, the accuracy of the material content, and grammar. The validation instruments by material experts are as follows.

Tabel 3. Validation Instrument by Material Experts

Aspect	Indicator	Score
1) Content Suitability	1. Suitability of the material to learning outcomes 2. Suitability of the material to learning objectives	
2) Accuracy of Material Content	1. The content of the material is clear 2. The material presented is relevant to the media developed	

	3. Suitability of the images to the material
3) Grammar	1. Communicative language 2. The use of punctuation in the media is correct

The questionnaire assessment used in the validity test by the three experts as mentioned above, is calculated using the following formula so that the results obtained are more objective and measurable.

V = (sum of scores / sum of maximum scores) × 100%

With the following assessment criteria.

Tabel 4. Expert Validation Assessment Criteria

Interval	Criteria
81%-100%	Very Valid
61%-80%	Valid
41%-60%	Quite Valid
21%-40%	Less Valid
0%-20%	Not Valid

The instruments given to experts were made on a Likert scale with a score of 1-5. The use of a Likert scale can provide freedom to experts in assessing the media being developed.

Tabel 5. Assessment Score

Assessment Score	Category
1	Very Bad
2	Bad
3	Enough
4	Good
5	Very Good

The suggestions and input obtained from the media validation test are very important. The validation results obtained from the three experts in the form of suggestions and input are very useful for improving and perfecting the media being studied (Afifah et al., 2022).

Implementation

At this stage, limited trials (small classes) and extensive trials (large classes) were carried out on grade V students of SDIT Wildan Mukholladun. Limited trials (small classes) were carried out on 7 students which were then expanded into large class trials with 31 students. At the implementation stage, students were given the opportunity to use VR media and after that were directed to fill out a questionnaire. Filling out this questionnaire aims to determine students' responses to the use of VR media in learning. These responses will later be used to assess the practicality of the media. The assessment of media practicality is also based on teacher

responses to the development of Virtual Reality-based compost learning modules to instill environmental awareness in students.

The results of filling out the questionnaire are calculated using the following formula.

V = (sum of scores / maximum sum of scores) × 100%

Then analyzed using the criteria listed in the following table.

Tabel 6. Student and Teacher Response Assessment Criteria

Interval	Criteria
81%-100%	Very Good
61%-80%	Good
41%-60%	Quite Good
21%-40%	Bad
0%-20%	Very Bad

Evaluation

The fifth stage is evaluation which is conducted after limited trials and extensive trials have been completed. At this stage, the effectiveness of the media is measured by comparing the pretest and posttest scores of students in small and large classes.

In this study, the main focus is not only on the cognitive aspect, but also on the affective aspect in the form of environmental awareness. Therefore, the measurement of both aspects is carried out by giving pretests and posttests to students that have been designed based on five indicators based on the affective domain proposed by Bloom.

Tabel 7. Environmental Awareness Indicators

Environmental Awareness Indicator	Description	Question Number
Recognizing environmental issues	Students understand the impact of human behavior on the environment and the importance of preserving it.	3, 7, 10, 13, 18
Understanding the importance of preserving the environment	Students show concern and empathy for environmental conditions and living things.	1, 2, 4, 5, 6, 8, 9, 15, 19
Participating in environmental conservation activities	Students are involved in real activities such as planting trees, sorting waste, or saving energy.	12, 14, 16, 17
Reflecting on and evaluating the impact of behavior on the environment	Students are able to assess their own actions and understand their consequences for the environment.	11, 20

Then, the average results of the pretest and posttest were calculated using the N-Gain formula to determine the effectiveness of media use after being tested.

RESULT AND DISCUSSION

1. Analysis Stage

The environmental learning approach in elementary schools in accordance with the facts in the field shows that the learning methods and teaching media used are still conventional which often do not attract students' interest in learning and only follow the directions given by the teacher (Ningtyas & Pradikto, 2025), and have not been able to touch on aspects of students' understanding and awareness as a whole. At SDIT Wildan Mukholladun, the environmental learning approach related to composting material based on observation activities carried out, it was found that science learning on the material was still delivered in theory only through lecture methods and textbooks, without any direct practice activities by students. As a result, learning is less than optimal because composting material basically requires understanding that is obtained through direct experience. In addition, without practice, learning becomes less meaningful because students do not really understand the composting process in real terms.

Analysis was also carried out on the availability of supporting learning facilities and infrastructure. From the observations that have been made, it was found that the availability of technology, both in schools such as LCD projectors, and owned by students such as smartphones, is adequate. With this technology, it should be used to support more interactive learning and provide a more real experience, especially in material that involves composting steps. The integration of technology in learning that is most often found in schools is in the use of learning media. Therefore, it is necessary to develop digital learning media that can bridge the gap between limitations in direct practice and a more real learning experience for students.

Learning that is procedural or that involves systematic steps in it requires supporting media to make it easier for students to understand the material given. In accordance with this, the right media to develop is Virtual Reality (VR) media. In line with the opinion of Alfarizi & Yugopuspito (2020) which states that the use of Virtual Reality-based media in learning can be used to study procedural tasks, namely when students study a sequence or steps to complete tasks in three-dimensional space. This is a strong foundation that the use of Virtual Reality-based media needs to be developed to meet the need for learning media in the science subject of compost making.

2. Design Stage

The design stage is directed at producing a teaching module that allows students to actively explore the material through Virtual Reality-based media. The design was carried out

by utilizing the MilleaLab platform because it was deemed capable of presenting an immersive, visual, and interactive learning experience and can be easily accessed via smartphone. At the design stage, there are several activities carried out, namely: 1) compiling a concept map of the learning flow using a Virtual Reality-based compost module, 2) preparing a module storyboard, 3) preparing a Virtual Reality media storyboard, and 4) making instruments. These stages are further explained as follows.

Compiling a Concept Map

The initial stage is carried out by compiling a concept map, namely designing the learning flow in the module and the navigation flow of the Virtual Reality media. The concept map is compiled with the aim of ensuring that the development process runs smoothly without errors.

Preparing the Module Storyboard

The module storyboard is compiled using the PjBL (Problem Based Learning) syntax which can encourage students to actively investigate environmental problems, design solutions, and present their results collaboratively. The PjBL model is very suitable to be applied in the context of the Independent Curriculum which emphasizes experience-based learning that can develop critical and innovative thinking skills through giving students project assignments (Kemendikbudristek, 2022 in Usoh et al., 2024). In addition, PjBL was also chosen to prepare students to face challenges in the 21st century which emphasizes the development of critical thinking skills, problem solving, communication skills, and collaboration (Usoh et al., 2024).

In terms of material content, the topic chosen is "Decomposers" which refers to the Learning Outcomes (CP) of Phase C Science for Grade V in the chapter "Harmony in Ecosystems". This material includes the concept of decomposers, types of organic waste, the role of microorganisms in decomposition, and the practice of making compost as a solution to waste management. The material is very relevant to the context of students' daily lives and can build environmental awareness from an early age.

The teaching module "Understanding the Role of Decomposers for the Environment" is systematically structured and integrated with TPACK, 21st century skills (4C), and the values of the Pancasila Student Profile. The module also contains teaching materials that are arranged in accordance with the learning outcomes (CP) of the Independent Curriculum, especially in the dimensions of the environment and applied science, to encourage relevant and contextual learning. LKPD is also designed as a thinking aid that facilitates active student involvement in the problem-based learning process. Meanwhile, evaluation questions are designed to measure students' understanding of concepts, critical thinking skills, and environmental awareness.

Virtual Reality Media Storyboard Preparation

The main learning media used is Virtual Reality developed through the MilleaLab platform. MilleaLab is a 3D and Virtual Reality (VR) based platform specifically designed for educational purposes. Through this platform, students can experience a fun learning experience like playing, but can still understand the essence and learning materials well through their Android devices (Putri & Firmansyah, 2024).

Virtual Reality is used to visualize the waste decomposition process, recognize types of waste, and see the steps for making compost virtually. The use of Virtual Reality technology allows students to interact in a virtual environment or a computer-simulated environment, which means a computer simulation environment projected on VR media (Abdillah & Alinawati, 2018).

Through VR media, students can see and explore the learning environment that is displayed in three dimensions. With the use of Virtual Reality media, learning feels more real, interesting, and abstract material becomes real (concrete) so that it is easier to understand (Sukmawati et al., 2022). In addition, the use of VR in learning is in line with the TPACK (Technological Pedagogical Content Knowledge) framework which emphasizes the integration of content-related knowledge (Content Knowledge/CK), pedagogical knowledge (Pedagogical Knowledge/PK), and knowledge regarding the use of technology (Technological Knowledge/TK) which aims to improve learning effectiveness (Maulida & Mufidah, 2024).

Instrument Creation

The instruments used as measuring tools in this study include validation sheets by teaching material experts, media experts, and material experts, then student and teacher response questionnaire instruments, as well as pretest and posttest questions integrated with environmental awareness indicators. After obtaining the results from filling out the instrument, further analysis will be carried out through the data processing stage. This analysis can involve quantitative analysis (descriptive and inferential statistics) for validation data, practicality, and effectiveness (pretest-posttest), as well as qualitative analysis for response and observation data (Sugiyono, 2019).

3. Development Stage

In the development stage, a validation process is carried out by three experts, namely teaching material experts, media experts, and material experts. Validation by teaching material experts who assess the aspects of material feasibility, presentation, language and grammar, and visuals of the Virtual Reality media being developed. The results of validation by teaching material experts obtained a score (percentage) of 97.5% with the category "Very Valid" which means that the media can be used directly without revision. The results were obtained after

going through improvements from the validator's suggestions, namely that student involvement in activities using VR media still needs to be improved.

Meanwhile, validation by media experts assesses the aspects of media completeness, use of media in the learning process, practicality of the media, and media appearance. The results of validation by media experts obtained a score (percentage) of 98.3% which is in the category "Very Valid" which means that the media is suitable for use without the need for revision. This score was obtained after going through improvements according to the validator's suggestions stating that it is necessary to provide instructions for using VR media.

Finally, validation by material experts who assess the aspects of content suitability, accuracy of material content, and grammar. Validation from material experts obtained a score (percentage) of 97%, which is also in the "Very Valid" category, which means that the media is suitable for use without the need for revision. These results were obtained after going through improvements according to expert suggestions, namely that the clarity of the material needs to be improved.

After the validation results by three experts, namely teaching material experts, media experts, and material experts were obtained, the average calculation was carried out and the results were "Very Valid" in all validated aspects.

4. Implementation Stage

The implementation stage is carried out by applying the media directly in the field. At this stage, a limited trial (small class) and a wide trial (large class) were carried out on grade V students of SDIT Wildan Mukholladun. The trial aims to obtain student responses to the use of VR media in learning which will later be used to assess the practicality of the media.

Limited Trial (Small Class)

Based on the results of filling out the questionnaire in a limited trial involving 7 students, a score (percentage) of 77.1% was obtained with the "Good" category. The score can be interpreted that the media is already practical to use in learning, but needs improvement according to student comments stating that students are less enthusiastic about participating in learning because the availability of VR media is still limited, causing them to take turns and wait for each other when the media is used. In addition, there are students who state that the material presented in VR media is still difficult to understand because it is not equipped with instructions for use.

Meanwhile, based on the results of filling out the questionnaire in a limited trial conducted by the teacher, namely Mrs. Nova as the homeroom teacher for class V of SDIT Wildan Mukholladun, a score (percentage) of 100% was obtained which is in the "Very Good" category, meaning that the media is very practical to use in learning. Mrs. Nova also said, "VR-

based learning is basically very cool, innovative, and has an extraordinary impact on learning." This statement strengthens the assumption that the use of immersive VR media can create a fun and meaningful learning experience (Wulandari et al., 2025). Obtaining this perfect score can also be caused by the small number of media users making each of them able to try VR media more freely.

Wide Trial (Large Class)

Based on the results of filling out the questionnaire in a wide trial involving 31 students, a score (percentage) of 78.7% was obtained with the category "Good". This score can be interpreted that the media is considered practical to use in learning as indicated by several positive comments on the use of this VR media, such as VR media which is very fun for learning and playing, the media feels comfortable when used in learning, and learning becomes more exciting. This is in accordance with the opinion of Makransky & Lilleholt (2018) who stated that the use of Virtual Reality (VR) in science learning can increase student motivation and help understand concepts more deeply compared to conventional learning methods. However, considering that the practicality value is in the "Good" category, this VR media still needs improvement in terms of the clarity of the material content. In accordance with the opinion of Ulfah et al. (2021) that media that is very valid or very suitable for use is media that meets the observation points such as clear and easy-to-understand material. In addition, improvements were also made by adding instructions for using VR media. This is in accordance with the opinion of Sutrisno et al. (2020) which states that media included in learning devices must be accompanied by instructions for use. This aims to facilitate the application of the device for its users, both teachers and students, when learning takes place.

Meanwhile, the results of filling out the questionnaire by teachers in the extensive trial (large class) obtained a practicality value of 80%. This value is in the "Good" category, meaning that the media is practical to use, but still needs improvement according to the suggestion from Mrs. Nova who stated, "In our school it is still difficult to implement because of limited facilities and infrastructure." The limited media is also the cause of the lack of student involvement in learning because students have to take turns using it and there is limited time which means that not all students get their turn to try. In line with this, based on the opinion put forward by Wibowo et al. (2022), the lack of student involvement in learning causes students to not understand the material given so that students are less than optimal in learning the material.

Overall, the results of filling out the questionnaire show that the VR media developed has the potential to be used in science learning on a large scale. This is because VR media is able to attract students' attention and support understanding of the material on making compost. Although Virtual Reality media in learning science on composting material is considered

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practical, improvements in further development still need to be made. These improvements are expected to encourage increased effectiveness and better student learning experiences, in accordance with the principle of sustainable development in learning design (Sahabuddin, 2015).

5. Evaluation Stage

Evaluation of the effectiveness of the Virtual Reality-based teaching module was carried out by measuring student learning outcomes (pretest and posttest), as well as observing student involvement during the learning process. The use of pretest-posttest instruments is in line with the opinion of Hidayah et al. (2023) which states that this method is effective for measuring the influence of a learning model, in this case the PjBL (Project-based Learning) model, on students' cognitive understanding of decomposer and composting materials.

Limited Trial (Small Class)

In a limited trial (small class) involving 7 fifth grade students of SDIT Wildan Mukholladun, there was a significant increase in the average value as shown in Figure 1 below.

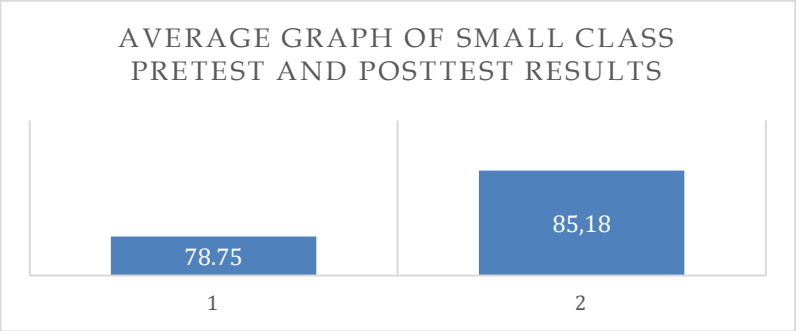

Figure 1. Graph of Small Class Pretest and Posttest Results

Based on the graph in Figure 1, the average pretest score (1) was 78.75 and increased to 85.18 in the posttest (2). This increase indicates an increase in students' cognitive understanding in small classes after using VR media.

Wide Trial (Large Class)

Meanwhile, in the wide trial (large class) involving 31 fifth grade students of SDIT Wildan Mukholladun, the results were obtained as in Figure 2 below.

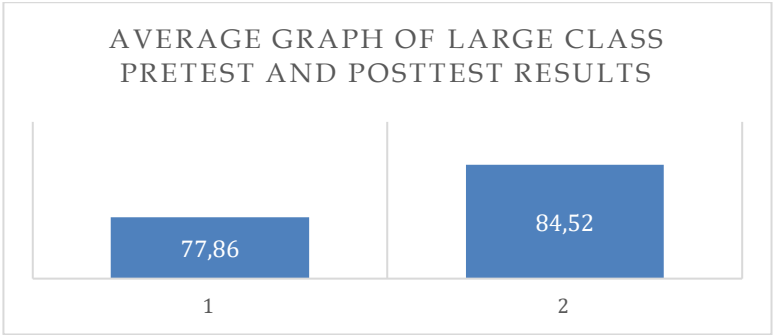

Figure 2. Graph of Large Class Pretest and Posttest Results

Based on the graph in Figure 2, the average pretest score (1) was 77.86 and increased to 84.52 in the posttest (2). These data indicate a consistent increase in cognitive understanding in large classes after conducting a trial of using VR media.

To determine the effectiveness of using the developed media, an effectiveness analysis needs to be carried out through the calculation of the N-Gain Score. Based on the results of the N-Gain Score calculation in small classes, a value of 0.303 was obtained and in large classes a value of 0.301 was obtained, both of which are in the Moderate Effectiveness category.

From these results, it can be interpreted that the media can help the student learning process, but not optimally. Improvements and refinements are expected, both in terms of the content presented and the approach used. Thus, the evaluation which is part of the basic components of this education system must be carried out systematically and in a planned manner so that learning objectives are achieved properly (Idrus, 2019).

Furthermore, the effectiveness of VR media is not only reflected in the increase in cognitive understanding, but is also seen from the affective domain of students. Based on observations of student behavior referring to Bloom's taxonomy of the affective domain, there are positive changes in attitudes in five indicators of environmental awareness, including: receiving, responding, valuing, organizing, and characterizing. For example, students take the issue of waste seriously, demonstrate a responsible attitude in group projects, and begin to display environmental care habits, such as sorting waste or creating slogans inviting students to maintain cleanliness.

By developing a Virtual Reality-based compost module in elementary school science learning, it is hoped that it can overcome the problem of the limitations of conventional learning methods that are theoretical and only focus on improving students' cognitive abilities. This is because the integration of technology in learning can make learning more meaningful, interactive, and enjoyable.

However, the implementation of this module still requires continuous improvement so that it can be used optimally and evenly in various educational units.

CONCLUSION

The developed Virtual Reality-based compost learning module has proven to be very valid, practical, and has a moderate effectiveness value. The designed modules and media are able to overcome the limitations of conventional learning by presenting immersive and contextual learning experiences. This innovation not only improves cognitive understanding, but also forms students' environmental awareness from an early age. The development of VR-

based modules should continue to be refined, both in terms of technical and pedagogical aspects, to ensure the sustainability and effectiveness of their use. Considering that not all schools have facilities such as VR media, there needs to be cooperation with related parties to support the availability of facilities so that they are evenly distributed across various educational units.

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