



Augmented Reality-Based Science Learning Design on Human Respiratory System for Elementary Students

Vina Siti Alifah¹, Eliya Rochmah^{2*}, Dewi Yulianawati³

^{1,2,3} Universitas Muhammadiyah Cirebon, INDONESIA

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ABSTRACT

The development of digital technology in the world of education is increasingly advancing. The rampant use of technology in learning encourages innovation in technology-based learning media. One of them is the use of augmented reality technology in learning IPAS material on the human respiratory system. This research uses descriptive qualitative methods. This research describes, analyzes, and provides an in-depth explanation regarding the design of IPAS learning on the human respiratory system material based on Augmented Reality in elementary schools. The location of this research was conducted at SD Negeri 1 Terusan with participants being class teachers and fifth-grade students. Data collection techniques were carried out through observation, interviews, and documentation. The results of the study indicate that learning planning includes the design of teaching modules by selecting appropriate learning media for the respiratory system material, namely augmented reality media that is integrated into the steps of the discovery learning model, resulting in an increase in conceptual understanding and clear visualization of the material. The renewal of this research is that in this study, the researcher integrates augmented reality media with the learning model used in the human respiratory system material in the fifth grade. Based on the research that has been conducted, it is necessary to design optimal learning so that learning runs well; in addition, the use of augmented reality media in the respiratory system material can facilitate students in understanding the concept of the material and create interactive learning that is in line with the times.

Keywords: Planning, Science, Augmented Reality, Human Respiratory System, Elementary School

INTRODUCTION

Science (IPAS) is one of the subjects included in the independent curriculum. The subject combines Natural Sciences and Social Sciences. It discusses living things, inanimate objects, and nature, as well as their interactions with human life and the environment [1]. The introduction of science (IPAS) in elementary schools aims to foster students' curiosity about events occurring around them and to foster their ability to interact with their environment as individuals and social beings. The implementation of science (IPAS) takes place in schools, where learning planning is necessary before implementing the learning process.

Natural sciences and social sciences learning certainly requires a learning plan so that the learning can be conveyed well. The learning plan is important to carry out before the learning is implemented because this learning plan serves as a guide for teachers when conducting learning in class. Learning design is a process that is prepared before carrying out learning, which includes preparing materials, selecting learning media, selecting teaching models and methods, as well as assessment techniques that will be applied at certain times so that learning objectives are achieved [2]. Learning design plays a crucial role in the learning process. This is because it serves as a guideline for teachers in classroom

instruction. This ensures effective and focused learning.

In implementing learning, it is necessary to design learning and select appropriate learning media according to the material to be presented so that students understand can be helpful. One of the learning designs is a teaching module. A teaching module is a learning design applied in learning that aims to achieve the specified objectives and competency standards [3]. If there is no planning in the learning process, such as not planning the creation of teaching modules, it is certain that the process of delivering learning to students will be less than optimal. Furthermore, if teaching modules are not well prepared, the learning process will be less engaging [4]. In addition to planning teaching modules as a learning plan, learning media are also needed to support the implementation of learning.

Implementing classroom learning requires supporting media, namely learning media. Learning media is a tool often used during the learning process to convey messages or information more clearly and achieve predetermined learning objectives. [5]. Over time, learning media has evolved. At the elementary school level, the application of technology-based learning media in science learning activities is important to introduce basic concepts to students who are still in the early stages of learning [6]. The use of technology-based learning media can visualize abstract objects in science material, one of which is the human respiratory system.

Implementing science learning on the human respiratory system in fifth grade requires media that can visualize the organs of the human respiratory system. Visualization and engagement in technology-based learning media help students understand, accept, and experience the material [6]. One of the media that can visualize objects from the human respiratory system is Augmented Reality (AR). The British Computer Society defines Augmented Reality (AR) as an integrated digital technology that enables users to blend real-world sensory experiences with perceptions of a digital environment. It combines human senses with virtual objects to enhance interaction with the physical world[7]. Augmented Reality is a technology-based media that is able to combine 2D and 3D virtual objects into the real world, so that both can be combined and create an integrated mixed environment and can be displayed directly in real-time [8].

Referring to the results of observations conducted in grade V of SD Negeri 1 Terusan in the process of learning science, especially the material of the human respiratory system, there is still less than optimal learning planning. This is evident from the results of observations of the implementation of learning in the classroom, the lack of use of learning media in delivering learning materials. In addition, the use of teaching modules only uses teaching modules that are already available without being developed. So the implementation of learning is less than optimal. In implementing learning material on the human respiratory system, which is abstract and cannot be seen directly, supporting media is needed. This requires teachers to design a learning plan that is not only in accordance with learning outcomes but also can provide clear understanding and visualization to students. Therefore, in this learning planning, an innovative plan is needed so that learning can be conveyed well. The lack of learning planning makes the process of learning science in the classroom less than optimal and interesting. So this will affect the interpretation students' understanding of the material. The selection of augmented reality media in learning design has begun to be implemented by several other researchers with good results.

In accordance with the research conducted [9] on the topic of designing learning media through augmented reality in introducing the human respiratory system to improve

learning outcomes, it shows that there is an increase in student learning outcomes after this planning is implemented. Related to the research [10] shows that augmented reality-based learning media in the human respiratory system material can improve student understanding. Research conducted by [11] shows that the application of augmented reality based learning media has the potential to increase the effectiveness and efficiency of the learning process. Although several studies have discussed learning planning using augmented reality, there is a gap with previous research, namely previous research focused more on developing augmented reality media and conducting trials without integrating it into the teaching module. While in this study, augmented reality learning media is integrated into the learning steps in the teaching module on the human respiratory system material.

This study aims to describe, provide explanations, and analyze the needs of teachers and students for media and teaching modules applied to the human respiratory system material in elementary schools, design a science teaching module that integrates technology in its learning steps, develop augmented reality media that is appropriate to the human respiratory system to support the learning process of students and analyze the impact of the application of Augmented Reality-based learning designs in science lessons on the human respiratory system material on student learning outcomes.

This research is important in the field of education because it offers an innovative and applicable learning solution by integrating augmented reality technology into the science learning design, specifically the abstract material on the human respiratory system that requires visualization for understanding. This allows students not only to understand the material visually and interactively but also to gain a new and memorable experience. Furthermore, this research supports technological transformation, conceptual understanding, and improved learning outcomes.

MATERIAL AND METHODS

Method

The method applied in this study is a descriptive qualitative approach to describe, analyze, and provide an in-depth explanation regarding the design of human respiratory system science learning based on Augmented Reality. Qualitative research is a research method that in its implementation focuses more on the results of natural and in-depth observations and understanding, which are then presented in the form of explanations and interpreted comprehensively [12]. This qualitative approach is used because it can provide flexibility in digging up in-depth data about the learning process [13]. This study was located at SD Negeri 1 Terusan, Sindang District, Indramayu Regency, West Java with research subjects being teachers and students in grade V and 39 students involved in the learning process. The research design is as follows:

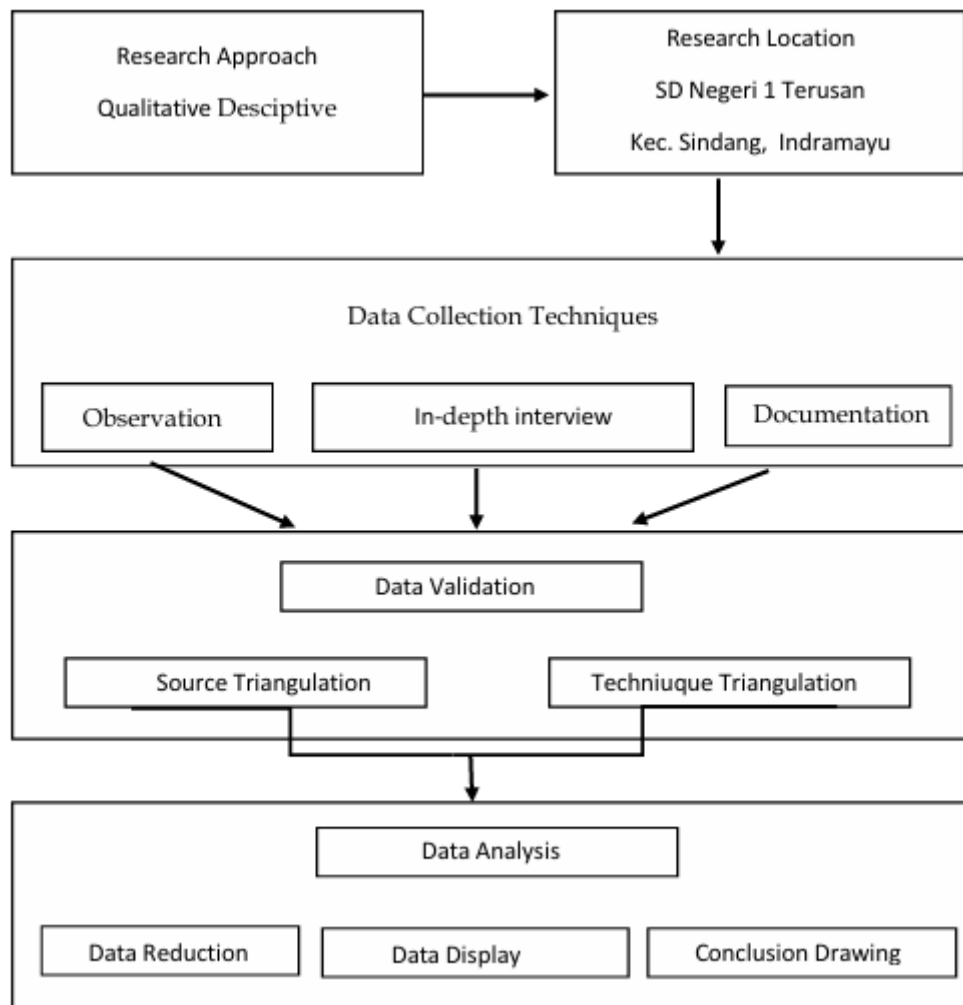


Figure 1. Research Flow Conducted

The research process was carried out through prior observation and interviews with class teachers, then documentation related to the design of the human respiratory system science learning, which was then continued with data validation using source triangulation and techniques. After the data was validated, it was continued with data analysis starting from data reduction, data presentation, and drawing conclusions.

Instrument

This study uses instruments, namely teaching module instruments, observation sheets, interviews and documentation. The teaching module instruments are used to see how science learning is planned on the human respiratory system material in grade V of SD Negeri 1 Terusan. Interviews were conducted by researchers with class teachers to obtain information about science learning planning on the human respiratory system material in grade V of SD Negeri 1 Terusan. Through the results of interviews carried out to obtain information related to learning design. Observation sheets were carried out to see directly how planning in schools was compiled and the implementation of the learning plans made. While documentation was carried out to collect visual evidence, find out the learning design and take pictures.

Procedure

Data collection techniques used observation, interviews, and documentation techniques. Observations were conducted by researchers to directly observe science learning planning in grade V, as well as observing learning activities in the classroom. Interviews were conducted with grade V teachers to obtain information related to science learning planning based on Augmented Reality. Meanwhile, documentation was used to collect images and visual evidence related to science learning planning based on Augmented Reality. To ensure the validity of the data, researchers used technical triangulation to compare the results of data obtained from interviews, observations, and documentation as well as source triangulation by comparing teacher data with student data.

Data Analysis

The implementation of this research uses observation, interview, and documentation data analysis techniques. The data analysis technique uses the Miles and Huberman interactive data analysis model which consists of three components, namely data reduction, presentation, and conclusion drawing [14]. Data reduction is carried out by selecting or selecting research data obtained that is relevant to what is being researched and data presentation is done in the form of a structured descriptive narrative while conclusion drawing is the final process of the analyzed data which is compared with data theories from various sources.

RESULTS AND DISCUSSION

Needs Analysis

The implementation of science learning in elementary schools, especially on the human respiratory system, requires learning planning with concrete and contextual supporting media to facilitate learning. students' understanding of material or concepts that are still abstract, such as the human respiratory system. Based on information from the homeroom teacher of grade V of SD Negeri 1 Terusan, it was found that in learning the human respiratory system, the material taught tends to be delivered verbally with the help of images from science books only without any other supporting media. This causes a lack of student visualization in the human respiratory system material. In fact, there are many digital and technology-based learning media that can visualize abstract material clearly. The use of visual media in learning can convey information or learning material in a real way, the use of visual media makes it easier for students to understand the material [15]. The use of digital or technology-based media is an alternative solution to create an active learning process , one of which is by utilizing gadgets or other technology [16].

In addition to the minimal use of learning media, the need for learning planning, such as module development, has also not been fully developed. Classroom learning often focuses on the teacher as the center of learning, also known as Teacher-Centered Learning (TCL). Teacher-Centered Learning is a one-way learning method, where students tend to be more involved in the learning process. listening to the teacher's presentation in class [17]. In the implementation of learning, the learning process is still carried out conventionally. This conventional learning process has an impact on students who are not given the opportunity to freely express their ideas because in the learning process, the teacher becomes more dominant in the learning process [18]. Therefore, learning planning requires optimal preparation to create maximum learning.

The lack of use of learning media is one factor contributing to low student learning outcomes. The continued lack of use of learning media that can visualize the human respiratory system in fifth grade is a problem that must be addressed. Based on these problems, this planning requires a solution that suits the learning needs. Such as the application of Augmented Reality technology based media called RespirAr. Augmented reality technology is a technology media that can be an option that can be used as a learning medium. In line with research [19], the use of augmented reality technology has great potential in the world of education because this technology is an extension of virtual reality that can combine virtual objects that are imposed on real-world objects. One of the augmented reality development media is RespirAr. RespirAr is a technology-based learning media that utilizes Augmented Reality technology that can display objects from the human respiratory system material, such as respiratory organs, in 2D and 3D forms that are presented visually. The purpose of this learning plan is to analyze how Augmented Reality-based science learning planning is made so that it can influence student learning outcomes through the use of RespirAr learning media. The use of RespirAr media can strengthen students' visualization abilities related to the material.

Designing Science Learning Based on Augmented Reality

This learning plan has several components, including the creation of teaching modules and learning media. In this study, planning was carried out to the maximum extent possible to support science learning on the human respiratory system using RespirAr learning media. The learning plan used in this study is described as follows:

1. Teaching Modules

Science learning planning on the human respiratory system material using Augmented Reality media called RespirAR was created to create interactive learning activities, can provide visualization of the material, and present memorable learning for students. The planning of this research implementation began with compiling a teaching module first. The preparation of this teaching module was adjusted to the applicable curriculum, namely the independent curriculum and learning materials in the classroom. The topics raised in this module came from the second semester material Chapter 5 for grade V, including the function of the respiratory organs, the respiratory process, and respiratory system disorders. This learning was carried out so that students could understand the material through the help of augmented reality media.

The preparation of this teaching module is based on the specified format. The development of this teaching module, in addition to aligning it with the learning materials and media, also aligns it with the assessment components for the teaching module validation. The components assessed range from the module's identity to the bibliography. The aspects assessed in the teaching module validation are as follows:

Table 1. Assessment Aspects of Teaching Module Validation

Aspect	Indicator	Item number
Module Author Identity	Consisting of the name of the compiler, year, institution, school level, class level, and time allocation.	1
Initial competencies	In the form of student knowledge and skills	2
Pancasila student profile	Has 6 elements of the Pancasila student profile	3
Facilities and infrastructure	Have tools and teaching materials in learning activities	4
Student targets	Have several target learners	5
Learning model	There is a learning model component in implementing learning	6
Selection of teaching materials	Suitability of learning objectives with student characteristics	7

Aspect	Indicator	Item number
Selection of learning resources/media	In accordance with the objectives, materials and characteristics of students	8
Learning objectives	Conformity with the learning process and results expected to be achieved and does not give rise to multiple interpretations and contains learning outcome behavior.	9
Assessment	Learning achievement is in accordance with learning objectives. Consisting of diagnostic, formative, and summative assessments.	10
Meaningful understanding	Conformity of information about the benefits that students will receive	11
Starting question	The suitability of questions to learning objectives and fostering students' curiosity	12
Clarity of learning scenarios (Steps in learning activities, initial learning activities: beginning, core, and closing)	The steps in learning according to the model used and according to the planned duration include 3 stages, namely introduction, core and closing based on interactive learning methods.	13
Details of the learning scenario (at each step the time allocation and model are reflected)	The use of syntax is in accordance with the model used, namely discovery learning.	14
Student reflection	The appropriateness of providing feedback to achieve learning objectives	15
Completeness of assessment (Questions, answer keys, and scoring)	The learning plan is very comprehensive in its instruments, including diagnostic, formative, and attitude assessments. It includes answer keys, assessment guidelines, and student worksheet (LKPD) attachments.	16
Student Worksheet	Have LKPD that is appropriate to the learning model used for students to work on during the learning process.	17
Teaching materials	Have teaching materials used by teachers	18
Glossary	Terms in the field alphabetically with their definitions and meanings	19
Bibliography	The sources used are relevant	20

The validation assessment of the teaching module uses a scale of 1-4. Based on the results of the validation of the teaching module that has been validated by two validators, it was found that the results of the first validator of 20 components of the teaching module had 15 components that obtained a score of 4 while the other 5 components received a score of 3. This is because it is still slightly less in accordance with the teaching module created. The results of the second validator found 18 components that obtained a score of 4 and 2 components that received a score of 3. One of the components that received a score of 4 is related to the selection of learning media. The learning media chosen is in accordance with the learning objectives and learning materials on the human respiratory system in grade V. The learning media used in this learning is *RespirAr*. From this validation, the researcher obtained the following validation results.

Table 2. Recapitulation of teaching module validation results

Description	Validator 1	Validator 2
Number of aspects assessed	20	20
Maximum score	80	80
Total score obtained	75	78
Presentation category	93%	97%
	Very worthy	Very worthy

The module eligibility criteria according to [20] as follows:

Table 3. Eligibility criteria for teaching modules

Presentation	Criteria
81%-100%	Very worthy
61%-80%	Worthy
60%-41%	Quite decent
40%-21%	Not feasible
20%-10%	Totally unworthy

Based on the validation results, the percentage obtained was 93% and 97% if referring to the eligibility criteria for the teaching module, it is in the very feasible category. In preparing learning plans such as this teaching module, not only do you determine the learning media but you also need to adjust the learning model so that it can be integrated with technology-based learning media.

Discovery Learning learning model is the learning model chosen in this planning. The Discovery Learning learning model is a learning model that in its learning requires students to be actively involved and think critically in the learning process through activities to find and investigate solutions to a problem, so that the knowledge gained by students becomes more meaningful and embedded [21]. This model was chosen because in its implementation, this learning model shows more of the application of Augmented Reality (RespirAr) media in the learning process. In its implementation, students search for information independently through RespirAr media and science books. The choice of this model makes the use of Augmented Reality (RespirAr) media more prominent in the core learning activities.

The learning implementation plan in this teaching module consists of three activities: preliminary activities, core activities, and closing activities. The preliminary activities begin by preparing students in a conducive environment for learning, starting with prayers, taking attendance, singing national songs, asking trigger questions, and providing learning motivation appropriate to the material being taught.

The core activities are planned by following the syntax of the Discovery Learning model, namely the stimulus stage, the problem identification stage (Problem Statement), the data collection stage (Data Collecting), the data processing stage (Data Processing), the proof stage (Verification) and the conclusion drawing stage (Generalization) [22]. Meanwhile, in the final activity, namely the closing activity, learning planning is carried out by planning closing activities such as concluding the learning, reflection and follow-up.

2. Augmented Reality Learning Media (RespirAr)

RespirAr is an Augmented Reality (AR) technology-based learning media that can display the organs of the human respiratory system in 2D or 3D, so that they can be displayed as if they were in the real world. Planning for the creation of this *RespirAr media* was carried out through several steps. The first step in creating this *RespirAr media* was creating a flashcard design that would be used as a marker for the barcode later. Then continued with creating a visualization of the human respiratory system with the help of the educational website *Assemblr Edu*. On this website, start composing the respiratory system objects to be displayed which are then adjusted to the desired size using the features available on the website. After everything is arranged, download the barcode which is then copied to the flashcard design in Canva. The next stage is to test the barcode created to be able to see the appearance of the human respiratory system organ objects. The description of the creation of *RespirAr media* is as follows:



Figure 2. RespirAr Media (Respiratory System Augmented Reality)

Through the use of RespirAr technology-based learning media, visualization of the respiratory system organs can be made clearer. This eliminates the need for abstract images for students. Therefore, RespirAr media can be applied in learning. Science and Natural Sciences (IPAS) on the human respiratory system. The media used is an Augmented Reality (AR) application that can display 3D objects from marker images, which, when scanned by a device's camera, will display models of human organs. In addition to preparing teaching module plans and learning media, teachers also need to prepare Student Worksheets (LKS) and learning evaluation questions.

Implementation of Augmented Reality Media (RespirAr) in learning

Based on the results of observations that have been carried out in grade V of SD Negeri 1 Terusan in the use of augmented reality media in learning science on the human respiratory system shows positive results. In the implementation of augmented reality media learning with the name RespirAr, it makes it easier for students to understand the image of the shape of the human respiratory organs that is presented clearly. The use of this media in learning is adjusted through the learning steps in the learning design in the teaching module that has been made. Technically, the learning process by integrating augmented reality technology with the steps of this teaching module occurs at the core activity stage, the use of Augmented Reality media begins to be used at the data collection stage. In the planning of the teaching module in the third and fourth stages, namely data collection and data processing, students are given the freedom to explore the material on the human respiratory system using Augmented Reality media according to the learning plan. The use of augmented reality media in this learning is done by dividing groups of students and distributing augmented reality flashcards (RespirAr) which are then scanned through Google Lens so that the scanned results from the flashcards can appear as if they are in the real world.

The observation results also show that the implementation of augmented reality media in the design of the human respiratory system science learning shows the active involvement of students. Students take turns in groups trying the respirAr media. The results of teacher and student interviews found that the learning design that integrates the use of augmented reality media in the human respiratory system material in this science learning helps students understand the human respiratory system material. The visualization of this augmented reality media provides clarity to students regarding the

shape of the human respiratory system organs which are no longer presented abstractly. The activity and involvement of students in using this augmented reality media has increased from before.

Obstacles and Solutions in Planning Augmented Reality-Based Science Learning on the Human Respiratory System

Even though learning planning has been implemented optimally and adapted to learning needs and learning materials, in its implementation Obstacles found The obstacle that occurred in the implementation of Augmented Reality-based science learning planning on the human respiratory system material was the lack of digital devices used in class. There was no agreement in the class to bring smartphones if needed for certain learning. So in planning the use of Augmented Reality media, students took turns in using Augmented Reality media. There was still minimal integration of technology in classroom learning. Lack of socialization or introduction of technology-based learning media. So learning only used books, concrete objects, and the surrounding environment. In addition to the lack of digital devices, in planning learning modules, another obstacle was found, namely that teaching modules were still rarely developed.

To address these challenges, an alternative solution was found, namely establishing a class agreement with the homeroom teacher and parents regarding the use of smartphones in class. This will facilitate teachers if learning requires technology such as smartphones. Regarding the lack of socialization or introduction of learning media to teachers, a solution can be implemented by conducting socialization of technology-based learning media. Meanwhile, regarding teaching modules, further development of existing teaching modules or learning plans must be adapted to the conditions and needs of students in learning so that teaching modules or learning plans become more innovative.

Discussion

With the development of the times, technology in learning has developed according to the times. So that learning is no longer done conventionally. Therefore, it is necessary to design and develop innovative learning to meet learning needs that are in accordance with the demands of its development. In line with research [23], a teacher or educator must be skilled in designing and developing learning according to the times in order to achieve learning outcomes that are appropriate to the times. Before implementing learning, learning design is necessary first. One of the needs analysis in learning design is the selection of learning media that are appropriate to the conditions and learning materials. In this digital era, the use of technology-based learning media in learning sciences, especially the human respiratory system, requires learning media that can visualize the material. The selection of technology-based media must be adjusted to the learning process. This is reinforced by research [24] that academics must be able to integrate and select effective technology that can be implemented during learning. In addition to the learning design in determining technology-based media, the integration of technology-based media with the learning model used is also important to consider. Augmented reality media is one media that can be integrated into the learning model. This is in line with the finding [24] that the implementation of augmented reality media can be integrated into learning models and other learning tools.

Based on the results of research related to the planning of learning of science material based on Augmented Reality on the material of the human respiratory system in class V of SD Negeri 1 Terusan, the results showed that before carrying out science learning on

the material of the human respiratory system, a learning plan was first made. The learning plan has urgency in learning activities. This is because learning design serves as a guideline for teachers in implementing learning in the classroom. This is reinforced by research [25] Without thorough learning planning, success in the learning process is difficult to achieve, so it will not be able to shape individuals who have the ability to be true learners. The learning planning process before the learning activities begin has begun to be well designed. This is evident in the selection of learning media that has begun to be adapted to the material on the human respiratory system, which requires clear visualization in recognizing the organs of the human respiratory system. Research [26] emphasizes that visualization of biology material using digital media is expected to facilitate students' understanding of the material.

In addition to selecting appropriate learning media, these media must be integrated with the learning model chosen in the lesson planning and module development. Research has found that teachers combine discovery learning with technology-based learning media in their planning. This is because using discovery learning in module development allows students to be more engaged in the use of augmented reality media in the human respiratory system science topic. This is in line with research findings [26]. The discovery learning process in augmented reality media aligns with the learning process, from providing stimulus, identifying problems, collecting data, managing data, verifying, and drawing conclusions. The selection and use of appropriate learning models and media can play a role in increasing student interest in the learning process, while also having a positive impact on the achievement of learning outcomes [28].

The successful implementation of the learning design using augmented media as a learning medium in learning can improve students' understanding of the human respiratory system material in grade V of SD Negeri 1 Terusan. In addition, the use of augmented reality media helps students visualize the human respiratory system material so that the objects of respiratory organs and human respiratory mechanisms are no longer presented only through books. In line with research, [29] increasing students' conceptual understanding in science learning in elementary schools can be improved through the use of augmented reality media so that it will have an impact on student learning outcomes. The Augmented Reality-based science learning design in the human respiratory system material is one of the innovative solutions through the use of augmented reality technology as a learning medium. So that in the learning process, students gain an interesting learning experience. In addition to gaining learning experience, student involvement in learning becomes more interactive as found in research [13] that learning through the use of augmented reality can show a positive impact on student motivation and involvement. This is supported by research [30] integrating technology in the learning process can provide a means to improve learning and student participation in class.

The success of the learning design is not without challenges or obstacles encountered during its implementation. Several obstacles remain, such as the limited use of digital devices like smartphones because students are not allowed to bring them. Furthermore, there is a lack of training for teachers on technology-based learning media, resulting in most teachers relying solely on textbooks without further development. Therefore, outreach or workshops on technology-based learning media are needed to create interactive learning. This aligns with research theory [31] that teachers need to improve their competency in actively utilizing digital media to support interactive and engaging learning processes.

Based on the discussion, it can be concluded that the design science learning Augmented reality-based learning on human respiratory system material in elementary schools, by combining discovery learning models and Augmented Reality technology-based media, is able to provide clear visualization to students related to human respiratory objects and can increase students' understanding of the human respiratory system material in grade V. The learning design using augmented reality media creates interactive learning and provides new experiences for students. The existence of a maximum learning design can create a quality learning process.

CONCLUSION

Classroom learning will be more optimal if lesson planning is carried out beforehand. Learning planning plays a crucial role before implementing the learning process in the classroom. The process of implementing science learning will be more interesting and enjoyable if the learning design and media are selected according to the material being taught and prepared in advance. If the lesson plan is optimally prepared, student understanding will improve. In this regard, teachers are required to be more creative and innovative in designing lesson plans that align with the material, supported by the selection of appropriate and suitable learning models, approaches, and media to facilitate student understanding and will impact their learning outcomes.

The results of the Augmented Reality (AR)-based science learning design on the human respiratory system have significant implications for teachers, curriculum developers, and other researchers. For teachers, the use of AR can help present material in a more engaging, interactive, and easily understood manner for students, as well as encourage teachers to improve their competency in using learning technology. For curriculum developers, these findings demonstrate the importance of integrating AR-based learning media into the elementary school science curriculum, including adjustments in the development of guidelines, teacher training, and learning evaluations that are relevant to technological developments. Meanwhile, for other researchers, this study can serve as a starting point for developing similar media on different materials or educational levels, as well as further examining the effect of AR use on other aspects such as learning motivation or learning outcomes.

This research is still limited in the design stage of augmented reality-based learning media in science learning on the human respiratory system. Therefore, the researcher recommends that further research can be conducted with a focus on testing the effectiveness of augmented reality media on improving learning outcomes, learning motivation, or student engagement in the learning process. In addition, other researchers can develop similar media such as the digestive system, the water cycle, or others and can expand its implementation to different levels of education. Further research can also examine technical and pedagogical aspects such as ease of use of augmented reality media, teacher readiness, and the integration of augmented reality media with other learning models.

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