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The Effect of the SrVER Learning Model Assisted by Augmented Reality Media on Biology Learning Outcomes

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Abstract: Effective biology learning requires various components to enhance learning, including implementing appropriate learning models and media. This study examines the effect of the SrVER learning model assisted by augmented reality (AR) media on the biology learning outcomes of 10th-grade students at SMAN 2 Mataram. This research employs a quantitative approach using a quasi-experimental method with a non-equivalent control group design. The study population consists of 13 10th-grade classes at SMAN 2 Mataram, from which four classes were selected as the research sample using purposive sampling. Data was collected through questionnaires and student learning outcome tests. The data analysis techniques used in this study include the N-Gain statistical test and the Mann-Whitney test. The results show that the experimental class achieved an N-Gain score of 0.4 (moderate), while the control class obtained an N-Gain score of 0.2 (low). Furthermore, the Mann-Whitney test yielded an Asymp. Sig (2-tailed) value of 0.001, which is less than 0.05, indicating a significant difference between the post-test scores of the control and experimental classes. These findings confirm that implementing the SrVER learning model assisted by augmented reality media can significantly improve the biology learning outcomes of 10th-grade students.

Keywords: Augmented Reality; Learning Models; Learning Outcomes; SrVER.

Introduction

Biology is the study of living organisms and their environments, and it is important to learn at the high school level as it helps shape students' understanding of life and their environmental awareness. However, not all aspects of biology are concrete and easy to observe; some concepts are abstract and difficult to visualize directly [1]. Based on this, there are several challenges in biology learning, including students' limited understanding of abstract concepts, low interest in learning, and limited availability of learning media. Certain topics in biology, such as genetics, evolution, and cell-level processes, are abstract and challenging to understand without the support of appropriate learning media and teaching models. As a result, many students face difficulties in gaining a deep understanding of the material. Direct experiences in biology learning are essential so students can develop various process skills, enabling them to explore the natural world [2]. Biology instruction requires various components to support the learning process, such as the application of teaching models and learning media. The teaching models and media used in biology instruction must be carefully considered. Teaching models should align with the material, student conditions, available resources, and the media used [3]. Learning media in teaching activities can enhance student motivation, interest, and understanding of the material, thereby improving learning outcomes [4].

A preliminary study conducted at a public high school in Mataram in 2024 revealed that while students' learning outcomes were relatively high, they were not optimal. Specifically, regarding viruses and their roles, 61.5% of biology teachers relied solely on PowerPoint presentations, 46.2% used lecture-based methods, 15.4% incorporated videos, and only 7.7% facilitated direct observations. Additionally, student responses indicated that 46.2% found the topic of viruses complex, making direct observation challenging, while 30.8% struggled to connect theoretical concepts with real-world applications. These difficulties were primarily due to the continued use of conventional teaching methods and a lack of interactive learning media. Implementing an effective learning model is one possible solution to enhance student learning outcomes [5].

A learning model is a framework for designing curricula, structuring learning materials, and guiding classroom instruction. It is a structured sequence of processes that provides a reference for planning learning activities [6]. Teachers typically choose learning models based on the subject matter being taught. The applied learning model should be able to create a learning process that focuses on students, encouraging dynamic interactions between students and teachers [7]. One recently developed learning model that can be applied is the SrVER learning model. This model emphasizes students' visual learning styles and consists of four stages: Screening, Visualization, Elaboration, and Reflection [8]. The effectiveness of a learning model can be further enhanced by integrating instructional media to optimize the learning process [9].

Instructional media serve as learning resources that help teachers facilitate students' understanding and broaden their knowledge [10]. Instructional media also aims to create an interactive, engaging, and suitable learning experience for students [11]. One type of instructional

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media that can be used in learning is Augmented Reality (AR)-based media. Augmented Reality is a technology that combines real-world environments with virtual objects in real-time [12]. AR-based learning media can support learning and help teachers create engaging and innovative teaching methods, fostering an interactive, stimulating, and creative learning environment [13]. AR media allows students to visualize complex processes, making it easier to grasp difficult concepts. Thus, AR proves to be an effective tool for integration into learning [14-15].

The SrVER learning model is a newly developed instructional approach, and no prior research has been conducted on its implementation in schools. Since SrVER emphasizes visual learning, its application requires instructional media capable of providing high-quality visual representations. Augmented Reality has been integrated into various learning models, such as guided inquiry [16], project-based learning [17], problem-based learning [18-19], and discovery learning [20-21]. However, no studies have explored its integration with the SrVER model. Implementing the SrVER learning model integrated with augmented reality (AR) can help students engage directly with the material through realistic simulations and visual exploration, making abstract concepts in biology easier to understand and apply in real-world contexts. This approach can encourage students to think conceptually, enhance their representation and perception skills, and ultimately improve learning outcomes [16,22]. Based on this background, this study aims to investigate The Effect of the SrVER Learning Model Assisted by Augmented Reality (AR) Media on Biology Learning Outcomes on the Topic of Viruses Among 10th-grade Students at SMAN 2 Mataram.

Research Methods

This study employs a quantitative approach using a quasi-experimental research method. The population consists of all 10th-grade science students at SMAN 2 Mataram, comprising 13 classes. The sample was selected using purposive sampling, a technique in which participants are chosen based on specific considerations [23]. The selection criteria included similar characteristics in terms of learning outcomes, student engagement, and attitudes. Based on these criteria, four classes were chosen as the research sample.

The research design used in this study is the non-equivalent control group design, which involves two groups: an experimental group that received instruction using the SrVER learning model assisted by augmented reality (AR) media) and a control group that received instruction using the conventional learning model. Both groups were given a pre-test, consisting of multiple-choice questions on viruses and their roles, to assess students' cognitive learning outcomes before the intervention. After the treatment, both groups were administered a post-test using the same multiple-choice questions as the pre-test.

Data collection techniques included distributing questionnaires and conducting learning outcome tests, with 25 validated multiple-choice questions administered to students. The research instruments used in this study included learning outcome tests and teaching modules. Before being utilized, the test instruments underwent validity and reliability testing to ensure the questions could accurately and consistently measure the intended aspects. In addition to statistical validity tests, these instruments were also validated by subject matter experts to ensure that the content of the questions was aligned with the basic competencies and learning indicators that had been established, as well as having an appropriate level of difficulty and structure. The expert validation process involved an assessment of the content, language, and relevance of the material to ensure that the questions could accurately assess students' competencies. The results of both types of validation indicated that the test instruments were of high quality and suitable for use in the study.

Before being used in the research, instructional design experts first validated the teaching modules to ensure that the material presented was in line with the curriculum, learning objectives, and students' needs. This validation included an assessment of the content relevance, presentation structure, and the suitability of using the modules in the classroom context. Therefore, the validated teaching modules are expected to provide optimal support for the learning process and play a significant role in data collection for research.

Data analysis was performed using the N-Gain test to measure the extent of students' learning improvement. Additionally, hypothesis testing was conducted using the Mann-Whitney test, with prerequisite tests, including homogeneity and normality tests, carried out using IBM SPSS Statistics 25. The criteria for assessing N-Gain scores are presented in Table 1 [24].

Table 1. N-Gain Score Categories

N-Gain Score (g)	Category
$g > 0.7$	High
$0.3 \le g \le 0.7$	Moderate
$g < 0.3$	Low

Results and Discussion

As measured through the pre-test and post-test, the student learning outcomes in both the control and experimental classes indicate a noticeable difference. Based on the N-Gain calculation, the experimental class demonstrated a greater improvement than the control class, as shown in Table 2 below.

Table 2. Pre-test and Post-test Results of Control and Experimental Classes

Class	Average Score		N-Gain	Category
	Pre-test	Post-test		
Control Class	37.9	54.5	0.2	Low
Experiment Class	43.8	66.8	0.4	Moderate

Based on Table 2, there is a difference in the average pre-test and post-test scores between the control and experimental classes. The control class had an average pre-test score of 37.9, which increased to 54.5 in the post-test. Meanwhile, the experimental class had an average pre-test score of 43.8, which increased to 66.82 in the post-test. The N-Gain calculation showed that the control class obtained an N-Gain score of 0.2, categorized as low, while the experimental class achieved an N-Gain score of 0.4, categorized as moderate. The improvement in scores in the experimental class was influenced by the implementation of the SrVER learning model supported by augmented reality (AR). The use of AR in learning significantly helped students observe objects and provided realistic representations of the topics being studied, making it easier for them to understand abstract concepts. Furthermore, AR made the learning experience more interactive, engaging, contextual, and meaningful.

After obtaining the N-Gain results, data analysis was conducted using the Mann-Whitney test, with normality and homogeneity tests as prerequisites. The Shapiro-Wilk normality test was performed using SPSS to assess data normality. If the significance value is less than or equal to 0.05 (sig. ≤ 0.05), the sample data is not normally distributed. Conversely, if the significance value is greater than 0.05 (sig. ≥ 0.05), the sample data is normally distributed. The results of the homogeneity test are presented in Table 3 below.

Table 3. Normality Test

Class	Shapiro-Wilk			Description
	Statistic	Df	Sig.	
Experimental Pre-test	.971	80	.070	Normal
Experimental Post-test	.925	80	.000	Not Normal
Control Pre-test	.964	80	.023	Not Normal
Control Post-test	.964	80	.022	Not Normal

Based on the results of the normality test for the pre-test and post-test scores in both the control and experimental classes, only one dataset was found to be normally distributed—the pre-test scores of the experimental class, with a significance value of 0.70 > 0.05. Meanwhile, the other three datasets—the pre-test and post-test scores of the control class and the post-test scores of the experimental class—had significance values less than 0.05, indicating that the data were not normally distributed.

The homogeneity test is used to interpret data variation in a study [25]. Data is considered homogeneous if the significance value is greater than 0.05 (sig. > 0.05). Conversely, if the significance value is less than 0.05 (sig. < 0.05), the data variation is considered non-homogeneous. The results of the homogeneity test are shown in Table 4 below.

Table 4. Homogeneity Test

	Levene statistic	df1	df2	Sig.
Based on Mean	2.810	1	158	.096

The homogeneity test results for the post-test scores showed a significant value of 0.096 > 0.05, indicating that the data is homogeneous. However, despite the data being homogeneous, the normality test revealed that some datasets were not normally distributed, requiring the use of non-parametric analysis. The Mann-Whitney test, a non-parametric statistical test, was used as an alternative to the independent sample t-test when the data did not follow a normal distribution. This test aims to determine differences between two independent groups. The results of the Mann-Whitney test are presented in Table 5 below.

Table 5. Hypothesis Test Results

Mann- Whitney U	2263.500
Wilcoxon W	5503.500
Z	-3.198
Asymp. Sig. (2-tailed)	.001

Based on the results of the Mann-Whitney hypothesis test for students' post-test scores, an Asymp. Sig (2-tailed) value of 0.001 (< 0.05) was obtained. This indicates that Ha is accepted, meaning that the SrVER learning model assisted by augmented reality media has a significant effect on students' learning outcomes in the virus and its role topic for Grade X students at SMAN 2 Mataram.

The research findings indicate a significant difference between the control and experimental classes, with the experimental class demonstrating greater improvement. This increase in performance is influenced by the implementation of the SrVER learning model, which emphasizes a visual learning style. Visual learning focuses on students' ability to process information through visual representations [26]. Additionally, the integration of augmented reality (AR) as a learning medium further contributed to the improvement in students' learning outcomes. The SrVER learning model consists of four stages: screening, visualization, elaboration, and reflection.

Screening is the process of assessing or diagnosing students' abilities to identify their prior knowledge of the learning material and ensure an appropriate learning level, preventing gaps between existing and new knowledge. In this stage, students are given questions related to the material they will study using Mentimeter, a tool that displays their responses in the form of mind maps, polls, and multiple-choice questions. This allows teachers to evaluate students' prior knowledge and create a more engaging learning experience. The Screening stage is similar to a diagnostic test conducted at the beginning of a lesson. Implementing initial identification in learning helps teachers assess students' understanding of the material, identify topics that may be challenging for them, and facilitate the formation of heterogeneous learning groups. This approach ensures a more interactive and enjoyable learning process while minimizing gaps in group learning [27].

Visualization is a method used to make abstract concepts more concrete, allowing for better comprehension [28]. At this stage, students are provided with instructional videos related to the subject matter. Augmented reality (AR) is used to help students visualize the objects being studied, such as the structure of viruses, their characteristics, and other relevant details, in a 3D format. Furthermore, AR technology enables students to gain a deeper understanding of the objects they are studying, explore the presented data, and transform abstract information into tangible concepts. This allows students to clearly explain the objects they have learned. This is consistent with a study conducted [29], which highlights that visualization serves as a tool that facilitates rapid understanding and exploration of data. The use of augmented reality at this stage significantly enhances the learning process. Implementing augmented reality as an educational tool supports students' learning processes while also helping teachers develop engaging and innovative teaching methods, ultimately creating a more interactive, engaging, and creative learning environment [13]. The integration of AR facilitates students' understanding of the material and fosters their independence in learning [30].

Elaboration is a collaborative learning activity in which students work together to solve problems presented in Student Worksheets. This stage aims to enhance students' communication and collaboration skills by encouraging them to discuss and analyze case studies within their groups. Through these discussions, students can find solutions, develop a deeper understanding of the material, and provide more detailed explanations. Elaboration involves expanding learning material from a general overview to a more detailed explanation, making the learning experience more meaningful and engaging [31]. By implementing this stage, students can better comprehend and master the subject matter, ultimately leading to improved learning outcomes. This aligns with the research conducted [32], which demonstrated that students' learning outcomes improved significantly through the application of the elaboration learning model. This method provides students with opportunities to exchange ideas, collaborate, and interact within their study groups, fostering a deeper understanding and mastery of the material.

Reflection is a process in which students evaluate their learning experiences and assess their abilities. The goal is to develop reflective thinking skills, enabling them to recognize what they have learned and what they still need to improve upon. Reflection helps measure students' knowledge and achievements in understanding the material after engaging in the learning process and conducting discovery activities [33]. During this stage, teachers pose questions related to the lesson using the Mentimeter platform, where students' responses are displayed on a screen in the form of mind maps and polls. This visual representation helps teachers assess and evaluate students' understanding of the material. Reflection allows students to identify challenges in their learning process and motivates them to review and reinforce their knowledge, ultimately improving their learning outcomes. This aligns with research conducted [34], reflection activities in the learning process enhance students' cognitive learning outcomes. The reflection method improves material retention, comprehension, and motivation in learning. Additionally, reflection strategies enhance students' creative thinking skills [35]. Furthermore, students gain greater confidence, particularly in expressing opinions and responding to questions. The reflection stage provides a comprehensive overview of what students have learned, helping them consolidate their knowledge effectively.

The use of AR in the SrVER learning model has a significant impact on improving students' learning outcomes. SrVER, as a learning model that integrates visualization technology, enables students to engage in a deeper and more meaningful learning process. This is because, during the visualization stage, students use AR media to observe objects more realistically, obtain three-dimensional visualizations, and concretize abstract concepts, allowing them to understand the concepts and theories being studied more effectively. The use of AR also makes students more actively involved in learning, as they can interact directly with virtual objects by rotating, enlarging, or exploring specific parts. This approach encourages students to become more explorative and independent in seeking information and solving problems. As a result, students not only passively receive information but also develop higher-level skills and competencies [36].

The use of AR media in learning significantly helps students visualize abstract concepts, particularly when understanding the structure of complex objects [14]. Additionally, AR can increase students' interest in learning by presenting material in a more engaging and innovative way. This interactive and meaningful learning approach helps students become more focused, enthusiastic, and motivated to actively participate in discussions and practical activities. The increased interest in learning, along with a better understanding of the material, positively impacts students' learning outcomes. Students who feel engaged and confident during the learning process are more likely to be self-motivated in their studies. This is consistent with [37], the use of AR can improve students' attention, confidence, and satisfaction during the learning process, ultimately contributing to better learning outcomes.

Conclusion

The implementation of the SrVER learning model, supported by augmented reality media, has been proven to significantly impact on the biology learning outcomes of Grade X students at SMAN 2 Mataram, particularly on the topic of viruses and their roles. This is evidenced by the Asymp. Sign (2-tailed) value of $0.001 < 0.05$, indicating a statistically significant effect. Additionally, this finding is supported by the higher post-test scores in the experimental class compared to the control class. The SrVER learning model consists of four stages that enhance students' learning processes: screening, visualization, elaboration, and reflection. Furthermore, the integration of augmented reality media significantly enhances the learning experience by enabling students to visualize abstract concepts, engage in interactive learning, and experience a more enjoyable and meaningful educational process, ultimately leading to improved learning outcomes. The results of this study highlight the importance of adopting AR-based technology to enhance the quality of education, particularly in subjects with complex concepts like biology. Teachers and educational institutions should consider using AR as an effective learning tool and provide training for teachers to ensure the optimal implementation of this technology. Additionally, the SrVER model can be further developed by integrating various other technology-based learning media, such as virtual reality (VR) and gamification, to increase motivation, active participation, and student learning outcomes, in line with the demands of 21st-century education.

Author's Contribution

Muliani contributed to the conceptualization and design of the study, data collection, data analysis, and article writing. Baiq Sri Handayani, Tri Ayu Lestari, and Dadi Setiadi supervised the overall research process, provided theoretical insights, and reviewed the final version of the paper. All authors have read and approved the final paper.

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