Jurnal Penelitian Pembelajaran Fisika
Vol. 16 Issue 4 – October 2025, p352-361
p-ISSN 2086-2407, e-ISSN 2549-886X
Available Online at http://journal2.upgris.ac.id/index.php/JP2F
DOI: 10.26877/jp2f.v16i4.2832

Virtual Reality Effect on Student Learning Outcomes in Nuclear Physics and Radioactivity Topics

Indira Gustaviana Nugroho[1], Rizqi Fajar Shidiq[1], Taufiq Al Farizi[1,2] and Reza Ruhbani Amarulloh[1]

[1]Universitas Islam Negeri Syarif Hidayatullah, Jl. Ir H. Juanda No.95, Ciputat, Kec. Ciputat Tim., Kota Tangerang Selatan, Banten 15412

[2]E-mail: taufiq.farizi@uinjkt.ac.id

Received: 30 September 2025. Accepted: 25 October 2025. Published:30 October 2025.

Abstract. Learning Nuclear Physics and Radioactivity is often perceived as difficult by student because the concepts are abstract, thus requiring learning media that can visualize these concepts more concretely. This study aims to analyze the effect of using Virtual Reality media on student's learning outcomes in the topic of Nuclear Physics and Radioactivity. The research employed a Quasi Experimental method with a Nonequivalent Control Group Design. The subject were 33 12th grade students of Al Adzkar High School, divided into two groups: an experimental group and a control group. The research instrument consisted of 20 multiple-choice questions mesuaring cognitive abilities from levels C2 to C6. The result indicated a significant difference between the control and experimental groups. The average post-test score of students in the experimental class (76.47) was higher than that of the control class (69.06). Improvement in learning outcomes was also reflected in the N-Gain score, which reached 0.57 (medium category) for the experimental class and 0.38 (medium category) for the control class. The analysis of cognitive indicators showed that improvement in the experimental class was more evenly distributed compared to the control class. Therefore, the use of Virtual Reality has been proven to enhance students learning outcomes by providing a more interactive and engaging learning experience, making it a potential alternative medium for classroom instruction.

Keywords: virtual reality, learning outcomes, nuclear physics, radioactivity

1. Introduction

Physics learning in Indonesia still faces various challenges, particularly in delivering abstract concepts that are difficult to visualize. This issue arises not only from the complex nature of the subject matter but also from the dominance of conventional teaching methods that emphasize theoretical explenations without being supported by contextual and applicable visualizations [1]. This indicates a problem in the learning process and the inadequete use of media in explaining abstract concepts. Moreover, students' learning outcomes in physics remain low, lagerly due to the use of non-contextual textbooks and learning approaches that fail to connect the material with real-life phenomena [2]. This directly affects students' academic achivement, showing a strong relationship between the quality of learning media used and students' cognitive ability to understand abstract topics such as radioactivity [3].

Nuclear physics and radioactivity require a deep understanding of object interactions in three-dimensional space as well as microcopic concepts [4]. Various studies and observations indicate that many high school students, partucularly those in grade XII, experience difficulties in understanding radioactivity topics [5]. According to studies [5] and [6], many students perceive atomic nucleus and radioactivity topics as boring and difficult to master, and even frightening due to their association with danger and destruction. According to [7] the reason students quickly lose interest and motivation on learning is the use of less engaging media, such as static videos. This problem not only reflects the inadequacy of the learning media used but also illustrates the low cognitive learning outcomes of students [2].

High school students' learning outcomes on the topic of analyzing the characteristics of atomic nuclei, radioactivity, and their applications in daily life are relatively low because students perceive this material as boring and very difficult. This finding is consistent with research conducted by [6] which reported that the average daily test score of Grade XII MIPA 1 students at SMA Negeri 1 Cibeber was 49.17—well below the minimum mastery criterion of 70. The low learning outcomes are caused by the reliance on conventional teaching methods, such as lectures, without the support of media or animations. As a result, students are not yet familiar with using learning media or simulations. A study conducted by [8] at SMA Negeri 1 Nita, East Nusa Tenggara, found that students were unfamiliar with virtual laboratory simulations such as PhET, due to the lack of laboratory activities and limited availability of instructional tools and media at school.

If the issue of low learning outcomes continues to be ignored, it may have serious implications for students' future learning processes. The inability to understand concepts in nuclear physics and radioactivity not only decreases students' interest in physics but also hinders the development of critical thinking skills and scientific literacy in general [2]. Misconceptions about radioactivity concepts may also lead to negative attitudes toward science, narrowing students' scientific perspectives, and reducing their readiness to comprehend other science- and technology-related subjects [9]. Therefore, concrete steps are needed to address this problem through a more interactive and contextual learning approach [3]. One alternative solution to improve students' achievement in physics is through a technology-based learning approach such as Virtual Reality (VR). The implementation of Virtual Reality (VR) technology serves as a solution to actively engage students, train their analytical thinking skills, and enable them to reflect on knowledge through immersive experiences [10]. The use of Virtual Reality in physics learning offers great potential to create meaningful learning experiences because students can directly interact with three-dimensional representations of complex phenomena [11]. This technology allows students to experience practical simulations in an immersive and contextual manner, enabling abstract concepts in nuclear physics to be visualized more concretely and engagingly. Research conducted by [12] shows that VR-based learning significantly improves students' conceptual understanding compared to traditional teaching methods, particularly in abstract physics topics. This finding reinforces the argument that VR is an effective learning medium for helping students understand abstract scientific concepts.

This study examines the effect of using application-based Virtual Reality (VR) media as a learning tool for the topic of Nuclear Physics and Radioactivity to help students overcome low learning outcomes. The study focuses on measuring students' cognitive learning outcomes in accordance with the learning objectives based on the revised Bloom's Taxonomy, which includes levels C2 to C6. Based on the background described, the use of Virtual Reality media is expected to assist students in improving their learning outcomes in this topic, as well as transform the learning process into a more interactive and applicable experience, thereby potentially enhancing students' academic performance.

2. Method

This research was conducted at SMA Al-Adzkar during the 2025/2026 academic year using a quantitative approach through a quasi-experimental method (Quasi-Experimental Design). The research design employed was the Nonequivalent Control Group Design. This design was chosen because it was not possible for the researcher to fully randomize the subjects; however, both an experimental class and a control class were included for comparison purposes [13]. The structure of the Nonequivalent Control Group Design is presented in Table 1.

Table 1. Nonequivalent control group design.

Group	Pre-Test	Treatment	Post-Test
Control	O_1	X	O_2
experimental	O_3	X_1	O_4

In this study, the control class received treatment using video-based learning media (X), while the experimental class received treatment using Virtual Reality (VR) media (X_1). To assess students' abilities, a Pre-Test (O_1 and O_3) was administered to measure their initial understanding before the treatment, and a post-test (O_2 and O_4) was conducted to measure their performance after the treatment.

The independent variable in this study is the use of Virtual Reality media, while the dependent variable is students' learning outcomes. The research population includes all 12th-grade students, with the sampling technique based on purposive sampling. The sample selection was determined according to specific criteria relevant to the research objectives [13]. The sampling criteria included 12th-grade students who were studying the topic of Nuclear Physics and Radioactivity. Based on these considerations, class XII IPA 1 was selected as the experimental group, and class XII IPA 2 was selected as the control group.

The instrument used to analyze the effect of media on students' learning outcomes consisted of 20 multiple-choice questions developed based on the competency achievement indicators for the topic of Nuclear Physics and Radioactivity. The test instrument was designed to measure students' cognitive learning outcomes, focusing on the cognitive domains limited to C2 (understanding), C3 (applying), C4 (analyzing), C5 (evaluating), and C6 (creating). The instrument blueprint is presented in Table 2. Before being used, the instrument was validated by experts based on three main aspects: content, construct, and language [13]. Content validity refers to the extent to which the items in a questionnaire or test measure all the material intended to be assessed [14]. Content validity was calculated using the Content Validity Ratio (CVR) to determine its validity, where the CVR value ranges from +1 to −1. The higher the CVR value above 0, the more "essential" the item is, indicating stronger content validity. After validation, the Content Validity Index (CVI) was calculated by averaging the CVR values [15]. The results of the validity analysis are presented in Table 3.

Table 2. Blueprint of the Learning Outcome Instrument

Concept/Subconcept	Learning Indicator	Cognitive Domain	Item Number
Fusion Reaction in the Sun	Comparing the potential impacts of various strategies to improve energy efficiency in nuclear fusion reactions (e.g., optimizing nuclear reactions vs. reducing energy loss)	C5 (Evaluating)	1
	Calculating fusion reaction energy using the formula $E = mc^2$	C3 (Applying)	2
	Understanding the fusion reaction equation in the Sun	C2 (Understanding)	3
	Analyzing the principles of nuclear fusion reactions and their challenges in energy technology applications	C4 (Analyzing)	4
Uranium Fission Reaction	Identifying the main potential negative consequences of reactor modification implementation on reactor operational stability	C5 (Evaluating)	5
	Calculating the energy produced in a fission reaction	C3 (Applying)	6
	Analyzing a schematic diagram of the uranium fission reaction and explaining the role of neutrons in initiating a chain reaction	C4 (Analyzing)	7

	Understanding the role of neutrons in sustaining a fission chain reaction	C2 (Understanding)	8
	Creating innovative solutions to anticipate reactivity instability in real-world scenarios	C5 (Evaluating)	9
Radioactive Decay (Alpha)	Understanding the relationship between the properties of alpha radiation (charge, mass) and its behavior in magnetic fields and penetration ability	C2 (Understanding)	10
	Analyzing the composition of alpha particles and their effects on atomic number and nuclear mass	C4 (Analyzing)	11
	Evaluating the relationship among decay constant (λ), half-life ($t_{1/2}$), and decay rate (A) based on experimental data	C5 (Evaluating)	12
Beta Decay	Creating ideas for utilizing beta energy in remote devices	C6 (Creating)	13
	Understanding the effect of beta decay on atomic number and mass number	C2 (Understanding)	14
Gamma Decay	Understanding the differences in material absorption of gamma rays within the context of radiotherapy procedures	C2 (Understanding)	15
	Analyzing the effect of the decay constant magnitude on the rate of radioactive activity reduction and the duration of significant hazard presence	C4 (Analyzing)	16
	Understanding the effects of gamma radiation on the human body	C2 (Understanding)	17
	Comparing the detection sensitivity of different types of particles using various detectors	C5 (Evaluating)	18
Application of Radioactivity	Designing innovative strategies for the use of radioactive isotopes in medicine that integrate effectiveness and minimization of negative impacts	C6 (Creating)	19
	Identifying types of radioisotopes commonly used in medical diagnosis	C2 (Understanding)	20

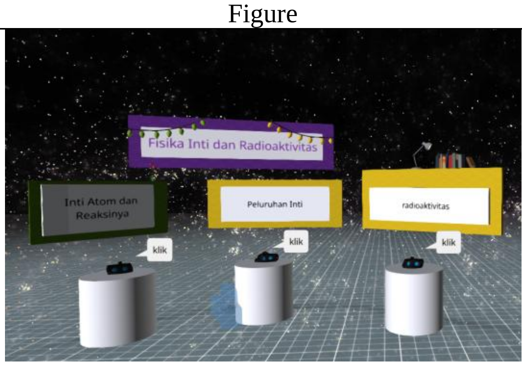
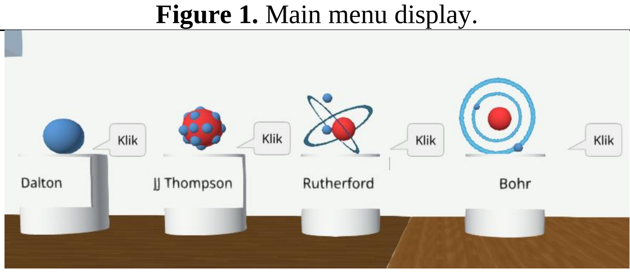
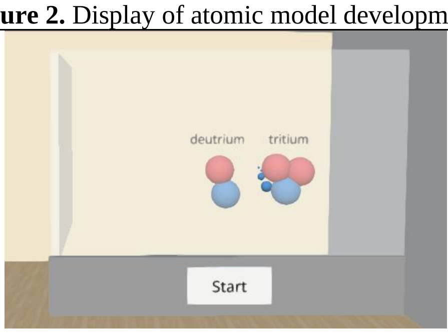
Table 3. Results of content validity testing.

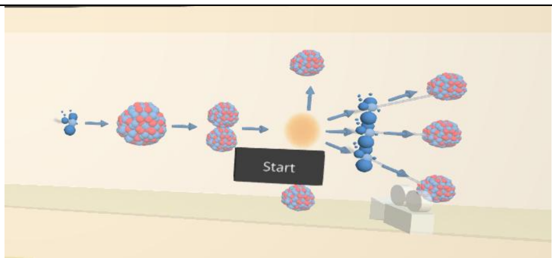
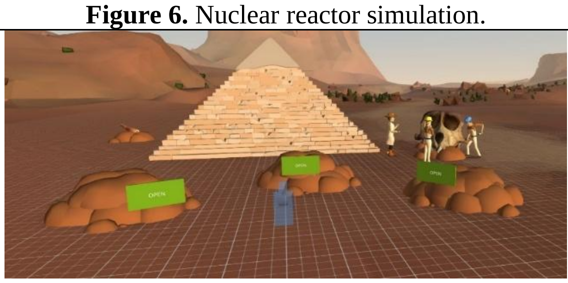
Assessed Aspect	CVI	Category
Language accuracy	1	Hughly appropriate
Content	0.950617	Hughly appropriate
Construct	0.97531	Hughly appropriate

From Table 3, it can be seen that the CVI values from the three assessed aspects indicate that the instrument is suitable for use, as all fall into the “highly appropriate” category. The test was administered twice: before the treatment (pre-test) to measure students' initial abilities, and after the treatment (post-test) to measure differences in learning outcomes between the control and experimental classes. The collected data were then analyzed using various statistical tests. Data analysis techniques were conducted as prerequisites to determine the effect of the treatment. The initial steps included normality and homogeneity tests as prerequisite analyses. After these prerequisite tests were completed, hypothesis testing was conducted. The t-test was used for both the pre-test and post-test since the data were normally distributed. The purpose of the pre-test t-test was to determine whether the two groups had the same prior knowledge, while the post-test t-test aimed to identify whether there were differences between the two groups after receiving different treatments. The analysis was carried out at a significance level of 0.05 as the basis for decision-making.

The learning media used in this study was the Delightex Edu application–based Virtual Reality (VR) platform, developed to help students understand concepts related to Nuclear Physics and Radioactivity. This application can be accessed via a smartphone connected to a VR Box (head-mounted display), providing an immersive experience in a three-dimensional environment. Within the application, students can explore atomic models, radioactive processes, and nuclear reactions through interactive animations and 360° simulations. The learning content was designed in accordance with the senior high school curriculum learning objectives and was validated by experts prior to implementation. This medium was designed to allow students to make virtual observations of phenomena that cannot be directly observed in a school laboratory setting.

Table 4. Display of the virtual reality application in the delightex edu app.

Number	Figure	Description
1	 **Figure 1.** Main menu display.	The initial display of the Virtual Reality application contains three main topics: atomic nuclei and their reactions, nuclear decay, and radioactivity. Source: Researcher's Documentation (2025)
2	 **Figure 2.** Display of atomic model development.	Display of atomic models ranging from J.J. Thomson, Rutherford, to Bohr. Source: Researcher's Documentation (2025)
3	 **Figure 3.** Nuclear fusion reaction simulation.	Display of a nuclear reaction simulation showing the fusion of deuterium and tritium nuclei into a helium nucleus. Source: Researcher's Documentation (2025)

4	 **Figure 4.** Nuclear fission reaction simulation.	Display of a nuclear reaction simulation illustrating the decay of an unstable atomic nucleus into a new nucleus. Source: Researcher's Documentation (2025)
5	 **Figure 5.** Simulation of radioactivity applications in the industrial field.	Display of a simulation showing the application of radioactivity technology in the industrial field, specifically food irradiation. Source: Researcher's Documentation (2025)
6	 **Figure 6.** Nuclear reactor simulation.	Display of a three-dimensional simulation of a nuclear reactor. Source: Researcher's Documentation (2025)
7	 **Figure 7.** Fossil discovery simulation.	Display of a simulation depicting the process of fossil discovery and the identification of its radioactive elements. Source: Researcher's Documentation (2025)
8	 **Figure 8.** Simulation of radiation types and penetration power.	Display of an interactive simulation demonstrating the differences among Alpha, Beta, and Gamma radiation types, along with their penetration abilities through various materials. Source: Researcher's Documentation (2025)
9	 **Figure 9.** Half-life simulation.	Display of a simulation illustrating the half-life process. Source: Researcher's Documentation (2025)

3. Result and Discussion

This study was conducted at SMA Al Adzkar from August 22 to September 2, 2025. The research sample consisted of 33 students, comprising 17 students from class XII IPA 1 as the experimental group, which received treatment using Virtual Reality, and 16 students from class XII IPA 2 as the control group, which used video-based media. Before the treatment, both classes were given a pre-test, and after the treatment, a post-test was administered to measure students' learning outcomes. The results of the statistical analysis of the pre-test and post-test data are presented in Table 4.

Table 4. Statistical analysis result.

Parameter	Control Class		Experimental Class	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Number of Samples	16	16	17	17
Highest Score	70	85	80	90
Lowest Score	40	50	20	65
Mean	51.56	69.06	42.35	76.47
Median	50	70	40	75
Standard Deviation	8.89	11.29	16.50	8.25

From Table 4, it can be seen that the average Pre-Test and Post-Test results obtained by the two classes differ. The mean Pre-Test score was relatively higher in the control class (51.56) compared to the experimental class (42.35). However, the Post-Test mean scores showed a significant difference between the control and experimental classes. The control class achieved an average Post-Test score of 69.06, while the experimental class obtained a higher average score of 76.47. Although both classes showed improvement overall, the experimental class demonstrated a higher mean score than the control class. The difference between the Pre-Test and Post-Test means varied greatly between the two classes. The control class showed an increase of 17.50 points, while the experimental class showed an increase of 34.12 points. This confirms that the treatment given to the experimental class was more effective in improving learning outcomes compared to the control class. The average data between the Pre-Test and Post-Test scores are illustrated in Figure 10, which shows a direct comparison.

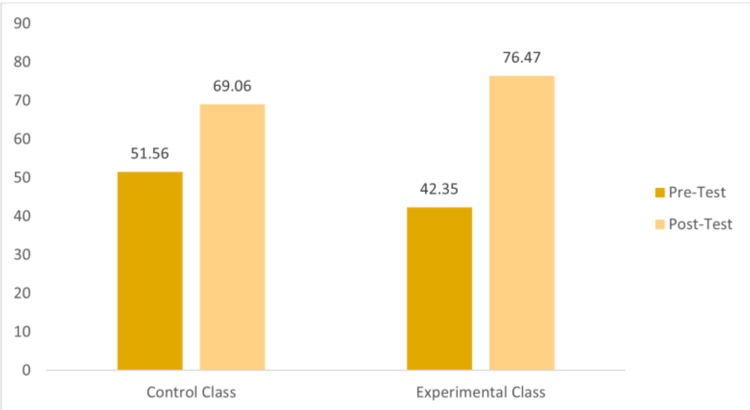


Figure 10. Histogram of average pre-test and post-test scores.

The improvement in students' learning outcomes in the control and experimental classes can be observed from the average N-Gain results, which were calculated by finding the difference between the Post-Test and Pre-Test scores, then dividing it by the difference between the ideal score and the Pre-Test score. The N-Gain results are presented in Table 5.

Table 5. N-gain result.

Class	N-Gain	Category
Control	0.38	Moderate
Experiment	0.57	Moderate

The improvement in students' learning outcomes in both the control and experimental classes can be further observed from the average N-Gain values. Table 5 shows the N-Gain scores for both classes. The control class obtained an N-Gain value of 0.38, indicating that students' learning outcomes were in the moderate category. Meanwhile, the experimental class obtained an N-Gain value of 0.57, also indicating a moderate category of improvement. Although both classes fall within the same category, the experimental class achieved a higher N-Gain score compared to the control class. The percentage representation of the average N-Gain values is shown in Figure 11.

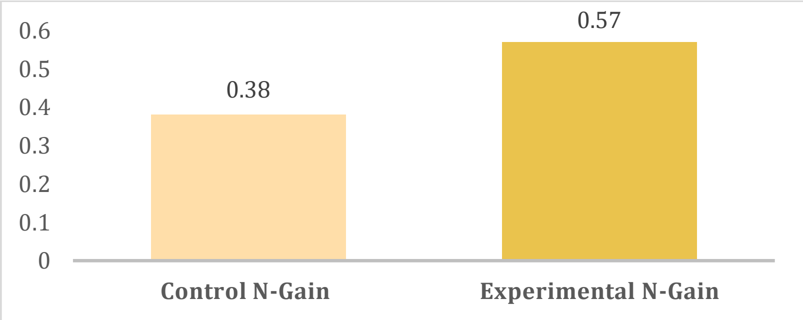


Figure 11. Histogram of n-gain in students' learning outcomes.

The learning outcome indicators targeted in this study cover five cognitive domains: C2, C3, C4, C5, and C6. The improvement in students' learning outcomes was obtained from the average N-Gain scores of the control and experimental classes. The N-Gain values of students based on each learning outcome indicator are presented in Table 6.

Table 6. N-Gain of students' learning outcome aspects.

Learning Outcomes Indicator	N-Gain			
	Control	Description	Experimental	Description
C2	0.36	Moderate	0.6	Moderate
C3	0.43	Moderate	0.65	Moderate
C4	0.28	Low	0.29	Low
C5	0.47	Moderate	0.79	High
C6	-0.29	Decrease	0.58	Moderate

The average N-Gain values in the control class were 0.36 for indicator C2, 0.43 for C3, 0.28 for C4, 0.47 for C5, and -0.29 for C6. Meanwhile, the average N-Gain values in the experimental class were 0.60 for indicator C2, 0.65 for C3, 0.29 for C4, 0.79 for C5, and 0.58 for C6. The five indicators in the control class tended to be lower than those in the experimental class. This demonstrates that students' learning outcomes improved across all indicators after the treatment using Virtual Reality. In contrast, the control class showed a low category in indicator C4 and a decrease in indicator C6. Although both classes experienced improvement in learning outcomes, the experimental class showed a more consistent and evenly distributed increase across all indicators. The average N-Gain values for each indicator are illustrated in Figure 12.

The results of this study demonstrate that the use of Virtual Reality (VR) media has a significant effect on students' learning outcomes in the topic of Nuclear Physics and Radioactivity. Virtual Reality media provides more concrete visualization, making abstract concepts easier to understand. This finding is consistent with studies [16] and [17] which state that Virtual Reality technology can enhance students' motivation and comprehension. Compared to video-based media, Virtual Reality is more effective in capturing students' attention as it offers an immersive learning experience. This aligns with study [8] which indicates that virtual laboratory-based media can serve as a viable alternative to improve students' understanding of complex material. Furthermore, study [18] also supports this finding by asserting that Virtual Reality–based science learning is an efficient technology for improving students' science learning outcomes. Similarly, study [19] revealed that the application of Virtual Reality in

Quantum Physics learning significantly enhances students' learning effectiveness because it enables the visualization of abstract concepts in a more tangible way.

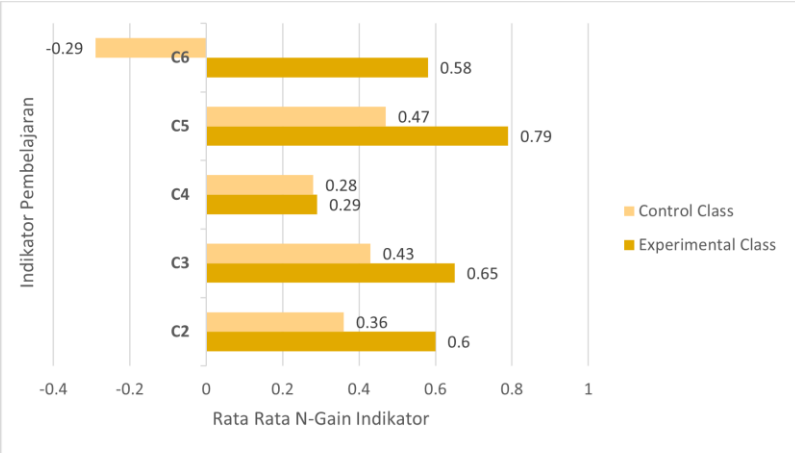


Figure 12. Histogram of n-gain on learning outcome indicators.

This study provides both practical and theoretical contributions. Practically, the use of Virtual Reality can serve as an alternative to conventional learning media, helping students comprehend abstract concepts such as atomic structure, radioactive decay, and nuclear reactions through interactive and engaging learning experiences. This medium also fosters higher engagement and active participation during the learning process. Therefore, the findings of this study can serve as a reference for educators and schools to implement Virtual Reality technology as an innovative approach in physics education. Theoretically, this study reinforces constructivist learning theory, which emphasizes the importance of interaction-based and concretely represented learning experiences in developing conceptual understanding. Moreover, the findings confirm the effectiveness of immersive technology in enhancing cognitive learning outcomes, consistent with [20] who stated that immersive technologies can increase engagement and improve learning performance. Thus, this study strengthens the theoretical foundation regarding the role of immersive media in enhancing the quality of science education in the digital era.

4. Conclusion

Based on the research findings and data analysis, it can be concluded that the use of Virtual Reality has a significant effect on students' learning outcomes in the topic of Nuclear Physics and Radioactivity. This is evidenced by the obtained N-Gain value of 0.57, which falls within the medium category. The positive influence of Virtual Reality in learning arises from its ability to capture students' attention and enthusiasm, thereby enhancing their understanding and contributing positively to learning outcomes.

Acknowledgment

The author would like to express sincere gratitude to all parties who contributed to this research. Special thanks are extended to the author's parents and siblings for their continuous prayers and support, which enabled the smooth completion of this study. The author also wishes to thank the academic supervisor for their patience and valuable guidance throughout the research process. Appreciation is likewise given to SMA Al-Adzkar for granting permission to conduct the study. Lastly, heartfelt thanks go to the author's research partner for their constant support and assistance during the research.

References

[1] Villada Castillo J F, Bohorquez Santiago L and Martínez García S 2025 Optimization of Physics Learning Through Immersive Virtual Reality: A Study on the Efficacy of Serious Games *Applied Sciences (Switzerland)* **15**

[2] Suparya I K, I Wayan Suastra and Putu Arnyana I B 2022 Rendahnya Literasi Sains: Faktor Penyebab Dan Alternatif Solusinya *Jurnal Ilmiah Pendidikan Citra Bakti* **9** 153–66

[3] Mufit F, Dhanil M and Hendriyani Y 2025 Development of Quantum Physics Laboratory Based on Immersive Virtual Reality *International Journal on Informatics Visualization* **9** 342–50
[4] Rizal R, Ridwan I M, Suhendi H Y and Mahmudah I R 2025 Student's Readiness in Using Virtual Reality for Physics Learning *Journal of Teaching and Learning* **19** 131–54
[5] Morales López A I and Tuzón Marco P 2022 Misconceptions, Knowledge, and Attitudes Towards the Phenomenon of Radioactivity *Science and Education* **31** 405–26
[6] Kriswahyudi B 2020 Meningkatkan Kemampuan Menganalisis Karakteristik Inti Atom , Radioaktivitas, dan Pemanfaatannya Dalam Kehidupan Sehari-hari Menggunakan Model Pembelajaran Jigsaw Pada Peserta Didik Kelas XII MIPA 1 SMAN 1 CIBEBER *Prosiding Seminar Nasional Sains* **1** 75–84
[7] Maulana S R, Ronggowulan L, Studi P, Geografi P, Keguruan F, Maret U S, Aktivitas T, Siswa B and Xi K 2024 Pengaruh Media Pembelajaran Virtual Reality Terhadap Aktivitas dan Hasil Belajar Siswa Kelas XI di SMAN 1 121–32
[8] Bogar D Y, Jufriansah A and Prasetyo E 2023 Pengembangan Laboratorium Virtual untuk Meningkatkan Hasil Belajar Peserta Didik *Buletin Edukasi Indonesia* **2** 102–12
[9] Bezen S 2024 Radiation knowledge and awareness : Evaluation from the perspective of high school students 01020
[10] Hendajani F, Hakim A, Sudiro S A, Saputra G E and Ramadhana A P 2019 Tracking Visualization of 3 Dimensional Object Natural Science Learning Media in Elementary School with Markerless Augmented Reality Based on Android *Journal of Physics: Conference Series* 1192
[11] Budi A S, Sumardani D, Muliyati D, Bakri F, Chiu P-S, Mutoharoh M and Siahaan M 2021 Virtual Reality Technology in Physics Learning: Possibility, Trend, and Tools *Jurnal Penelitian & Pengembangan Pendidikan Fisika* **7** 23–34
[12] Salihu ahmed and Sabitu Abdulmalik 2024 Issues and Ideas in Education *CHITKARA* 12 14–8
[13] Sugiyono 2013 *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D* (Bandung: Penerbit Alfabeta)
[14] Budiastuti Dyah dan Bandur Agustinus 2018 *Validitas dan Reliabilitas Penelitian Dilengkapi Analisis dengan NVIVO, SPSS dan AMOS* (Jakarta: Penerbit Mitra Wacana Media)
[15] Suwarna, Iwan dan Ilmi D 2016 Pengembangan Instrumen Ujian Komprehensif Mahasiswa
[16] Suci E and Kusumawati A 2024 RODA : Jurnal Pendidikan dan Teknologi Otomotif Meta Analisis : Pengaruh Penggunaan Media Pembelajaran Virtual Reality terhadap Hasil Belajar **4** 24–8
[17] Nisa A and Dwiningsih K 2022 Analisis Hasil Belajar Peserta Didik Melalui Media Visualisasi Geometri Molekul Berbasis Mobile Virtual Reality (MVR) *PENDIPA Journal of Science Education* **6** 135–42
[18] Dhanil M and Mufit F 2024 How Virtual Reality Impacts Science Learning? A Meta-Analysis *International Journal of Interactive Mobile Technologies* 18 77–96
[19] Tarng W and Pei M C 2023 Application of Virtual Reality in Learning Quantum Mechanics *Applied Sciences (Switzerland)* **13**
[20] Tene T, Bonilla García N, Coello-Fiallos D, Borja M and Vacacela Gomez C 2024 A systematic review of immersive educational technologies in medical physics and radiation physics *Frontiers in Medicine* **11** 1–18