Journal of Educational Sciences
Journal homepage: https://jes.ejournal.unri.ac.id/index.php/JES
P-ISSN 2581-1657
E-ISSN 2581-2203

Development of Interactive Virtual Reality Learning Media Based on the RADEC Model for Science Learning in Elementary Schools

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ARTICLE INFO

Article history:

Received: 09 Dec 2025
Revised: 10 Feb 2026
Accepted: 27 Feb 2026
Published online: 05 March 2026

Keywords:

Elementary Schools,
Interactive Learning Media,
RADEC Model,
Science Learning,
Virtual Reality

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Article Doi:

https://doi.org/10.31258/jes.10.3.p.343-358

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A B S T R A C T

This study was motivated by low student engagement, limited use of innovative learning media, and students' difficulties in understanding abstract concepts, particularly the human digestive system in Integrated Science and Social Studies learning at the elementary school level. The study aimed to develop an interactive Virtual Reality learning medium based on the RADEC (Read, Answer, Discuss, Explain, Create) approach for fifth-grade students. The research employed a Research and Development design using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The developed VR-based RADEC medium was validated by material, language, and media experts, achieving a validity score of 92.66%, categorized as highly valid. Practicality testing conducted in four elementary schools showed very high practicality, with student and teacher response scores of 93.8% and 96.2%, respectively. Effectiveness testing using pre-test and post-test results demonstrated a significant improvement in student learning outcomes, indicated by an average N-Gain score of 0.76, classified as high. These findings indicate that the developed VR-based RADEC interactive learning medium is valid, practical, and effective. Furthermore, it supports the implementation of the Merdeka Curriculum by providing realistic, engaging learning experiences that enhance student motivation and learning achievement.

1. Introduction

Education in the era of globalization and rapid digital technological development plays a strategic role in preparing a generation capable of facing 21century challenges. Education is no longer focused solely on academic achievement but also on the development of critical thinking, creativity, collaboration, communication, and digital literacy skills (Herlina et al., 2025). This view is consistent with

Frydenberg & Andone, (2023), who argue that 21century learning emphasizes critical thinking skills, knowledge mastery, and digital, information, and media literacy to produce graduates who are competitive in the global era. The integration of technology in learning is a crucial aspect of improving the quality of the learning process and optimizing students learning potential in the digital era. Technology is regarded as a tool that can enrich learning experiences, expand access to learning resources, and encourage active student engagement (Azizah et al., 2023; Subroto et al., 2023). In line with this perspective, national education policy through the implementation of the Kurikulum Merdeka emphasizes the importance of utilizing information and communication technology effectively and efficiently to realize student-centered learning (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2022).

One form of technology integration in learning is the use of innovative instructional media. Instructional media function as a means of delivering learning messages that can clarify content, increase learning motivation, and help students understand concepts more concretely (Syafira & Ahmad, 2023). In addition to serving as teaching aids, instructional media also play an important role in enhancing interaction between teachers and students, thereby creating more meaningful learning experiences (Chisunum & Nwadiokwu, 2024). Within the context of the Kurikulum Merdeka, instructional media should be designed in accordance with students characteristics and needs to support contextual learning and deep conceptual understanding (Nikma et al., 2025).

However, based on observations and interviews conducted in several elementary schools, IPAS learning is still dominated by conventional media such as textbooks and static images. Digital media are used in a limited manner and are not yet interactive, resulting in students being less actively involved in the learning process. Moreover, learning methods are still dominated by lectures and question and answer sessions, making learning teacher centered and not fully aligned with the principles of the Kurikulum Merdeka, which emphasizes student centered learning (Pramesti et al., 2025). This condition affects students' interest and understanding, particularly in abstract IPAS topics such as the human digestive system.

The discrepancy between curriculum expectations and classroom realities highlights the need for innovative solutions through development research. One proposed solution is the development of interactive learning media based on Virtual Reality (VR). VR technology enables students to interact directly with simulated objects and phenomena, thereby increasing learning engagement and facilitating deeper and more concrete conceptual understanding (Marougkas et al., 2023). Several previous studies have demonstrated that the use of VR based media in elementary science learning significantly improves students' learning outcomes and motivation (Nugrahaningrum et al., 2023). Other studies have reported that Android-based VR learning media are categorized as highly feasible by experts and effective in enhancing student engagement (Firmansyah & Nurharini, 2024). In addition, the development of VR media for geometry topics in elementary schools has received positive responses from students and high validation scores from experts (Febriana & others, 2023).

Despite these findings, most existing studies focus primarily on the general effectiveness of VR media without integrating them into a specific instructional model. Research that specifically develops VR based learning media for IPAS within the framework of the Kurikulum Merdeka, while comprehensively examining validity, practicality, and effectiveness, remains limited. Therefore, there is a need to develop VR based instructional media that are not only technologically innovative but also pedagogically integrated.

One instructional model considered relevant is the RADEC model (Read, Answer, Discuss, Explain, Create), which encourages students to actively read, comprehend, discuss, explain, and construct knowledge both independently and collaboratively. The integration of VR-based learning media with the RADEC model is expected to create interactive and meaningful IPAS learning experiences that align with the characteristics of 21century learning. Accordingly, this study aims to develop and evaluate VR based interactive learning media integrated with the RADEC model for fifth-grade IPAS learning in elementary schools, particularly on the topic of the human digestive system, by examining the validity, practicality, and effectiveness of the developed media in supporting the implementation of the Kurikulum Merdeka.

2. Methodology

This study employed a Research and Development (R&D). Development research is a systematic process aimed at creating new products or improving existing ones to enhance their effectiveness and relevance to users needs (Amini, 2020; Martinopa & Amini, 2023; Rustamana et al., 2024). approach using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation stages (Furkan & Yanti, 2023; Khasyyatillah & Isra, 2019; Maisaroh et al., 2025) The ADDIE flow can be seen in Figure 1.

Figure 1. Addie's plot

The research was conducted in Indonesia, specifically in elementary schools located in Pesisir Selatan Regency that have implemented the Kurikulum Merdeka. The participating schools were SDN 07 Pasar Salido, SDN 13 Painan Utara, SDN 23 Painan Selatan, and SDN 08 Painan Selatan (Classes A and B). The research subjects consisted of 119 fifth-grade students who participated in the implementation and effectiveness testing stages. In addition, fifth-grade teachers from the participating schools were involved as respondents in the practicality assessment. Expert validators comprising material experts, language experts, and media experts were involved to evaluate the quality of the developed learning media during the development stage. The data obtained from the validation results and

practicality of learning media will be analyzed through the application of the Likert scale. Referring to the validation and practicality sheets, the scoring in each category can be observed in Table 1.

Table 1. List of Scoring Validity and Practicality of Learning Media

Score	Category
1	Not Good
2	Pretty Good
3	Fair
4	Good
5	Excellent

Source: Modification (Purwanto, 2013)

The scores obtained from the earlier data collection stage, based on the validity and practicality questionnaires, were analyzed and converted into percentage form to assess the feasibility of the developed product (Rosa Karlina, 2022; Oktama et al., 2026). This analysis was conducted to determine the extent to which the learning media fulfills the validity and practicality requirements. Each score was calculated and interpreted objectively according to predetermined classification intervals. Higher percentage results indicate that the media meets the required standards, whereas lower percentages signal the need for further refinement. The calculation formula is presented below, and the validity and practicality categories are outlined in Tables 2.

$$NP = \frac{S}{MS} X100\%$$

Information :
NP = Percent value searched
S = Score
MS = Maximum score
100 = Fixed value

Table 2. Categories of Learning Media Validity

Intervals	Category
86-100%	Highly Valid
76-85%	Valid
60-75%	Quite Valid
55-59%	Less Valid
00-54%	Invalid
Intervals	Category
86-100%	Very Practical
76-85%	Practical
60-75%	Quite Practical
55-59%	Less Practical
00-54%	Impractical

Source: Modification Suharsimi Arikunto (2014:285)

3. Result and Discussion

Analysis

At the analysis stage, this study critically examined four interrelated aspects curriculum, content, students, and learning needs to identify not only the instructional requirements but also the pedagogical gaps that justify the development of Virtual Reality (VR) based interactive learning media using the RADEC approach within the framework of the Kurikulum Merdeka. This stage directly addressed the first research objective by establishing a strong theoretical and contextual foundation for media development. The curriculum analysis revealed that while the Kurikulum Merdeka strongly emphasizes student centered learning, competency mastery, character development, and 21 century skills, its successful implementation is highly dependent on the availability of learning media that can support active, contextual, and meaningful learning. In fifth-grade IPAS learning, students are expected to integrate scientific and social perspectives, relate abstract concepts to real life situations, and demonstrate critical thinking and problem solving skills.

However, the findings indicate a clear discrepancy between these curricular demands and the instructional practices commonly employed in classrooms, which still rely heavily on conventional, text based media. Such media tend to position students as passive recipients of information, limiting opportunities for exploration and higher order thinking. This gap highlights the need for innovative instructional media that can operationalize the principles of the Kurikulum Merdeka. Consequently, the proposed VR-based learning media integrated with the RADEC approach is not merely an alternative delivery tool but a pedagogical response to curricular demands, offering immersive, inquiry oriented, and reflective learning experiences that align with the intended learning outcomes.

The content analysis further strengthened this rationale by identifying the human digestive system as a topic with high conceptual complexity and abstraction. Traditional explanations through textbooks or static images often fail to adequately represent dynamic biological processes, leading to fragmented or superficial understanding among elementary school students. From a pedagogical standpoint, this limitation constrains students' ability to construct coherent mental models of the digestive process.

The integration of VR technology addresses this challenge by enabling three dimensional visualization, sequential observation of processes, and interactive exploration of organ functions. When combined with the RADEC approach, VR supports structured learning phases from initial reading and answering questions to discussion, explanation, and reflection thereby transforming abstract content into meaningful learning experiences. This finding directly supports the second research objective and is consistent with the argument of Mesy Kurnia, (2025), who emphasized that RADEC is most effective when learners are provided with concrete, engaging, and context rich learning environments.

Student analysis provided further critical insights into the necessity of media development. Fifth grade students, typically aged 10–11 years, are cognitively positioned in the concrete operational stage, where learning is optimized through direct manipulation, visualization, and experiential activities. Classroom observations revealed that conventional instructional methods often fail to accommodate these developmental characteristics, resulting in low participation, limited interaction, and reduced learning motivation. This mismatch between instructional strategies and students' cognitive needs suggests that learning difficulties are not solely rooted in students' abilities but also in the inadequacy of instructional design. VR-based learning media responds to this issue by offering multisensory experiences that promote active exploration and knowledge construction, aligning with constructivist learning theory and reinforcing the student-centered orientation of the Kurikulum Merdeka.

The needs analysis conducted across several elementary schools in Pesisir Selatan Regency (SDN 13 Painan Utara, SDN 07 Pasar Salido, and SDN 27 Sago) further confirmed the urgency of this development. Despite the availability of basic technological infrastructure, instructional practices remained dominated by textbooks and printed materials, which students perceived as monotonous and disengaging. The absence of VR based or other interactive digital media indicates a missed opportunity to leverage technology for meaningful learning. This condition reflects a broader systemic issue in which technological potential is underutilized due to limited pedagogical innovation. The development of VR based learning media using the RADEC approach, therefore, represents a strategic intervention to address this gap by enhancing student engagement, encouraging active participation, and supporting deeper conceptual understanding. These findings are in line with Dewi & Santosa, (2021), who reported that limited use of interactive learning media contributes to passive classroom environments and suboptimal learning outcomes in elementary education.

Overall, the analysis stage not only identified instructional needs but also critically revealed the misalignment between curricular expectations, student characteristics, content complexity, and existing instructional practices. This misalignment provides a strong empirical and theoretical justification for the development of VR based interactive learning media integrated with the RADEC approach as a relevant and necessary innovation in fifth grade IPAS learning.

Design

At the design stage, the researcher developed an interactive Virtual Reality (VR) based learning media integrated with the RADEC approach (Read, Answer, Discuss, Explain, Create). This media was designed to support Science and Social Studies (IPAS) learning for fifth-grade elementary students, particularly in the topic of the human digestive system. The primary purpose of this design was to help teachers deliver technology-enhanced instruction that is more engaging, interactive, and contextual, while also assisting students in understanding abstract concepts through immersive learning experiences. The designed media aims to provide a realistic and exploratory learning environment, allowing students to virtually enter

a 3D simulation to observe digestive organs and their functions. Hence, students do not only read or listen to explanations but also experience the learning process directly, consistent with the principles of the RADEC learning model. The media design was developed through several systematic steps, including needs analysis, interface and content design, 3D object creation, and integration of RADEC-based learning activities.

(a) Material Collection

The first step involved collecting instructional materials such as images of digestive organs, anatomical illustrations of the human body, supporting videos, backgrounds, narrative texts, and other multimedia elements. The materials were adapted from the Grade V IPAS textbook aligned with the Kurikulum Merdeka, complemented by student worksheets (LKS), teacher modules, and reliable online references. In addition, 3D images and animations depicting the digestion process from the mouth, stomach, and intestines to waste excretion were developed. These elements made the content more concrete, engaging, and visually representable in the VR environment.

(b) Instrument Development

The next step was designing instruments to assess the feasibility, practicality, and effectiveness of the learning media. The feasibility instrument consisted of expert validation sheets addressing three main aspects: content, language, and media quality. This validation ensured that the media aligned with learning outcomes, was easy to understand, and suitable for elementary students. Furthermore, practicality questionnaires were developed for both teachers and students to evaluate the ease of use, clarity, and usefulness of the media in classroom practice. Additionally, learning achievement tests (pre-test and post-test) were prepared to measure students' understanding of the digestive system after using the VR-based learning media.

(c) Media Development

The final step was the creation of the interactive VR learning media tailored to the characteristics of fifth-grade students and the selected topic. The design was structured to be teacher-friendly, incorporating RADEC-based learning scenarios and interactive 3D visual elements accessible via VR devices. As a result, the learning process became not only informative but also experiential, promoting meaningful and context-based learning that enhances both student engagement and conceptual understanding. The following section presents the interactive Virtual Reality (VR) learning media developed based on the RADEC model for science learning in elementary schools, as shown in Figures 2, 3,4, and 5

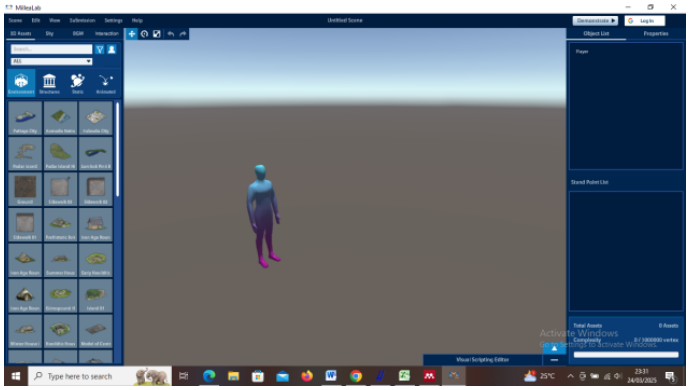

Figure 2. Initial design preparation

Figure 3. Getting Started Designing

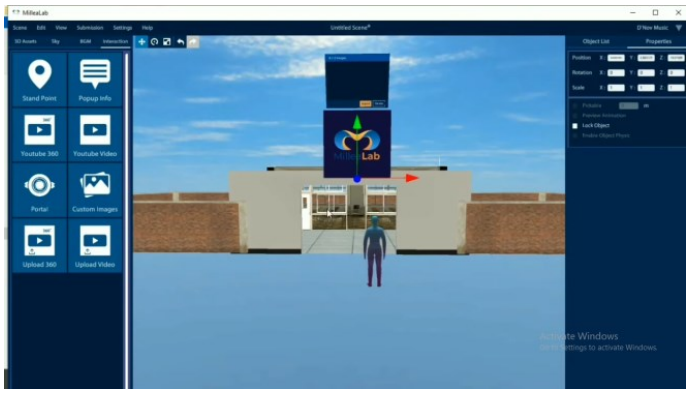

Figure 4. Entering material

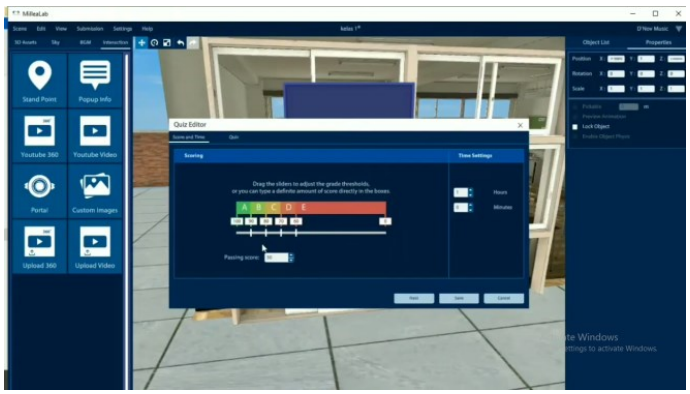

Figure 5. Entering the Quiz

Development

At the development stage, the designed VR-based interactive learning media underwent expert validation to achieve the fourth research objective, namely to ensure the validity of the developed product. Validation was conducted by content experts, media experts, and language experts using structured evaluation instruments. The validation results indicated that the media met high standards in terms of content relevance, linguistic clarity, and technical design. Expert feedback highlighted the strengths of the media in visual representation, interactivity, and alignment with learning objectives. Revisions were made to improve content sequencing, simplify language for elementary learners, and enhance visual communication. This iterative revision process is consistent with the ADDIE framework and strengthens the credibility of the final product.

The high validation outcomes demonstrate that the developed VR-based learning media is pedagogically sound and technically feasible. These findings are consistent with previous studies (Aulia & Fitria, 2024; Choirin Attalina et al., 2024), which reported that VR-based learning media significantly enhance engagement and conceptual understanding when validated and refined through expert review. Overall, the results from the analysis, design, and development stages collectively confirm that the VR-based RADEC interactive learning media effectively addresses the identified learning problems, aligns with the objectives of the Kurikulum Merdeka, and contributes to innovative IPAS learning practices in elementary schools. The results of the validation can be seen in Table 3.

Table 3. Validation by Material, Media, and Language Experts

No	Type of Validation	Aspect	Score	Percentage	Category
1	Material	Content Feasibility	22	89%	Very Valid
		Concept and Illustration Accuracy	23		
		Material Integration with Learning Objectives	22		
		Clarity and Attractiveness of Presentation	22		
2	Media	Visual Display Quality	23	92%	Very Valid
		Media Interactivity	23		
		Technical Feasibility	22		
		Media Integration with Learning Process	24		
3	Language	Clarity of Language	25	97%	Very Valid
		Text Readability	25		
		Language Suitability to Student Characteristics	24		
		Appropriateness to Learning Context	23		

The feasibility of the developed Virtual Reality (VR)-based interactive learning media using the RADEC approach was evaluated through expert validation involving material experts, media experts, and language experts. The validation

results are presented in Table, which summarizes the scores, percentages, and validity categories for each aspect assessed.

Material validation focused on content feasibility, accuracy of concepts and illustrations, integration of materials with learning objectives, and clarity and attractiveness of presentation. The material expert awarded a total score of 22 for content feasibility (89%), categorized as very valid. High scores were also obtained for concept and illustration accuracy (23), material alignment with learning objectives (22), and presentation clarity (22). These results indicate that the instructional content is scientifically accurate, conceptually coherent, and well aligned with the expected learning outcomes of fifth-grade IPAS learning. The high validity category confirms that the material presented in the VR media adequately supports students' conceptual understanding, particularly for abstract topics such as the human digestive system.

Media validation examined visual display quality, interactivity, technical feasibility, and integration with the learning process. The media expert awarded a percentage of 92%, placing the media aspect in the very valid category. High scores for visual display quality (23) and media interactivity (23) suggest that the VR environment is visually appealing and capable of engaging students through interactive simulations. The technical feasibility score (22) indicates that the media can be effectively operated using available devices, while the highest score for integration with the learning process (24) demonstrates that the VR media is well embedded within the RADEC-based instructional flow. These findings support the role of VR as not only a visualization tool but also an effective instructional medium that facilitates active learning.

Language validation assessed clarity of language, text readability, suitability to student characteristics, and appropriateness to the learning context. The language expert provided the highest validation percentage of 97%, categorizing the language aspect as very valid. High scores across all indicators (23–25) indicate that the language used in the media is clear, readable, age-appropriate, and contextually relevant for elementary school students. This ensures that students can easily comprehend instructions, explanations, and learning tasks within the VR environment, thereby supporting effective learning interactions. Overall, the expert validation results demonstrate that the developed VR-based RADEC interactive learning media meets high standards of content quality, media design, and language use. These findings directly support the research objective of producing a learning medium that is valid and suitable for fifth-grade IPAS learning. Furthermore, the high validity across all aspects suggests that the media is ready to be implemented in classroom settings and further evaluated in terms of practicality and effectiveness.

Implementation

The implementation stage represents a crucial step following the validation and revision of the interactive Virtual Reality (VR)-based learning media developed using the RADEC approach. At this stage, the finalized product was applied in the

real classroom setting of fifth-grade Ilmu Pengetahuan Alam dan Sosial (IPAS) learning to evaluate the practicality and feasibility of its use in actual teaching practice.

The implementation involved a total of 119 students as participants, ensuring that the data obtained were sufficiently representative to assess both the practicality and effectiveness of the media. During the implementation, students were asked to complete a practicality questionnaire evaluating aspects such as ease of use, visual appeal, and the extent to which the media facilitated their understanding of the human digestive system topic. In addition, teachers provided their assessments through a teacher practicality questionnaire, which examined the alignment of the media with the learning objectives of the RADEC-based IPAS curriculum, its ease of classroom management, and its ability to enhance student engagement and participation.

Thus, this stage not only served to test the media's applicability in real classroom conditions, but also to provide a comprehensive understanding of teacher and student responses regarding the practicality and suitability of the VR-based interactive learning media. The findings from the implementation phase subsequently served as the foundation for evaluating the extent to which the media effectively supported an engaging, interactive, and meaningful learning process in elementary education. The results of student and teacher practical work can be seen in Table 4.

Table 4. Results of Practicality Test by Students and Teachers

No	Respondent	Aspect	Score	Percentage	Category
1	Students (n = 119)	Ease of Use	94	93.8%	Very Practical
		Display Attractiveness	95		
		Clarity of Instructions	93		
		Usefulness in Understanding the Material	94		
2	Teachers (n = 5)	Ease of Operation	96	96.2%	Very Practical
		Relevance to Learning Objectives	95		
		Classroom Management Support	96		
		Benefits for Student Engagement	98		

The practicality of the Virtual Reality (VR)-based interactive learning media using the RADEC approach was evaluated through user response questionnaires administered to students and teachers. The results of the practicality assessment are presented in Table X, which summarizes the scores, percentages, and practicality categories for each aspect evaluated. Student responses (n = 119) indicated a very high level of practicality, with an average percentage score of 93.8%, categorized as very practical. High scores were obtained across all assessed aspects, including ease of use (94), display attractiveness (95), clarity of instructions (93), and usefulness in understanding the material (94). These results demonstrate that students were able to operate the VR media easily, follow the learning instructions

clearly, and benefit from its visual and interactive features. The high attractiveness score suggests that the immersive VR environment successfully captured students' attention, which is crucial for maintaining engagement during IPAS learning, particularly when dealing with abstract concepts such as the human digestive system.

Teacher responses (n = 5) also indicated a very high level of practicality, with an average percentage score of 96.2%, categorized as very practical. Teachers rated the media highly in terms of ease of operation (96), relevance to learning objectives (95), classroom management support (96), and benefits for student engagement (98). These findings indicate that the VR-based learning media is not only easy for teachers to implement but also effective in supporting instructional goals and classroom dynamics. The highest score was obtained for the aspect of enhancing student engagement, suggesting that the integration of VR technology combined with the RADEC approach facilitates active participation and interaction during the learning process. Overall, the practicality test results confirm that the developed VR-based RADEC interactive learning media is highly usable from both student and teacher perspectives. These findings directly address the research objective related to media practicality, indicating that the product can be efficiently implemented in real classroom settings without causing operational difficulties. In line with previous studies, the results further support the conclusion that well-designed VR learning media can enhance engagement while remaining manageable for teachers and accessible for students.

Evaluation

The evaluation stage was conducted to address the final research objective, namely to determine the effectiveness of the Virtual Reality (VR) based interactive learning media integrated with the RADEC approach in improving fifth-grade students' learning outcomes in Ilmu Pengetahuan Alam dan Sosial (IPAS). Effectiveness was evaluated using a one-group pretest–posttest design, focusing on changes in students' conceptual understanding of the human digestive system. The evaluation process consisted of three main steps. First, a pre-test was administered to measure students' initial understanding prior to the intervention. Second, the learning process was implemented using the VR-based interactive media integrated with the RADEC stages Read, Answer, Discuss, Explain, and Create allowing students to actively explore digestive system concepts through immersive simulations and collaborative activities. Third, a post-test was administered after the learning session to assess improvements in students' learning outcomes.

The effectiveness of the media was determined by comparing pre-test and post-test scores using N-Gain analysis. The results showed a high average N-Gain score, indicating a significant improvement in students' conceptual understanding after using the VR-based RADEC media. This finding demonstrates that the developed learning media effectively facilitated meaningful learning and successfully achieved its intended instructional objectives. The improvement in learning outcomes suggests that immersive VR experiences, combined with structured active learning stages such as RADEC, can enhance students' ability to understand

abstract scientific concepts. Beyond cognitive learning outcomes, the evaluation also examined student engagement during the learning process. Classroom observations revealed a noticeable increase in student participation, attention, and enthusiasm. Students actively interacted with the VR simulations, engaged in discussions, and confidently explained concepts during the RADEC stages. These findings indicate that the VR-based learning media not only improved conceptual mastery but also fostered a more active, enjoyable, and student-centered learning environment.

The results of this study are consistent with previous research reporting that VR-based instructional media can significantly enhance learning outcomes and student engagement by providing immersive and experiential learning. Moreover, the structured RADEC approach supports higher order thinking and active participation, which further strengthens learning effectiveness. Compared to conventional instruction, the integration of VR and RADEC offers added value by combining technological immersion with pedagogically sound learning stages. Overall, the evaluation results confirm that the developed VR based RADEC interactive learning media is effective in improving both learning outcomes and student engagement. These findings reinforce the conclusion that the media is suitable for supporting IPAS learning in elementary schools and aligns with the goals of the Kurikulum Merdeka in promoting active, meaningful, and student centered learning. The results of the effectiveness can be seen from the N-Gain value in table 5.

Table 5. Results of Pre-test and Post-test of Students' Learning Outcomes

No	Pre-test	Post-test	N-Gain Score	Category	N-Gain (%)	Effectiveness Category
1	60.23	90.74	0.76	High	76.18%	Effective

Based on the comparison between the pre-test and post-test results, a significant improvement was observed after students participated in learning activities using the interactive Virtual Reality (VR) based learning media with the RADEC approach. The average pre-test score obtained from five participating schools was 60.23, which increased to 90.74 after the post-test. This considerable improvement indicates that the developed learning media contributed positively to students' understanding of the topic Human Digestive System within the IPAS subject. Furthermore, analysis of the N-Gain score revealed an average gain of 0.76, equivalent to 76.03%, which falls into the high category. This finding demonstrates that the interactive VR-based learning media was highly effective in enhancing students' learning outcomes and comprehension of scientific concepts, particularly for fifth-grade elementary students.

4. Conclusion

Based on the findings and discussion, this study concludes that the interactive Virtual Reality (VR)-based learning media developed using the RADEC (Read, Answer, Discuss, Explain, Create) approach through the ADDIE model has been

successfully designed and implemented for fifth-grade Ilmu Pengetahuan Alam dan Sosial (IPAS) learning, particularly on the topic of the human digestive system. The research objectives were achieved, as the developed media demonstrated feasibility, practicality, and effectiveness in supporting the learning process. Expert validation results confirmed that the VR-based learning media met the required standards in terms of content accuracy, media design, and language suitability, indicating that the product is appropriate for use in elementary school settings. The practicality evaluation further showed that the media was easy to use, supported classroom management, and facilitated learning activities from both teacher and student perspectives. This indicates that the developed media can be effectively implemented in real classroom situations without significant obstacles.

Furthermore, the effectiveness of the VR-based RADEC learning media was evident in its ability to enhance students' learning processes. The immersive and interactive nature of Virtual Reality, combined with the structured stages of the RADEC approach, encouraged active participation, improved conceptual understanding, and supported the development of cognitive, psychomotor, and affective aspects of learning. Students were more engaged, focused, and enthusiastic during the learning activities, resulting in a more meaningful and student-centered learning experience. Overall, this study confirms that VR-based interactive learning media integrated with the RADEC approach is a successful and innovative solution for IPAS learning in elementary schools and supports the objectives of the Kurikulum Merdeka in fostering active, contextual, and engaging learning environments.

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How to cite this article:

Furkan, I. M., Amini, R., Muhammadi., & Rayendra. (2026). Development of Interactive Virtual Reality Learning Media Based on the RADEC Model for Science Learning in Elementary Schools. *Journal of Educational Sciences*, *10(3)*, 343-358.