



Enhancing Learning Effectiveness in Sports Physiology through Green Screen–Based Instructional Media: An ADDIE Development Study

Sanusi Hasibuan^{1*}, Indra kasih¹, Rahmi Aulia¹, Andes Martua¹, Nur Khilolah¹, Muhammad Ishak¹

¹ Physical Educatio Health and Recreation, Faculty of Sport Science, Universitas Negeri Medan, North Sumatra, Indonesia
sanusihhasibuan@unimed.ac.id

Abstract. The integration of digital media in sport science education has become increasingly critical for enhancing conceptual understanding and learner engagement. This study investigates the effectiveness of Green Screen–based animation as an instructional medium in a Sports Physiology course. Employing a research and development design, the study follows the ADDIE framework (Analyze, Design, Develop, Implement, Evaluate) to systematically produce and evaluate the learning media. The research was conducted within a Physical Education and Sport Science program at the tertiary level. Content validity and feasibility were assessed through expert evaluations, yielding high scores across domains: subject-matter experts (91%), language experts (94%), and media experts (95%), all categorized as highly appropriate. Empirical testing demonstrated a measurable improvement in learning outcomes, with both small- and large-group implementations indicating a 15% increase in performance. Furthermore, comparative analysis revealed that students exposed to the Green Screen–based media achieved a mean score of 95%, significantly outperforming the control group (78%), reflecting a 17% performance gap. These findings suggest that immersive visual media grounded in multimedia learning theory can substantially enhance cognitive processing and retention in sport physiology education [1], [2]. The use of Green Screen technology enables contextualized visualization of complex physiological processes, thereby improving instructional effectiveness. This study contributes to the growing body of evidence supporting technology-enhanced learning in sport science and highlights its pedagogical relevance in higher education settings.

Keywords: Green Screen technology, sports physiology education, ADDIE model, instructional media development, learning effectiveness.

1 Introduction

The quality of higher education is fundamentally shaped by the effectiveness of interactions between lecturers and students, where learning is conceptualized as a dynamic and reciprocal process aimed at achieving clearly defined educational outcomes. In this context, lecturers function not only as knowledge transmitters but also as facilitators who design meaningful learning experiences that actively engage students. The synergy between teaching and learning activities is therefore essential in promoting deeper understanding and academic achievement.

The rapid transformation of higher education, particularly in the era of the Industrial Revolution 4.0, demands continuous innovation in instructional practices. Universities are increasingly required to integrate digital technologies to remain adaptive and relevant in a globalized educational landscape [1]. This transformation highlights the urgency of adopting technology-enhanced learning approaches that support flexible, interactive, and student-centered environments [2]. Consequently, the integration of multimedia tools has become a strategic priority in improving instructional quality and learning outcomes.

Within the domain of sport science, sports physiology represents a foundational discipline that examines the body's acute and chronic responses to physical activity and training stimuli. A comprehensive understanding of physiological mechanisms—such as cardiovascular adaptation, muscular endurance, and metabolic regulation—is essential for designing effective training programs and optimizing athletic performance [3], [4]. However, the abstract and complex nature of physiological concepts often presents challenges for students, particularly when instruction relies predominantly on conventional, text-based methods.

To address these challenges, the use of innovative instructional media is increasingly advocated. One such approach is Green Screen–based learning media, which utilizes chroma key technology to integrate instructors with dynamic visual content. This technique enables the visualization of abstract physiological processes in a more concrete and engaging manner, thereby facilitating cognitive processing and knowledge retention. From the perspective of multimedia learning theory, the combination of visual and auditory information enhances learners' ability to construct meaningful mental representations [5].

Empirical evidence suggests that technology-enhanced multimedia learning environments can significantly improve student motivation, engagement, and academic performance in higher education settings [6], [7]. In sport science education specifically, interactive visual media have been shown to support conceptual understanding of complex biomechanical and physiological processes. Therefore, the implementation of Green Screen–based instructional media is expected to provide an innovative solution for improving the effectiveness of learning in sports physiology courses.

Based on this rationale, the present study aims to develop and evaluate Green Screen–based learning media using the ADDIE instructional design model. This study contributes to the advancement of pedagogical practices in sport science education by integrating technological innovation with evidence-based instructional design.

2 Methodology

This study employed a research and development (R&D) approach to design, produce, and evaluate Green Screen–based instructional media for a Sports Physiology course. The development process followed the ADDIE instructional design framework, which consists of five systematic phases: Analyze, Design, Develop, Implement, and Evaluate. This model is widely recognized for its structured and iterative approach to educational product development, ensuring both pedagogical validity and practical applicability [8].

The research was conducted at the Faculty of Sports Science, Department of Physical Education, Health, and Recreation, Universitas Negeri Medan. The participants comprised 75 undergraduate students enrolled in the Sports Physiology course. These participants were selected using a purposive sampling technique to ensure their relevance to the instructional context and learning objectives.

During the Analyze phase, a needs assessment was conducted to identify learning challenges, particularly students' difficulties in understanding abstract physiological concepts such as energy metabolism, cardiovascular responses, and muscular adaptation. The findings informed the design of multimedia-based instructional solutions. In the Design phase, learning objectives, content structure, and media specifications were formulated, integrating principles of multimedia learning to optimize cognitive processing.

The Develop phase involved the production of Green Screen–based instructional videos using chroma key techniques to integrate visual simulations with instructor explanations. The developed media were subsequently evaluated through expert validation, including subject-matter experts, instructional design specialists, and language experts, to ensure content accuracy, pedagogical appropriateness, and linguistic clarity. The validation instrument employed was a structured questionnaire using a Likert scale, designed to assess key indicators such as content relevance, visual quality, instructional clarity, and usability.

In the Implementation phase, the validated media were applied in classroom settings involving small- and large-group trials. Learning effectiveness was measured using pre-test and post-test assessments to examine improvements in students' cognitive understanding of sports physiology concepts. Finally, the Evaluation phase involved both formative and summative analyses, including descriptive statistics (mean scores, percentage gains) and comparative analysis between experimental and control groups to determine the effectiveness of the developed media.

The integration of multimedia instructional design with sport science pedagogy in this study aligns with contemporary evidence indicating that technology-enhanced learning environments significantly improve conceptual understanding and student engagement in higher education [9].

3 RESULT AND RESEARCH DISCUSSION

3.1 Result of Research

The development of Green Screen–based instructional media followed the ADDIE framework, yielding systematic outputs across each phase. The findings demonstrate both high feasibility and significant learning effectiveness [10].

During the analysis phase, needs assessment—conducted through observations and stakeholder interviews—identified key challenges in understanding abstract sports physiology concepts (e.g., cardiovascular dynamics, respiratory mechanisms, and neural regulation). These findings informed the design of visually enriched instructional materials.

In the design and development phases, the media product was constructed and subsequently validated by experts. The validation results indicate a high level of content accuracy and usability. Subject-matter validation showed strong performance across physiological domains, with cardiovascular (96%), respiratory (90%), and nervous system (89%) indicators, producing an overall average of 91%. Language validation yielded an average score of 94%, reflecting clarity, pronunciation accuracy, and subtitle alignment. Media expert evaluation reported an average score of 95%, confirming the visual quality, instructional structure, and operational usability of the product .

Small-group testing demonstrated moderate effectiveness, with scores ranging between 78% and 79% across all indicators, resulting in an overall mean of 80%, categorized as acceptable. Following iterative improvements, large-group implementation revealed substantial gains, with performance scores increasing to an average of 95%, categorized as excellent. In contrast, the comparison (control) group achieved an average score of 78%, indicating a 17% performance difference in favor of the experimental group.

Table 1. Summary of Validation and Learning Outcomes

Evaluation Component	Score (%)	Category
Content Expert Validation	91	Highly Valid
Language Expert Validation	94	Highly Valid
Media Expert Validation	95	Highly Valid
Small Group Trial	80	Acceptable
Large Group Trial	95	Excellent
Control Group	78	Good

These results confirm that the developed Green Screen–based instructional media meets high standards of feasibility and demonstrates strong effectiveness in improving student learning outcomes in sports physiology.

3.2 Discussion

The findings indicate that Green Screen–based instructional media significantly enhances students' understanding of sports physiology concepts. This improvement can be explained through multimedia learning theory, which posits that the integration of visual and verbal information facilitates deeper cognitive processing and knowledge retention [11]. By embedding instructors within dynamic visual simulations, the Green Screen approach enables learners to connect abstract physiological processes with concrete representations.

In sport science education, many concepts—such as cardiovascular adaptation, neuromuscular coordination, and metabolic energy systems—are inherently complex and difficult to observe directly. The present findings demonstrate that visualizing these processes through animation improves conceptual clarity and reduces cognitive load. This aligns with recent studies indicating that interactive and immersive media significantly improve learning outcomes in science-based disciplines [2], [3].

The substantial improvement observed in the large-group trial (95%) compared to the control group (78%) suggests that the instructional media not only enhances comprehension but also increases engagement and motivation. From a pedagogical perspective, this can be attributed to the dual coding mechanism, where information is processed through both visual and auditory channels, leading to stronger memory encoding [12]. Furthermore, dynamic visualization supports the understanding of sequential physiological processes, such as oxygen transport, muscle contraction, and fatigue development.

Another important implication relates to learning engagement and motivation. The integration of animation and contextual visualization creates a more immersive learning environment, reducing monotony often associated with traditional lecture-based instruction. Prior research confirms that video-based and animation-supported instruction increases student attention and active participation, particularly in higher education settings [5].

From a sport science perspective, the use of Green Screen technology allows lecturers to simulate real-time physiological responses during exercise, such as heart rate changes, oxygen consumption (VO_2), and energy system transitions. This enhances students' ability to apply theoretical knowledge to practical contexts, which is essential in physical education and coaching sciences.

In addition, the scalability and flexibility of Green Screen–based media make it highly compatible with hybrid and digital learning environments, which are increasingly prevalent in higher education. This aligns with current trends in educational technology, emphasizing the integration of digital tools to support adaptive and student-centered learning [6].

Overall, the results confirm that Green Screen–based instructional media is not only technologically innovative but also pedagogically effective. It provides a robust solution for addressing conceptual challenges in sports physiology and contributes to the advancement of technology-enhanced learning in sport science education.

4 CONCLUSION

The findings of this study demonstrate that Green Screen–based instructional media constitutes an effective and pedagogically robust approach for teaching Sports Physiology at the tertiary level. The developed media achieved high feasibility across expert validations ($\geq 91\%$) and produced a substantial improvement in student learning outcomes, with experimental group performance exceeding the control group by approximately 17%. These results confirm that integrating dynamic visualizations with instructor-led explanations can significantly enhance conceptual understanding of complex physiological processes, including cardiovascular responses, respiratory mechanisms, and neuromuscular adaptations.

From a theoretical perspective, the effectiveness of the developed media is consistent with multimedia learning principles, which emphasize the integration of visual and auditory channels to optimize cognitive processing and knowledge retention [1]. The use of Green Screen technology enables contextualized and immersive representations of abstract sport physiology concepts, thereby reducing cognitive load and facilitating deeper learning. This is particularly relevant in sport science education, where many physiological mechanisms are not directly observable and require visualization to support comprehension.

Moreover, the implementation of Green Screen–based media contributes to increased student engagement and motivation by creating an interactive and visually enriched learning environment. Such technology-enhanced approaches are aligned with current trends in higher education, which prioritize digital innovation and flexible learning modalities to improve instructional effectiveness [13].

In conclusion, this study highlights the potential of Green Screen animation technology as an innovative instructional solution in sports physiology education. Its integration into teaching practice not only improves learning outcomes but also supports the development of more engaging, adaptive, and student-centered learning environments. Future research is recommended to explore its long-term impact on knowledge retention, practical skill transfer, and its applicability across other domains within sport science.

Acknowledgments. The authors would like to express their sincere appreciation to Universitas Negeri Medan (UNIMED) for its institutional support in facilitating this study. Gratitude is also extended to colleagues and academic peers who provided valuable insights and constructive feedback throughout the research process. Their contributions have significantly enhanced the conceptual clarity and academic quality of this work.

Disclosure of Interests. The authors declare that there are no competing interests associated with this study. The research was conducted independently, without any financial or commercial relationships that could be interpreted as a potential conflict of interest.

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