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THE EFFECTIVENESS OF MOBILE LEARNING-BASED INTERACTIVE LEARNING MEDIA AS A MEANS TO DEVELOP CONCEPT UNDERSTANDING IN JUNIOR HIGH SCHOOL SCIENCE MATERIALS

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Abstract

Natural Science (IPA) learning at the Junior High School (SMP) level faces challenges in improving students' understanding of concepts effectively and interestingly. The use of conventional learning media is considered less able to motivate students and visualize scientific concepts optimally. In today's digital era, mobile learning (m-learning) is an innovative solution that allows the teaching and learning process to be carried out anytime and anywhere through mobile devices such as smartphones and tablets. Mobile learning-based interactive learning media provides various features such as animations, simulations, interactive quizzes, and educational videos that are able to increase students' interest, motivation, and understanding of science materials. Based on various studies and research, it was found that the use of this media significantly improved students' learning outcomes and concept understanding compared to traditional learning methods. In addition, this media is able to provide a more enjoyable and meaningful learning experience, as well as facilitate flexible access to information and practice. The results of this study show that mobile learning-based interactive learning media is an effective alternative to support the science learning process in junior high school, as well as support the development of learning that is more innovative and relevant to today's needs.

Keywords: *interactive learning media, mobile learning, effectiveness, concept understanding, science materials*

INTRODUCTION

Natural Science (IPA) learning at the Junior High School (SMP) level is an important stage in the educational process because it serves as the main foundation in instilling the foundation of scientific knowledge and developing critical thinking, analytical, and scientific inquiry skills in students from an early age (Rahmat et al., 2023). At this level, students are exposed to various scientific concepts that are complex and abstract, such as atomic structure, energy, life cycles, and other natural phenomena that require a learning approach that is able to facilitate the understanding and internalization of these concepts in an effective, interesting, and fun way (Laumann et al., 2025).

However, in reality, student learning outcomes in science subjects in junior high school often have not reached the expected target. The main factor that causes this is the low interest

and motivation of students in science subject matter. This lack of interest can result in students becoming passive, less actively participating, and even feeling bored during the learning process (Fitriyah & Affifah, 2023). In addition, conventional methods that are one-way and less interactive are also the main obstacles in achieving a deep and sustainable understanding of concepts. Lecture methods, filling out traditional practice questions, and monotonous use of media are often unable to foster student involvement and creativity optimally, so that learning outcomes become less meaningful and difficult to maintain (Dimitrios et al, 2024).

In facing these problems, innovation in learning methods and media is an urgent need to increase the effectiveness of the teaching and learning process. One of the innovations that shows great potential is the application of mobile learning (m-learning) technology (Sinaga et al., 2024; Pedraja et al., 2024). Mobile learning utilizes mobile devices such as smartphones, tablets, and other devices that are able to support internet access, so that the learning process can be carried out anytime and anywhere according to the needs of students (Qazi et al., 2024).

The main advantage of m-learning lies in its high flexibility, allowing students to access the subject matter directly, at their pace and interest in learning, without having to depend on a specific space and time in the classroom (Parusheva et al., 2025; moya et al., 2024). In addition, this mobile-based learning media is able to provide a more interesting, interactive, and innovative learning experience through features such as simulations, animations, educational videos, and interactive quizzes that are able to explain scientific concepts visually and practically (Hardika et al., 2024). These features not only help visualize difficult concepts, but also stimulate students' critical, analytical, and creative thinking processes in answering problems and testing their understanding directly through interactive exercises (Thornhill et al., 2023; Kwangmuang et al., 2021).

With the presence of this learning media, the science learning process in junior high schools can become more fun, meaningful, and relevant to technological developments and the needs of modern society today. Therefore, the application of mobile learning-based interactive learning media is expected to be able to significantly improve the quality of science learning, increase students' interest and motivation, and produce a better, sustainable, and competitive understanding of concepts in the digital era.

Limitations of Traditional Teaching Methods

This section contains literature that is referenced and linked to hypothesis research and development. This section also contains theories and literature that are referenced and connected to article writing. It is highly recommended that the referenced literature be published no more than 10 years in advance in the following order: well-known international journals, accredited national journals, national journals, international symposiums, national symposiums, textbooks, and daily reputations. Conventional science teaching in junior high schools tends to be teacher-centered, with an emphasis on passive learning. This approach typically involves lectures supplemented by static visual aids like static images, diagrams, and textbook explanations. While these methods provide a foundational framework, they frequently encounter several limitations:

1. Many scientific concepts such as atomic structures, electromagnetic waves, metabolic pathways, or ecological cycles are inherently abstract and difficult to visualize. Static images or verbal descriptions alone often fail to provide an adequate mental model for students, leading to superficial understanding or misconceptions (Wachidyastuti & Wilujeng, 2024).
2. Traditional methods tend to promote passive absorption of information, resulting in decreased motivation and interest. When students are merely recipients of knowledge, they are less likely to develop curiosity or motivation to explore further, which can diminish their enthusiasm for learning science (Kooloos et al., 2020).
3. Active learning strategies such as experimental investigations, discussions, and problem-solving activities are essential for deep understanding. Nonetheless, traditional approaches often do not effectively facilitate hands-on experiences, especially in resource-constrained environments, rendering students passive observers rather than active participants (Fitriyah & Affifah, 2023).
4. Standardized teaching methods may not accommodate the diverse learning styles, paces, and prior knowledge levels of individual students, limiting personalized learning opportunities (Barrera et al., 2025).
5. The fixed classroom setting constrains learning time and location, reducing opportunities for independent study, review, or reinforcement outside school hours van Dijk et al., 2020).

The Need for Innovative Educational Tools

In response to these limitations, educators and researchers have been exploring innovative instructional strategies and media to enhance science learning. One promising solution that has gained considerable attention is mobile learning (m-learning). As digital devices such as smartphones and tablets become increasingly prevalent among students, these tools open new horizons for more interactive, engaging, and personalized science education (Qazi et al., 2024).

Mobile learning refers to the utilization of portable digital devices and wireless communication technologies to facilitate learning experiences that are flexible, accessible, and interactive. Its integration into science education is driven by several compelling advantages:

1. Mobile devices support rich multimedia content, including animations, simulations, 3D models, and videos, which can vividly illustrate complex and abstract scientific phenomena. For example, animations of molecular interactions or celestial movements help students visualize otherwise intangible concepts (Hardika et al., 2024).
2. Interactive features such as quizzes, games, and simulations allow students to engage actively with the content, experiment in virtual environments, and receive immediate feedback. This fosters inquiry-based learning and enhances conceptual understanding (Wachidyastuti & Wilujeng, 2024).
3. Mobile devices enable learners to access educational materials anytime and anywhere, promoting self-directed learning and review outside classroom settings. This flexibility

supports diverse learning paces and styles, making education more inclusive (Qazi et al., 2024).

4. The multimedia and interactive nature of mobile learning environments tend to be more engaging than traditional methods, capturing students' interest and motivating them to explore scientific topics deeply (Kassa et al., 2024)
5. In regions where laboratories, teaching aids, or visual materials are scarce, mobile learning can provide alternative means of visualization and experimentation through virtual simulations, making science concepts accessible to all students regardless of their geographic or economic constraints (Kharki et al., 2021).

RESEARCH METHOD

In this study, the author uses a literature review approach by analyzing various research sources, scientific articles, study reports, and relevant case studies regarding the use of mobile-based interactive learning media in the context of science learning at the junior high school level. Data was collected through a systematic review of scientific journals, research reports, and articles containing experimental results and empirical studies on the effectiveness and impact of mobile learning media on student learning processes and outcomes. The provisions for data inclusion include research conducted in the last five years, which focuses mainly on the development and application of mobile-based learning media, as well as those that present quantitative and qualitative data related to improving students' understanding of concepts. The data obtained were then analyzed qualitatively to assess the main patterns, significant findings, and supporting factors for the successful use of this media in improving the understanding of science concepts in junior high school. This analysis is also enriched by linking the results of these studies to the theoretical framework of constructivism and the principles of modern pedagogy that emphasize interactivity, visualization, and active learning experiences. Through this approach, the author aims to compile a comprehensive overview of the effectiveness of mobile learning media and its usefulness as an innovation in science education in junior high school.

RESULT

The analysis of numerous recent empirical studies indicates that the integration of mobile learning-based interactive media significantly enhances students' comprehension of scientific concepts at the junior high school level. The key findings from these studies are outlined below:

1. Enhanced Student Engagement and Motivation

Research consistently shows that mobile interactive media can effectively increase students' interest and enthusiasm toward science learning. (Hardika et al., 2024) conducted an experimental study involving junior high school students who utilized mobile-based interactive platforms during science lessons. The results demonstrated that students showed a higher level of engagement, with increased participation in learning activities compared to traditional teaching methods. The multimedia features such as animations illustrating scientific processes, simulations allowing virtual experimentation, and interactive quizzes created a dynamic and

stimulating learning environment. This environment helped reduce feelings of boredom often associated with conventional teaching approaches, thereby boosting intrinsic motivation and fostering a positive attitude toward science learning. Moreover, students expressed greater enthusiasm in exploring topics independently outside classroom hours through the mobile applications.

2. Improved Visualization of Abstract Concepts

One of the most notable advantages of mobile learning media is its capacity to visualize complex and abstract scientific phenomena. (Wachidyastuti & Wilujeng, 2024) highlighted that visual tools embedded within mobile platforms such as 3D models and interactive simulations allow students to observe and manipulate representations of atomic structures, Newtonian physics, biological cycles, and chemical reactions. Their study found that these visual aids significantly improved students' cognitive understanding, as they could see the dynamic nature of scientific processes, which are often difficult to grasp through static images or textual descriptions alone. For instance, students who interacted with simulations of planetary orbits or biochemical reactions could better comprehend the underlying principles, resulting in higher scores in concept mastery assessments compared to their counterparts who relied solely on traditional instruction.

3. Better Conceptual Understanding and Retention

The incorporation of interactive features in mobile media facilitates active learning, which is known to lead to deeper understanding and better long-term retention of knowledge. (Fitriyah & Affifah, 2023) investigated how interactive activities such as virtual experiments and immediate feedback quizzes affected students' mastery of science concepts. Findings revealed that students who engaged with these features not only improved their immediate understanding but also retained the information more effectively over time. The active manipulation of variables in simulations and the real-time feedback mechanism fostered a constructivist learning process, encouraging students to reflect, analyze, and correct their misconceptions promptly. Consequently, their conceptual grasp stabilized and became more durable, as evidenced by higher scores in post-tests administered weeks after the instructional activity.

4. Increased Accessibility and Flexibility in Learning

The portability and ubiquity of mobile devices allow students to access learning materials anytime and anywhere facilitating flexible and personalized learning experiences. Studies, including those reviewed by (Hardika et al., 2024), have documented that mobile learning provides students the opportunity to review lessons, practice exercises, and explore additional content beyond the constraints of the classroom environment. This flexibility supports self-paced learning and caters to individual learning paces, encouraging students to revisit difficult topics multiple times, which enhances mastery. Furthermore, mobile access helps bridge gaps caused by resource limitations, allowing students to learn in various contexts at home, during travel, or in less equipped classrooms making science education more inclusive and adaptable.

5. Positive Impact on Learning Outcomes

Quantitative analyses from multiple studies reveal that students using mobile learning-based interactive media significantly outperform their peers in standard assessments of science concepts. For example, experimental groups exposed to mobile multimedia platforms regularly achieved higher scores on tests and concept inventories than control groups taught via conventional lectures and textbooks. Statistical significance was confirmed in various research reports, indicating that the use of such media contributes to measurable improvements in students' academic achievement. The enhanced understanding correlated with increased motivation, visual learning, and active participation in learning activities facilitated through mobile platforms. (Gebremeskel et al., 2024)

DISCUSSION

The findings from the analyzed studies clearly demonstrate that mobile learning-based interactive media significantly enhances students' understanding of science concepts at the junior high school level. Several interconnected themes and pedagogical principles emerge from the results, providing a deeper understanding of why and how such media influence learning outcomes.

1. Active Engagement and Motivation as Catalysts for Learning

One of the most conspicuous advantages of mobile interactive media is its capacity to boost student engagement and motivation. As (Hardika et al., 2024) discovered, the multimedia features animations, simulations, and interactive quizzes transform passive learners into active participants. This shift aligns strongly with constructivist theories (Nitiasih et al., 2024), which posit that meaningful learning occurs when students actively construct knowledge through hands-on experiences. The engaging nature of these features reduces boredom and fosters curiosity, leading to increased enthusiasm and sustained attention during science lessons. Motivated students are more likely to invest effort, explore topics independently, and develop positive attitudes toward science, which are critical factors influencing academic achievement (Amerstorfer & Kistner, 2021).

2. Visualizations as Enablers of Conceptual Clarity

A central challenge in science education involves conveying abstract phenomena that are inherently difficult to visualize, such as atomic structures or biological processes. (Wachidyastuti & Wilujeng, 2024) highlighted that mobile media's visualization tools like 3D models and dynamic simulations play a vital role in overcoming this hurdle. These digital visualizations serve as cognitive scaffolds, helping students form accurate mental models and reducing misconceptions. The ability to manipulate and observe processes interactively enhances comprehension and supports cognitive processes like dual coding (Rafifing et al., 2025), where visual and verbal information work together to improve understanding and memory retention.

3. Promoting Deep Learning Through Interactive and Experiential Activities

The results indicate that interactive features virtual experiments, immediate feedback quizzes, and scenario-based activities encourage deeper engagement with the material. (Fitriyah & Affifah, 2023) emphasized that such activities foster active experimentation, exploration, and reflection, essential components of meaningful learning. This experiential approach allows learners to test hypotheses, analyze outcomes, and self-correct, thereby reinforcing correct conceptions and enabling durable understanding. The immediate feedback loop fuels metacognition, guiding students to identify their strengths and weaknesses, which further promotes autonomous learning.

4. Flexibility and Personalization in Learning

The portability of mobile devices grants learners the freedom to access educational content anytime and anywhere. This flexibility facilitates a personalized learning experience, accommodating different paces and styles a crucial factor given the diverse needs of students (Qazi et al., 2024). For instance, students can revisit challenging topics multiple times or explore supplementary resources, thereby reinforcing mastery through repeated exposure. Such self-directed learning mechanisms often lead to increased confidence and independence, vital attributes for lifelong learning.

5. Implications for Pedagogy and Policy

The positive outcomes associated with mobile learning media suggest several implications for educators, curriculum developers, and policymakers:

a. Curriculum Integration: Mobile learning should be incorporated systematically into science curricula, incorporating activities aligned with learning objectives and assessment standards.
b. Teacher Training: Educators need professional development to effectively design, facilitate, and evaluate mobile-based learning experiences.
c. Infrastructure Development: Sufficient access to devices and reliable internet connectivity must be prioritized to ensure equitable opportunities for all students.
d. Content Development: High-quality, culturally relevant, and age-appropriate interactive content should be continuously developed and updated.

Challenges and Limitations

Despite its benefits, mobile learning implementation faces obstacles such as technological disparities, potential distractions, and the need for pedagogical shifts in teaching strategies. Ensuring equitable access remains a challenge, particularly in underserved areas. Moreover, the efficacy of mobile learning depends on well-designed, pedagogically sound content and active facilitation by teachers to prevent superficial engagement (Song et al., 2021).

Advances in emerging technologies such as Augmented Reality (AR), Virtual Reality (VR), and Artificial Intelligence (AI) offer exciting prospects for further enriching mobile

science education. These innovations can foster immersive and customized learning environments that transcend traditional limitations. Longitudinal studies are also needed to assess the sustained impact of mobile learning on long-term knowledge retention, attitudes toward science, and development of scientific skills (Peikos et al., 2024).

CONCLUSION

The integration of mobile learning-based interactive media into junior high school science education has been demonstrated to be highly effective in improving students' understanding of scientific concepts. Empirical evidence from various recent studies shows that this approach significantly enhances student engagement, motivation, visualization of abstract phenomena, and deepens conceptual comprehension. The interactive features such as animations, simulations, and immediate feedback activate learners in meaningful ways, fostering active participation and long-term retention of knowledge.

Furthermore, the flexibility and accessibility offered by mobile learning tools support individualized learning experiences, enabling students to explore and review content at their own pace and convenience. These advantages align with contemporary pedagogical principles emphasizing student-centered and inquiry-based learning, making science education more engaging, effective, and inclusive.

Despite some challenges related to infrastructure and content development, the promising results highlight the importance of further integrating mobile interactive media into the curriculum. Policymakers, educators, and content developers should collaborate to ensure equitable access, train teachers effectively, and produce high-quality, contextualized media resources. Embracing this technological innovation has the potential to transform science teaching practices, produce more competent learners, and prepare students to thrive in a digital, knowledge-driven society.

Overall, mobile learning-based interactive media emerges as a vital tool to modernize science education in junior high schools, offering an exciting pathway toward fostering a deeper understanding of science concepts, increasing student motivation, and cultivating essential 21st-century skills.

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