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The Conceptualization of VIVO LEARN (Visual Interactive Virtual Object) in the Transformation of Science Learning in Elementary Schools

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Abstract

The advancement of Artificial Intelligence (AI) presents significant opportunities for transforming instructional media in elementary education, however, its implementation often lacks a robust theoretical foundation. This study aims to formulate the conceptualization of VIVO LEARN (Visual Interactive Virtual Object) as a novel framework in elementary science learning to bridge the understanding of abstract concepts. A qualitative descriptive method was employed, utilizing content analysis and literature review to synthesize theories of multimedia learning, cognitive load, and constructivism. The analysis establishes that the VIVO LEARN concept comprises four primary components: AI-based precision visualization, guided interactivity, contextual virtual objects, and visual interactive scaffolding. The study further demonstrates that, theoretically, VIVO LEARN can reduce extraneous cognitive load and enhance active student engagement through the manipulation of digital objects. This research provides a theoretical foundation for the systematic development of AI-based animation media. The conceptualization of VIVO LEARN offers a new paradigm that integrates technological sophistication with theoretical pedagogical strength. These findings imply a necessary shift in digital media design concepts from mere information presenters to instruments of knowledge construction.

Keywords: VIVO LEARN, Artificial Intelligence, Science Learning, Elementary School.

INTRODUCTION

The advancement of digital technology in the Industry 4.0 and toward the 5.0 era has brought a major transformation to the landscape of elementary education. Science learning in elementary schools, which has traditionally relied on face to face interactions

and print media, is now required to adapt to the characteristics of the digital cognitive generation. However, current realities indicate that technology integration is often merely a substitution, where digital media simply transfers textbook text onto screens without altering the essence of learning interaction (Aeni, & Fatharani, 2025);(Astri et al., 2025). In essence, science education is not merely a transfer of information but a process of constructing understanding of complex natural phenomena.

A primary challenge in elementary science education is the abstract and microscopic nature of the subject matter. According to Piaget's theory of cognitive development (Piaget, 1972), elementary school students are in a transition phase from the concrete operational to the formal operational stage. During this phase, students require robust visual aids to comprehend concepts that cannot be observed directly, such as photosynthesis, energy flow, or the molecular structure of water (Swistiyawati, 2024);(Nurhidayanti, 2025). Without appropriate media intervention, students are prone to developing permanent misconceptions.

While conventional video media has long been implemented in science learning, it possesses limitations regarding active cognitive engagement. One way video often positions students as passive observers, causing the loss of the "inquiry" element, which is the soul of science education (Prananda et al., 2021);(Sae & Radia, 2023). This necessitates media innovation that not only visualizes objects but also provides space for virtual interaction. This serves as the foundation for the conceptual development of VIVO LEARN (Visual Interactive Virtual Object) as a solution to the constraints of traditional audiovisual media.

The researchers adopt the term VIVO LEARN as a conceptual construct in learning rather than a commercial representation. In this study, VIVO LEARN is defined as an intelligent digital media based learning concept that integrates dynamic visualization, precision interactivity, and adaptive virtual objects to facilitate exploration, manipulation, and the active construction of contextual conceptual understanding for students.

Etymologically, VIVO LEARN is a Learning Ecosystem. The word "Learn" emphasizes that all integrated technologies are subordinate to pedagogical objectives. Through the Visual component, this concept prioritizes the sense of sight to concretize invisible abstract phenomena, while the Interactive aspect creates a responsive reciprocal relationship to student manipulation during experimentation. The presence of Virtual Objects completes this concept by presenting "real objects in digital space," allowing students to move beyond

observing static images to experiencing the direct sensation of holding, dismantling, and testing virtual objects similar to interacting with physical objects in the real world.

Through this approach, abstract scientific phenomena are transformed into digital representations that can be observed and manipulated from various virtual perspectives. The responsive nature of these interactions enables students to engage actively, moving from passive reception to knowledge construction through direct experience. This aligns with Faber, (2024), who argues that effective instructional media must provide dynamic visual scaffolding to help manage students' cognitive load.

Conceptually, VIVO LEARN integrates three core characteristics: Visual, Interactive, and Virtual. The Visual aspect enables the presentation of scientific phenomena through detailed and precise graphical representations. The Interactive aspect allows students to manipulate learning objects directly, encouraging active engagement through the principle of "learning by doing." Meanwhile, the Virtual aspect provides flexible, safe, and repeatable simulations accessible without space and time constraints. This synergy aligns with Mayer, (2021) views on visualization effectiveness and Schunk, (2020) emphasis on interactive features in learning by doing. Furthermore, the flexibility of the virtual aspect provides boundless exploration space, which Dede, (2009) considers crucial for building deep scientific understanding in a safe digital environment.

The integration of Artificial Intelligence (AI) in the development of the VIVO LEARN concept acts as a significant game changer. The use of AI, such as Whisk AI, enables the creation of precise and responsive animated content more efficiently than conventional methods. AI plays a role in generating smoother visualizations and personalized narratives tailored to the elementary school curriculum (Amalia, 2024);(Shaniya, 2024). This offers a significant opportunity for educators to create digital learning ecosystems that are smarter and more adaptive to varying student learning paces.

Furthermore, while local wisdom often serves as an effective bridge in explaining science concepts, it is rarely integrated into modern virtual media. AI-based VIVO LEARN allows local values to be embedded into virtual objects, making science learning more relevant and meaningful. This approach aligns with the principles of Contextual Teaching and Learning (CTL), which emphasizes the connection between subject matter and students' real-life contexts (Johnson, 2002).

Despite the perceived potential of VIVO LEARN, literature regarding its conceptualization and fundamental framework remains limited. Most research focuses on

application usage without establishing a strong theoretical foundation on how virtual objects function within the cognition of elementary students. Therefore, an in-depth study is required to dissect how the elements within VIVO LEARN can be transformed into valid and practical instructional media designs.

Based on this background, this article aims to formulate the conceptualization of VIVO LEARN as a framework for transforming elementary science education. The primary focus is on the integration of Visual Interactive Scaffolding via AI technology to overcome visualization barriers of abstract concepts. The results of this conceptual study are expected to provide a solid theoretical foundation for future AI-based instructional media development while contributing to the literature on primary education technology.

METHOD

This study employs a qualitative approach with a descriptive-analytical method to dissect the conceptualization of VIVO LEARN in science education. As explained by Creswell, (2014) qualitative research is an approach for exploring and understanding the meaning that individuals or groups ascribe to a social or human problem. The primary focus of this method is to explore in depth how the integration of virtual objects and artificial intelligence can transform the cognitive processes of elementary school students. This research does not aim to test product effectiveness directly in the field; instead, it seeks to establish a robust theoretical framework through the synthesis of contemporary literature on educational technology and cognitive psychology.

Data collection procedures were conducted through a systematic search of relevant secondary literature, including reputable scientific journals, pedagogical textbooks, and reports on the development of AI technology in education from the last five years. The researchers classified the gathered data based on the three fundamental pillars of the VIVO LEARN concept: visualization aspects, interactivity, and the characteristics of virtual objects. Additionally, an analysis of the technical capabilities of AI-based software was performed to map the extent to which such technology can support the principles of Visual Interactive Scaffolding.

The data analysis technique utilized is dialectical content analysis, wherein the researchers compared established multimedia learning theories with the innovative potential offered by AI. The analysis process began with data reduction, where information irrelevant to the characteristics of elementary school students was eliminated. Subsequently,

the data were presented in the form of conceptual drafts and media design frameworks. The researchers linked these theoretical findings with the practical needs of fifth-grade science instruction to ensure pedagogical relevance.

RESULTS AND DISCUSSION

The findings indicate that the conceptualization of VIVO LEARN (Visual Interactive Virtual Object) is a manifestation of digital media transformation centered on creating an adaptive learning ecosystem. VIVO LEARN is designed as a digital entity with specific pedagogical attributes that function as a cognitive bridge. This aligns with Mayer, (2021) Cognitive Theory of Multimedia Learning, which posits that deeper learning occurs when words and pictures are presented simultaneously to build a coherent mental model. As an initial step, the fundamental differences between conventional media and the VIVO LEARN concept are mapped in the following table:

Table 1. Comparison of Conventional Media and VIVO LEARN Characteristics

Dimension	Conventional Video Media	VIVO LEARN Concept (AI-Based)	Pedagogical Impact
Nature of Content	Static and Linear	Dynamic and Non-Linear	Flexibility of student exploration.
Student Role	Passive Observer	Active Participant	Deep cognitive engagement.
Visualization	General Representation	AI-Generated Precision	Reduction of abstract misconceptions.
Interaction	Limited (Play/Pause)	Interactive Scaffolding	Supports inquiry-based methods.

The analysis of the Visualization element in VIVO LEARN emphasizes the principle of Representational Accuracy. By utilizing AI, visualizations can display microscopic details with a level of realism tailored for elementary students. This is supported by Sweller, (2020) Cognitive Load Theory, where the use of precise visuals reduces *extraneous cognitive load*, allowing students' working memory capacity to focus entirely on understanding core

abstract science concepts.

Regarding Interactivity, VIVO LEARN is designed to trigger reflection through *scaffolded interaction*. Students are encouraged to manipulate virtual objects, which, according to Vygotsky, (1978) supports students within their Zone of Proximal Development (ZPD). This interactivity enables students to shift from being passive information recipients to active participants. VIVO LEARN provides space for virtual trial-and error experimentation, which is the heart of developing early scientific literacy.

Concerning the Virtual Object component, this study finds that such objects must be contextual and manipulatable (*digital manipulatives*). This concept is rooted in constructivist theory, which states that knowledge is constructed through direct experience. Virtual objects in VIVO LEARN can be adapted with local wisdom (such as the local flora of West Sumatra), making learning more relevant. To operationalize this concept, the following operational component matrix has been formulated:

Table 2. Operational Component Matrix of the VIVO LEARN Concept

VIVO LEARN Component	Operational Element	Theoretical Basis	Pedagogical Function
Visual	AI Animation	Multimedia Principle	De-abstraction of concepts.
Interactive	Simulated Task	Active Learning	Hypothesis testing.
Virtual Object	Manipulatives	Constructivism	Contextualization of material.
Scaffolding	Dynamic Cues	ZPD (Vygotsky)	Cognitive navigation.

The role of Artificial Intelligence (AI) as the development engine within the VIVO LEARN concept serves as a solution for instructional efficiency. The use of AI, such as Whisk AI, ensures visual consistency, which is vital for maintaining students' selective attention. Consistent with Luckin, (2018) findings, AI in education functions as "intelligence augmentation," enabling the creation of learning environments responsive to individual student needs, thereby making virtual interaction more meaningful.

This study also identifies the role of Visual Interactive Scaffolding (VIS) as a cognitive navigation strategy. This scaffolding works by providing dynamic visual aids that are gradually reduced as student independence increases (*fading*). This strategy is crucial for

elementary school students in the transition from concrete to formal operational thinking, as it provides a stable structure while they explore complex scientific concepts.

As a final synthesis, the conceptualization of VIVO LEARN offers a new paradigm that integrates technological sophistication with theoretical pedagogical strength. The integration of AI visualization, deep interactivity, and contextual virtual objects creates an academically robust learning model. These results provide a strong theoretical foundation for subsequent research phases to empirically prove the effectiveness of this framework in improving student learning outcomes.

DISCUSSION

The discussion regarding the conceptualization of VIVO LEARN (Visual Interactive Virtual Object) begins with the understanding that digital transformation in elementary education is not merely the digitalization of materials, but a restructuring of how students interact with information. VIVO LEARN places virtual objects at the center of the cognitive process; by presenting objects that can be simultaneously visualized and interacted with, VIVO LEARN overcomes the working memory limitations of elementary school students when processing abstract and complex information.

The significance of visualization in VIVO LEARN, supported by Artificial Intelligence (AI), provides advantages in terms of precision and engagement. In science learning, misconceptions frequently occur because students struggle to build accurate mental models of invisible phenomena. The use of AI-based animation within the VIVO LEARN framework enables high-fidelity representations of scientific phenomena. This aligns with the Signaling Principle Sweller, (2020) where visual emphasis on key elements within a virtual object helps students distinguish between essential and redundant information.

Furthermore, the interactivity dimension within the VIVO LEARN concept offers a learning experience that transcends physical manipulation, moving toward cognitive manipulation. Fifth-grade students require active engagement to understand causal relationships in science. Through VIVO LEARN, interactivity functions as Visual Interactive Scaffolding that guides the student's train of thought. As emphasized by Vygotsky, (1978) through the Zone of Proximal Development (ZPD), the presence of structured assistance within interactive media allows students to achieve a higher level of understanding than they could independently through conventional text.

The integration of AI in developing VIVO LEARN also impacts the personalization of learning. AI allows for the creation of virtual objects tailored to local wisdom without

compromising scientific validity. Integrating local content such as the flora, fauna, or natural phenomena of West Sumatra into VIVO LEARN strengthens the Contextual Teaching and Learning (CTL) aspect. According to Tjhong, (2025), learning linked to the real life contexts of students enhances information retention because the human brain more easily organizes information that possesses environmental and emotional relevance.

The advantage of VIVO LEARN over one way video media lies in its ability to facilitate virtual trial and error experimentation. In science learning, failure within a simulation is part of the discovery process. Virtual objects in VIVO LEARN allow students to test various variables within a phenomenon without physical risk. This approach supports social constructivism, where knowledge is not merely delivered by the teacher but is discovered and constructed by students through interaction with their learning environment (Duffy, T. M., & Jonassen, 2013). In this regard, VIVO LEARN acts as an adaptive virtual laboratory environment.

From a cognitive load perspective, VIVO LEARN is designed to optimize Germane Cognitive Load, which is the mental effort dedicated to constructing understanding schemas. With AI's ability to simplify visualizations without losing scientific essence, students do not need to exhaust mental energy interpreting confusing imagery. Kirschner, (2018) argues that effective instructional media directs a student's cognitive energy toward higher order thinking skills, which in VIVO LEARN is realized through the interactive features of virtual objects.

The transformation of science learning through VIVO LEARN also has implications for intrinsic motivation. The use of responsive and interactive animation technology creates an immersion effect. Students no longer perceive learning as a tedious formal activity but rather as exploration within a scientific virtual world. This phenomenon is often referred to as the "flow" state in learning, where the challenges provided by interactive media are balanced with the student's abilities, making the learning process a psychologically rewarding experience (Csikszentmihalyi, 2014).

Theoretically, the conceptualization of VIVO LEARN successfully synthesizes elementary pedagogical needs with current AI capabilities. VIVO LEARN functions not only as a visual aid but as a transformative instrument that renders the classroom ecosystem more dynamic. This discussion reinforces that the successful future implementation of VIVO LEARN will depend heavily on the extent to which this theoretical framework is translated into media designs that respect the psychological characteristics of students. Thus, VIVO

LEARN becomes a crucial foundation for the development of future science media that is more intelligent, interactive, and contextual.

CONCLUSION

Based on the conceptual analysis, it can be concluded that VIVO LEARN (Visual Interactive Virtual Object) serves as a transformative framework for science education that is theoretically capable of bridging the understanding of abstract concepts for elementary school students. The integration of AI-based precision visualization and interactive scaffolding is proven to be a robust foundation for managing students' cognitive load. This conceptualization reinforces that future instructional media must shift from being mere information presenters to becoming interactive instruments that facilitate autonomous knowledge construction.

Suggestions Based on these theoretical findings, it is suggested that educators and media developers should not only focus on the aesthetic aspects of technology when designing digital media but also prioritize the depth of interactivity capable of triggering active cognitive processes. The implementation of the VIVO LEARN concept in elementary schools must consider the psychological characteristics of students in cognitive transition; therefore, the use of visual aids (scaffolding) must be provided proportionately. Furthermore, collaboration between subject matter experts and AI technology specialists is essential to ensure that every generated virtual object maintains high scientific validity.

Future Research Directions As a follow-up to the formulation of this theoretical framework, the researchers have developed a subsequent research plan focusing on implementation and empirical testing. This plan will be realized through Research and Development (R&D) to create animation media products that fully integrate the VIVO LEARN concept (The ScienceGo Project). Future research will test the validity, practicality, and effectiveness of this media in several elementary schools in West Sumatra, aiming to prove that the conceptual foundation formulated in this article has a tangible impact on improving students' science learning outcomes in the field.

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