A WEB-BASED LEARNING ENVIRONMENT (ELSA) INTEGRATING GOVERNMENT-PROVIDED AUGMENTED REALITY TO SUPPORT LEARNING OUTCOMES AND STUDENT ACTIVENESS IN SIXTH-GRADE ELEMENTARY SCHOOL

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ABSTRACT
Education in the era of the Industrial Revolution 4.0 requires learning environments that integrate digital technology in pedagogically meaningful and contextually appropriate ways, particularly in elementary education. This study reports a classroom-based instructional innovation using ELSA (E-Learning SDN Sadeng 03), a web-based learning environment developed with Google Sites and integrated with government-provided augmented reality (AR) resources from *Ruang Murid* within *Rumah Pendidikan*, the national digital education platform developed by the Indonesian Ministry of Education (Kemendikdasmen). The study involved 28 sixth-grade students at a public elementary school in Indonesia and employed a one-group pretest-posttest design to explore changes in learning outcomes and student activeness before and after the intervention. Data were collected through achievement tests, structured classroom observations, and teacher reflective notes. The results indicate an increase in learning mastery on the solar system topic from 50% to 82%, accompanied by an increase in observed student activeness from 25% to full participation. These findings provide preliminary evidence suggesting the potential of a web-based learning environment integrated with augmented reality to support student engagement and learning in elementary science education. However, due to the absence of a control group, the results must be interpreted cautiously, as improvements may also be influenced by maturation, instructional context, or novelty effects. This study contributes practical and pedagogical insights into the integration of government-supported AR resources within low-cost, web-based learning environments for elementary schools.

Keywords: Web-Based Learning Environment; Augmented Reality; Elementary Science Education; Learning Outcomes; Student Activeness

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INTRODUCTION

The rapid development of digital technology in the era of the Industrial Revolution 4.0 has significantly transformed educational practices. Learning is no longer confined to conventional classroom settings but increasingly occurs within digital environments supported by mobile devices, internet connectivity, and interactive multimedia resources. When designed with clear pedagogical intent, digital learning environments can enhance accessibility, flexibility, and student engagement (Fischer et al., 2020; OECD, 2021).

Despite these opportunities, the integration of digital technology in elementary education remains uneven. In many school contexts, smartphones owned by students are predominantly used for entertainment purposes such as social media and online games rather than for learning activities. Excessive recreational smartphone use has been associated with reduced learning motivation, weak self-regulation, and declining academic performance (Kuss & Griffiths, 2017; Twenge, 2019). Similar conditions were observed at SDN Sadeng 03, where all sixth-grade students had access to smartphones, yet their use was largely disconnected from instructional goals.

Initial classroom observations revealed that only 50% of students achieved learning mastery in science, particularly on the topic of the solar system, while observed student activeness during lessons reached only 25%. Teachers and parents expressed concerns regarding low student engagement, limited learning discipline, and frequent off-task behavior related to smartphone use. These conditions highlighted the need for an instructional innovation capable of redirecting smartphone use toward structured, productive, and pedagogically meaningful learning activities.

One promising approach is the use of web-based learning environments that integrate multimedia content and emerging technologies such as augmented reality (AR). Prior research indicates that AR can enhance conceptual understanding and engagement, particularly for abstract and spatially complex science topics, by providing interactive three-dimensional representations (Akçayır & Akçayır, 2017; Ibáñez & Delgado-Kloos, 2018). However, many AR-based learning solutions rely on custom-developed applications, which may limit accessibility and sustainability in elementary schools due to technical and financial constraints.

In response to these challenges, ELSA (E-Learning SDN Sadeng 03) was developed as a web-based learning environment using Google Sites and integrated with AR learning objects provided through *Ruang Murid*, a component of *Rumah Pendidikan*, the official digital education ecosystem developed by the Indonesian Ministry of Education (Kemendikdasmen). Rather than functioning as a standalone software application, ELSA operates as a browser-accessible learning environment that integrates multimedia, interactive activities, and AR resources within a structured instructional flow.

This study aims to explore the potential of ELSA to support learning outcomes and student activeness in a sixth-grade elementary science classroom, while explicitly acknowledging methodological limitations and situating the findings within established pedagogical theories.

METHOD

Research Design

This study employed a one-group pretest-posttest design to explore changes in student learning outcomes and activeness before and after the implementation of ELSA. This design was selected due to practical constraints within the school context. It is explicitly acknowledged that the absence of a control group constitutes a limitation, as it restricts the ability to attribute observed changes solely to the intervention and introduces potential threats to internal validity, including maturation effects, testing effects, instructional context, and novelty effects.

Participants

The participants were 28 sixth-grade students (aged 11-12 years) at SDN Sadeng 03, Indonesia. All students had access to smartphones and basic internet connectivity, enabling them to engage with the ELSA learning environment during classroom instruction and guided independent learning activities.

Learning Intervention

ELSA was developed using Google Sites as a web-based learning environment. The platform included: 1) curriculum-aligned digital learning materials, 2) instructional videos, 3) practice exercises and quizzes, 4) augmented reality (AR) visualizations, 5) educational games, and 6) supplementary learning resources.

The intervention focused on the science topic of the solar system, which requires spatial reasoning and understanding of three-dimensional relationships among celestial objects. Marker-based augmented reality was employed, whereby students scanned printed markers using smartphone cameras to access three-dimensional models of planets and their spatial arrangements.

The AR learning objects were provided through *Ruang Murid* within *Rumah Pendidikan*, a government-developed digital platform by Kemendikdasmen that offers curriculum-aligned multimedia and AR resources. These materials were integrated into the ELSA Google Sites environment via embedded links, allowing seamless access within the learning sequence without requiring additional application installation.

Data Collection

Data were collected using three techniques: 1) pretests and posttests to measure cognitive learning outcomes, 2) structured classroom observation sheets to assess student activeness, and 3) teacher reflective notes to capture qualitative insights into student engagement and classroom dynamics. Learning mastery was determined based on the school's Minimum Competency Criteria.

Data Analysis

Data were analyzed descriptively by comparing pretest and posttest results and changes in observed student activeness. The analysis aimed to identify patterns of improvement rather than to establish causal relationships.

RESULTS & DISCUSSION

Student Learning Outcomes

The findings indicate an improvement in student learning mastery on the solar system topic following the implementation of ELSA. Prior to the intervention, only 50% of students met the Minimum Competency Criteria. After the intervention, this proportion increased to 82%.

From a pedagogical perspective, this improvement can be associated with the multimodal learning design of ELSA, which integrates textual explanations, instructional videos, interactive exercises, and AR visualizations. According to the Cognitive Theory of Multimedia Learning, learning is more effective when information is presented through coordinated verbal and visual channels, as this facilitates deeper cognitive processing and reduces extraneous cognitive load (Mayer, 2020).

The solar system topic demands strong spatial visualization skills, which are difficult to support through static images alone. The AR visualizations provided through *Ruang Murid* enabled students to dynamically explore three-dimensional planetary models, supporting the construction of more accurate mental representations. This aligns with previous findings that AR is particularly effective for astronomy-related learning content (Ibáñez & Delgado-Kloos, 2018; Radu, 2014).

Nevertheless, these learning gains cannot be interpreted as definitive causal effects of the intervention. Given the one-group pretest-posttest design, alternative explanations—such as

increased familiarity with the material, teacher scaffolding, or natural cognitive maturation—cannot be ruled out.

Student Activeness

Student activeness increased substantially from 25% prior to the intervention to 100% after the implementation of ELSA. Observed behaviors included active participation in discussions, consistent task completion, peer collaboration, and engagement with digital learning activities. This increase is closely related to the interactive characteristics of ELSA. Features such as quizzes, educational games, and AR-based exploration positioned students as active participants rather than passive recipients of information. From a constructivist perspective, learning occurs when learners actively construct knowledge through interaction with their environment (Piaget, 1972; Vygotsky, 1978).

However, the heightened level of activeness may partially reflect a novelty effect, whereby students show increased engagement due to exposure to new and visually appealing technologies. Further research with longer implementation periods is needed to examine whether such engagement can be sustained over time.

Pedagogical Role of Government-Provided Augmented Reality

The AR component used in this study was sourced from *Ruang Murid* within *Rumah Pendidikan*, demonstrating the pedagogical potential of government-supported digital learning resources. The marker-based AR design allowed students to engage in exploratory learning aligned with constructivist principles, particularly for content requiring spatial cognition.

Rather than positioning AR as a technological novelty, its pedagogical value in this study lies in its alignment with the epistemic characteristics of the solar system topic. AR functioned as a cognitive scaffold that supported visualization, exploration, and conceptual linkage, thereby justifying its integration within elementary science instruction.

This approach also highlights the feasibility of integrating nationally curated digital resources into classroom practice without requiring schools to develop proprietary software, enhancing sustainability and scalability.

Methodological Reflection

Although improvements in learning outcomes and student activeness were observed, these findings should be interpreted as preliminary evidence rather than definitive proof of effectiveness. The absence of a control group introduces potential confounding variables, including maturation effects, instructional context, and novelty effects associated with AR use. By explicitly acknowledging these limitations, this study adopts a cautious interpretative stance consistent with rigorous academic standards.

CONCLUSION

This study provides preliminary evidence that a web-based learning environment integrating government-provided augmented reality resources has the potential to support learning outcomes and student activeness in elementary science education. Improvements were observed in learning mastery and classroom engagement following the implementation of ELSA.

However, due to methodological limitations, particularly the absence of a control group, the findings should be interpreted cautiously. Rather than establishing definitive effectiveness, this study contributes pedagogical insights into how and why AR-integrated web-based learning environments may support student learning when aligned with content characteristics and instructional goals.

Overall, ELSA demonstrates a practical and contextually relevant model for technology integration in elementary education, leveraging accessible web platforms and national digital learning resources to enhance classroom instruction.

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