Deep Learning-based Interactive E-module to Enhance English Learning Motivation in Elementary School

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Abstract. This study investigates the impact of a Deep Learning-based interactive e-module on the motivation of primary school students learning English as a foreign language. A quasi-experimental design with a pre-test and post-test control group was employed, involving 60 fifth-grade students in West Java, Indonesia. The experimental group (n=30) used the Deep Learning-based module, while the control group (n=30) received traditional instruction. Motivation levels were measured using a validated questionnaire based on Self-Determination Theory, supported by interviews and classroom observations for qualitative insight. Quantitative analysis revealed a statistically significant increase in motivation among students in the experimental group (t(29) = 10.45, p < 0.001, d = 2.17), whereas the control group showed no significant change. Thematic analysis of interviews and observations confirmed higher engagement, enjoyment, and autonomy among students using the e-module. These findings demonstrate that Deep Learning technology, when applied thoughtfully, can create personalized, responsive learning experiences that foster intrinsic motivation in young learners. This study contributes to the limited body of research on AI-powered educational interventions at the primary level and offers practical implications for digital learning design in EFL contexts. Future research is recommended to explore long-term effects and broader implementation across diverse educational settings.

Keywords: Interactive e-module; Deep Learning; Motivation; English as a Foreign Language (EFL); Elementary education;

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Introduction

In the digital era, the integration of technology in education has become a global imperative to enhance learning effectiveness and student engagement. Particularly at the elementary school level, the adoption of interactive learning media has shown promising results in addressing the challenge of low student motivation, a recurring issue in English as a Foreign Language (EFL) classroom (Widagdo & Asmarani, 2025). Despite the rapid advancement of digital learning tools, most available resources remain limited to static modules, offering minimal interactivity and personalization (Abusaimeh et al, 2025). Recent studies have underscored the potential of artificial intelligence, particularly Deep Learning (DL), in creating adaptive and responsive learning environments that accommodate students' individual learning behaviors (Padmaloshani et al., 2024). In this study, the DL component embedded in the interactive e-module operates at a conceptual level by processing learner interaction data, such as students' response accuracy, completion time, and task progression. These data serve as input for a simple supervised learning model that identifies learning patterns and difficulty levels, enabling the system to adapt feedback, hints, and content sequencing in real time. For example, when students repeatedly struggle with specific tasks, the module provides additional scaffolding and simplified explanations, while more advanced tasks are presented to learners who demonstrate higher mastery. Despite this potential, the application of Deep Learning-based interactive e-modules at the elementary level remains underexplored, particularly in Indonesia, where digital literacy and infrastructural readiness vary widely. This gap highlights the need to design and empirically examine DL-informed digital learning media that not only incorporate adaptive algorithms but also align with pedagogical and motivational principles suitable for young learners. Addressing this issue supports the national agenda of digital education transformation and contributes to the global discourse on the pedagogically grounded use of AI-assisted learning technologies in early education.

While the integration of technology in education has gained considerable momentum, its implementation at the elementary level remains uneven and often lacks pedagogical depth. Particularly in English language instruction, students in primary schools frequently encounter challenges related to low learning motivation and limited engagement, which can impede language acquisition and affect long-term academic performance (Xu et al., 2020; Rafiqa et al., 2024). Although various digital learning tools have been introduced, many are static, lacking personalization and real-time adaptability to students' cognitive needs. In this regard, interactive e-modules have emerged as a promising alternative to traditional materials; however, their design often overlooks the potential of advanced computational technologies such as Deep Learning (DL). DL offers unique capabilities for modeling student behavior, providing adaptive feedback, and customizing content delivery—features that are especially valuable for young learners who require responsive and motivating environments (Garfan et al., 2025). Nevertheless, most existing studies on DL in education focus on higher education or STEM-related subjects, leaving a significant gap in its application to language learning at the elementary level. Moreover, empirical investigations exploring the relationship between DL-powered interactive modules and the enhancement of student motivation in primary English classrooms are still scarce, particularly in the

Indonesian context. This gap highlights the need for research that bridges educational technology and motivational psychology to inform the design of more effective digital learning interventions for young English learners.

Prior research in educational psychology and instructional design emphasizes the crucial role of motivation in shaping learning outcomes, particularly in language learning contexts (Hiver & Papi, 2020). Self-Determination Theory (Deci & Ryan, 2000) suggests that learners are more likely to engage deeply with tasks when their needs for autonomy, competence, and relatedness are supported—conditions that interactive digital environments are well-positioned to fulfill. Empirically, studies have shown that digital tools such as gamified applications and multimedia-based modules can significantly enhance student motivation and participation in English as a Foreign Language (EFL) setting (Hung, 2015; Reinders & White, 2016). More recently, Deep Learning has gained attention as a powerful computational approach that enables systems to detect, predict, and respond to learner behaviors, allowing for greater personalization and adaptivity in instructional delivery (Addas et al., 2024; Zhang, 2025). Despite its demonstrated success in higher education and STEM learning environments, applications of Deep Learning in primary language education particularly through interactive e-modules remain limited. This theoretical and empirical gap underlines the importance of investigating how Deep Learning-based interactive e-modules can enhance elementary students' motivation to learn English, thereby contributing both to the advancement of AI-supported learning frameworks and to improving foundational language education.

The evolution of educational technology has led to a surge in the development of digital learning tools aimed at increasing student engagement and improving learning outcomes. Among these, interactive e-modules have gained attention for their ability to offer multimedia-rich content, self-paced learning, and increased learner autonomy, particularly in language education (Hung, 2015; Reinders & White, 2016). In parallel, advancements in artificial intelligence specifically Deep Learning (DL) have opened new pathways for personalized education by enabling systems to analyze learner behavior and adapt content dynamically (Addas et al., 2024). While DL-based applications are gaining traction in higher education and STEM fields, their pedagogical potential in elementary language instruction remains largely underexplored.

Current research in the field has predominantly focused on digital gamification, mobile learning, or multimedia tools in general without sufficiently addressing how AI-powered systems—especially those based on DL algorithms—can directly impact motivation in young learners. Furthermore, most existing studies either examine motivation as a secondary outcome or lack integration with a robust computational framework that supports real-time interactivity and personalization (Pessoa et al., 2023). Few empirical efforts have been made to explore how DL-powered e-modules can be meaningfully applied in primary English as a Foreign Language (EFL) classroom, particularly in the Indonesian educational context. This presents a critical gap in both theoretical and practical discourse concerning the use of intelligent technologies in foundational language learning.

Given the increasing emphasis on digital transformation in Indonesia's education system as evidenced by the Ministry of Education's Merdeka Belajar

initiative there is a pressing need to explore AI-driven pedagogical tools that address the specific needs of elementary learners. Motivation plays a pivotal role in early language acquisition, and without engaging learning environments, young students are at risk of disengagement and poor performance (Song et al., 2025). Implementing DL-based interactive e-modules not only aligns with national policy goals but also contributes to the broader educational challenge of ensuring equitable access to high-quality, adaptive learning experiences for all students. Thus, the current study responds to both a practical educational demand and a scientific call for innovation.

This study offers a novel contribution by designing and testing an interactive English e-module for primary school students that incorporates Deep Learning mechanisms to enhance motivational engagement. Unlike previous tools that rely on static multimedia or rule-based adaptation, this module employs DL to analyze student responses and dynamically tailor content delivery and feedback. This research bridges the fields of educational technology, artificial intelligence, and language pedagogy by providing an empirically grounded framework that integrates motivational theory with intelligent systems. It represents a significant departure from conventional approaches and provides practical insights for educators, developers, and policymakers.

To address the identified gaps and advance the application of Deep Learning (DL) in primary education, this study examines how a DL-based interactive e-module influences students' motivation in learning English. Unlike most previous studies that employ static digital materials, rule-based adaptation, or focus on DL applications in higher education and STEM subjects, this research integrates DL to dynamically adapt instructional feedback and task sequencing based on learners' real-time interaction patterns in an elementary EFL context. In addition, while earlier studies often treat motivation as a secondary or descriptive outcome, this study positions learner motivation as the primary dependent variable, measured through a theory-driven instrument grounded in Self-Determination Theory and supported by qualitative classroom evidence. By combining DL-informed adaptive instructional design with a rigorous, motivation-focused evaluation at the elementary level, this study offers a novel contribution to the literature on AI-assisted language learning and provides empirically grounded insights into how intelligent learning systems can support motivational engagement among young EFL learners.

Method
Research Methodology

This study employed a quasi-experimental design with a pre-test and post-test control group structure to investigate the effect of a Deep Learning-based interactive e-module on elementary students' motivation in learning English. This design is appropriate for educational settings where random assignment is not feasible, yet a degree of control and comparison is required to determine the impact of an intervention (Creswell, 2012). To gain a comprehensive understanding of the intervention's effectiveness, the study also integrated a mixed-method approach, combining quantitative data from standardized motivation questionnaires with qualitative insights from interviews and classroom observations.

Participants and Sampling

The participants were 60 fifth-grade students from two comparable elementary schools in Majalengka, West Java, Indonesia. Schools were selected using purposive sampling, considering criteria such as digital infrastructure readiness, teacher willingness to implement technology, and demographic similarity. The students were assigned to two groups: an experimental group (n = 30) that used the Deep Learning-based interactive e-module, and a control group (n = 30) that received conventional English instruction using printed materials and teacher-led discussions. Prior to the intervention, both groups completed a baseline motivation survey to ensure initial equivalence in motivational levels, aligning with recommendations by Fraenkel, Wallen, and Hyun (2012) for group comparability in quasi-experiments.

Research Instruments

To measure student motivation, this study used a modified version of the Motivation for Learning English Questionnaire (MLEQ) adapted from the framework of Self-Determination Theory (Deci & Ryan, 2000). The instrument contained 20 items rated on a 5-point Likert scale, focusing on intrinsic motivation, extrinsic motivation, and student engagement. The questionnaire was translated and validated for Indonesian elementary learners through expert review and a pilot study to ensure reliability (Cronbach's $\alpha > 0.80$). Complementary qualitative data were collected through semi-structured interviews with selected students and non-participant classroom observations using an observation sheet adapted from Reeve (2012), which tracked indicators of behavioral and emotional engagement.

Procedure

The research was conducted over a six-week instructional period. In the first week, all students took the pre-test motivation questionnaire. From weeks two to five, the experimental group engaged with the Deep Learning-based e-module during their English lessons. This module utilized DL algorithms to monitor student learning behavior and deliver adaptive feedback and content tailored to their learning pace and responses. Meanwhile, the control group continued learning using traditional teacher-centered methods. Teachers involved in the experimental group were trained prior to the intervention to ensure consistent implementation. In the final week, both groups completed the post-test motivation survey, followed by interview sessions and classroom observations to collect qualitative feedback on learner experiences.

Data Analysis

Quantitative data from the motivation questionnaires were analyzed using paired sample t-tests and ANCOVA to compare changes within and between groups while controlling for pre-test scores. The effect size (Cohen's d) was also calculated to determine the magnitude of the intervention's impact (Field, 2013). For the qualitative data, interview transcripts and observation notes were analyzed using thematic analysis, following the six-step process by Braun and Clarke (2006), which involved data familiarization, coding, theme identification, and interpretation. The integration of statistical and thematic findings provided a

deeper insight into how the DL-based e-module influenced students' motivational profiles and classroom engagement.

Findings and Discussion
Quantitative Results: Motivation Questionnaire (MLEQ)

The analysis of students' motivation before and after the intervention revealed significant differences between the experimental and control groups. Using paired sample t-tests, the experimental group who used the Deep Learning-based interactive e-module showed a statistically significant increase in motivation scores (M_pre = 3.12, SD = 0.41; M_post = 4.01, SD = 0.38; $t(29) = 10.45$, $p < 0.001$). The control group, in contrast, showed no significant change in motivation (M_pre = 3.11, SD = 0.45; M_post = 3.17, SD = 0.42; $t(29) = 1.32$, $p = 0.19$).

Further analysis using ANCOVA, controlling for pre-test scores, confirmed that the post-test motivation scores were significantly higher in the experimental group compared to the control group ($F(1, 57) = 49.23$, $p < 0.001$, $\eta^2 = 0.46$). The effect size (Cohen's d) for the experimental group was 2.17, indicating a large effect of the DL-based e-module on student motivation.

Qualitative Results: Interviews and Classroom Observation

The thematic analysis of interview transcripts from 10 selected students revealed three major themes: (1) Engagement through personalization, (2) Increased confidence and curiosity, and (3) Enjoyment of interactive learning. Students reported that the e-module made them "want to keep learning" and "felt like a game but with English." Several noted that the feedback and hints offered by the system helped them understand better without feeling embarrassed.

Observation data supported the interview findings. Students in the experimental group demonstrated more frequent hand-raising, voluntary participation, and time-on-task behaviour during English lessons. Compared to the control group, they showed higher levels of emotional engagement (e.g., smiling, laughter, attentive posture) and cognitive involvement (e.g., asking clarification questions, completing tasks independently).

Teacher Reflection

Reflections from the two English teachers involved in the experimental group further confirmed the positive impact of the module. One teacher stated, "The students were more active and enthusiastic. They even asked to use the module outside class hours." Both teachers also noted a reduction in classroom management issues during the e-module sessions, attributing it to higher student focus and interest.

Table. 1 Summary of Research Findings

Data Source	Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	Statistical Result	Interpretation
Motivation Questionnaire (MLEQ)	Experimental (n=30)	3.12 (0.41)	4.01 (0.38)	$t(29) = 10.45$, $p < 0.001$, $d = 2.17$	Significant increase in motivation; large effect size

Motivation Questionnaire (MLEQ)	Control (n=30)	3.11 (0.45)	3.17 (0.42)	t(29) = 1.32, p = 0.19	No significant change in motivation
ANCOVA (post-test controlling pre-test)	Exp. vs Control	—	—	F(1,57) = 49.23, p < 0.001, η² = 0.46	Post-test motivation significantly higher in experimental group
Student Interviews (n = 10)	Experimental only	—	—	Thematic analysis: 3 major themes	Increased engagement, enjoyment, personalized learning
Classroom Observation	Experimental only	—	—	Consistent indicators of behavioral engagement	More active participation, attentiveness, and task completion
Teacher Reflections (n = 2)	Experimental only	—	—	Narrative analysis	Positive perception of student response and instructional value

Discussion

The findings of this study provide strong empirical support for the effectiveness of a Deep Learning-based interactive e-module in enhancing elementary school students' motivation to learn English. The significant improvement in the experimental group's motivation scores compared to the control group indicates that intelligent, adaptive learning environments can play a vital role in engaging young learners. These results are consistent with prior studies suggesting that interactive and adaptive digital tools are more effective than static instructional materials in promoting student engagement and self-directed learning (Hung, 2015; Reinders & White, 2016).

From a theoretical perspective, the results align with the core tenets of Self-Determination Theory (SDT), which posits that motivation increases when learners' needs for autonomy, competence, and relatedness are met (Deci & Ryan, 2000). The DL-based e-module, by offering personalized feedback and adapting content to individual performance, likely supported students' sense of competence. Moreover, its interactive and game-like features fostered a sense of autonomy and enjoyment, both of which are key components of intrinsic motivation. The qualitative data further reinforce this interpretation, as students described the module as "fun," "easy to understand," and "motivating," emphasizing the emotional and cognitive engagement fostered by the digital environment.

This study also contributes to the state of the art in educational technology by demonstrating how Deep Learning a subfield of Artificial Intelligence often underutilized in primary education can be meaningfully applied to English

language learning. Previous research has largely focused on DL in higher education and STEM domains, while its application in early EFL instruction remains scarce. This study fills that gap by showing not only the feasibility of integrating DL in elementary classrooms but also its measurable benefits on motivational outcomes.

Another important aspect of the findings lies in their practical implications for teachers and curriculum designers. The use of DL-powered systems can help differentiate instruction, reduce teacher workload in monitoring individual progress, and create more responsive learning experiences. The positive responses from both students and teachers in this study underscore the importance of investing in AI-enhanced educational materials, especially in developing countries like Indonesia, where motivation and engagement are critical issues in early language education.

Nevertheless, it is important to acknowledge certain limitations of the study. The sample size, while sufficient for a quasi-experimental design, was limited to two schools in West Java and may not fully represent the diversity of elementary learners in other regions. Additionally, the intervention lasted only six weeks, which may not be enough to assess long-term motivational effects. Future research could explore longitudinal impacts, include larger and more diverse populations, and further refine the DL algorithms to enhance pedagogical adaptability.

In summary, this study affirms that Deep Learning-based interactive e-modules offer a promising pathway to enhance motivation in elementary English learners. By bridging AI technologies with motivational theory, the findings highlight a novel direction for both research and practice in 21st-century language education.

Conclusion

This study investigated the impact of a Deep Learning-based interactive e-module on elementary students' motivation to learn English. The findings demonstrated that students in the experimental group experienced a significant increase in motivation compared to those in the control group, suggesting that intelligent, adaptive digital tools can be highly effective in supporting early language education. The use of Deep Learning technology in this context provided personalized learning experiences, fostered engagement, and addressed individual learner needs—an approach aligned with contemporary trends in digital pedagogy.

From a theoretical standpoint, the study reinforces the principles of Self-Determination Theory by showing how technological affordances can fulfill learners' psychological needs for autonomy, competence, and relatedness. The personalized feedback and adaptive learning paths delivered by the DL-based module created a sense of control and competence among learners, enhancing their intrinsic motivation. These findings contribute to the growing body of literature on AI-supported learning and expand the application of SDT into early childhood digital learning environments.

Despite its contributions, the study has certain limitations. The research was conducted over a relatively short intervention period (six weeks) and involved a limited sample size from two public elementary schools in West Java, Indonesia. Therefore, generalizability is constrained, and long-term motivational outcomes remain unexplored. Additionally, while the module incorporated key DL features such as pattern recognition and adaptive content delivery, the full potential of

intelligent learning analytics was not explored due to technical and infrastructural limitations in the field setting.

Future research should consider longitudinal studies to assess sustained motivational and academic impacts of DL-based interventions. Expanding the participant pool to include diverse school types and geographic regions would enhance external validity. Furthermore, integrating more sophisticated DL features—such as emotion recognition or predictive feedback loops—could provide deeper personalization and more robust learning support. Finally, future work might also examine the role of teacher facilitation and professional development in maximizing the pedagogical effectiveness of AI-based learning environments.

In conclusion, this study provides empirical and theoretical evidence for the transformative potential of Deep Learning in elementary language education. As education systems globally move toward digital transformation, intelligent instructional media that support student motivation will become increasingly essential in ensuring inclusive, engaging, and effective learning for all.

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