



Technology-Supported Deep Learning in Indonesian EFL Classrooms: Teachers' Strategies and Learners' Experiences

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Abstract

Deep learning has become an increasingly popular topic in the literature as a solution to Indonesia's surface-level learning outcomes. However, little is known about how teachers turn this pedagogical approach into every day, technology-mediated EFL practice. Using a qualitative multiple-case study design, this study examined how four Indonesian senior high school EFL teachers and eight students across two public senior high schools enacted deep learning through semi-structured interviews, classroom observations, and document analysis. Findings show that technology worked as an interactional interface between teachers' pedagogical goals and students' engagement. This extends the HCI perspective in educational technology by showing that technology's mediating role depended not only on tool affordances, but also on task design, interaction demands, and feedback patterns. Four technology-mediated functions were found. Pen pal platforms repositioned English as an authentic communication tool. ChatGPT helped reduce speaking anxiety through low-pressure practice. Padlet and Facebook expanded the audience for students' writing and provided space for peer feedback. YouTube brought language learning into contact with global media and critical engagement with it. Pedagogy, rather than technology, established the level of cognitive involvement in the learning process. These factors impeded it: large class sizes, administrative pressure on teachers, an exam-based learning culture, and unequal access to technology. The results further our understanding of technology's role as a pedagogical medium in language teaching from a Human-Computer Interaction perspective.

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INTRODUCTION

As education changes rapidly, deep learning is becoming increasingly popular as an approach that focuses on deep understanding, critical thinking, and the proper use of knowledge (McGregor, 2020; Mystakidis, 2021; Times Higher Education, 2021). While surface learning typically relies on memorization and exam preparation, deep learning fosters long-term understanding by helping learners link new knowledge to what they already know, challenge their assumptions, and apply what they learn in different situations (Hailikari & Nevgi, 2020). This educational approach aligns with modern educational principles such as autonomous learning, critical thinking, adaptability, and

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problem-solving (Andina et al., 2020). However, educational achievement in Indonesia still lags behind global standards because learners have weak critical thinking and problem-solving skills (Kemendikbudristek, 2022; OECD, 2024; World Bank, 2024).

Learning in Indonesia has usually involved lower-order cognitive activities, and students have struggled to analyze, evaluate, and transfer knowledge (Lestari & Winangun, 2026). This problem is also evident in Indonesia's results on international and national tests (Badan Pusat Statistik, 2022; Pusmenjar Kemendikbudristek, 2023; OECD, 2024). These conditions call for instructional designs that intentionally promote higher-order thinking and meaningful knowledge construction. As a result, while graduates can demonstrate basic content summarization skills, they often struggle to analyze arguments, evaluate evidence, and transfer knowledge to new situations. These skills fall under the higher-order thinking skills defined by the revised Bloom's taxonomy (Anderson & Krathwohl, 2001), and research shows that students find them difficult to master through planned instructional design (Ismeirita et al., 2025). In 21st-century education, where evaluation, judgment, and decision-making are seen as critical competences to combat misinformation and build accountable solutions to complex issues (OECD, 2024; Trilling & Fadel, 2009), this skill gap poses a serious threat to educational quality.

In this regard, deep learning offers a suitable pedagogical approach because it emphasizes meaningful learning, authentic tasks, inquiry, reflection, and applying knowledge to the real world (Cahyono et al., 2024; Mystakidis, 2021; Weng, 2022). These components foster active knowledge construction and the development of higher-order thinking skills, self-regulation, and reflective thinking (Alzahrani, 2024; Farrokhnia, 2025; Kovač, 2025). Technology can support deep learning when it is integrated with meaningful tasks, interaction, collaboration, reflection, and feedback. In EFL classrooms, technology-enhanced learning can offer richer learning experiences while also presenting challenges in selecting and integrating digital tools into instruction (Metaria & Cahyono, 2024). Such integration also requires adequate digital literacy among teachers to ensure that digital resources are used purposefully for learning rather than merely for content delivery (Deiniatur & Cahyono, 2024). In English Language Teaching (ELT), there has been research on deep learning in relation to online EFL learning, smart classroom model, learning process, and interventions (Huang, 2022; Jiang, 2022; Jin, 2024; Metaria & Cahyono, 2024; Shi, 2024; Wang, 2024; Zhang, 2025). However, much of this research has relied on surveys, experiments, or effectiveness-oriented designs, providing limited insight into how teachers and students understand, enact, and reflect on deep learning in actual classroom contexts (Chen, 2024; Gu, 2025; Liu, 2024; Tan, 2024). Recent reviews have therefore called for more contextual and qualitative investigation of teachers' and students' experiences of deep learning (Bal and Öztürk, 2025; Eid, 2022; Mariani et al., 2024; Oktavianus and Rido, 2025).

In the Indonesian EFL context, teaching practices remain influenced by grammar-based instruction, test preparation, and rigid curricular demands (Andriani et al., 2021; Wati & Syafii, 2020; Wibowo et al., 2023; Zainal, 2024). Although recent studies have examined deep learning in Indonesian education, its classroom implementation in EFL, particularly from teachers' and students' perspectives, remains insufficiently understood (Sihombing et al., 2025; Subiyantoro et al., 2024). Although research on deep learning has mostly focused on primary education (Burner & Schipor, 2025; Luthfiah et al., 2025), evidence at the senior high school level remains limited. This context warrants specific attention because older learners engage in more complex abstract thinking, critical thinking, and problem-solving relevant to deeper language learning, particularly in reading and writing (Malik & Marwaha, 2023; Pakpahan, 2022).

This study focuses on senior high schools in Indonesia that demonstrate sustained implementation of deep learning, indicated by (a) the existence of school policies and documented lesson plans; (b) classroom tasks that require higher-order thinking and encourage learner agency; and (c) assessment practices that are consistently aligned with the goals of deep learning. This study uses a qualitative case study approach to explore how Indonesian EFL teachers and students understand and enact deep learning in their learning practices, with a specific focus on reading and writing skills. These skills are particularly relevant to deep learning because they involve higher-order cognitive processes such as analyzing information, integrating ideas, revising, and metacognitive reflection (Bal & Öztürk, 2025; Jin, 2024; Kim, 2024). They also receive substantial attention in Indonesia's senior high school curriculum (Lestari & Kusumawati, 2024; Ningsih et al.,

2023; Sulyati & Kuswara, 2024). By examining teachers' and students' experiences and the contextual conditions shaping classroom practice, this study aims to provide an in-depth understanding of how technology-supported deep learning is enacted in Indonesian EFL classrooms.

METHOD

This study used a qualitative case study design (Yin, 2018) to explore how Indonesian EFL teachers and learners perceive and enact deep learning in senior high school classrooms. The design followed an embedded multiple-case approach, in which each school constituted a bounded case and the two participating teachers (with their respective classes) within each school served as embedded units of analysis, allowing both within-case description and cross-case comparison. The study was conducted in two public (negeri) senior high schools in East Java, Indonesia, recognized as reference schools for deep learning implementation (BBPMP Jawa Timur, 2025). This focus responds to the limited evidence on deep learning in EFL at the senior high school level compared with the larger body of primary-level research. The two schools were purposively selected for their established commitment to deep learning-oriented EFL instruction.

Participants included four EFL teachers (two from each school) and eight students (four from each school, drawn from the teachers' intact classes). Teachers were recruited purposively based on relevant experience and demonstrated use of practices aligned with deep learning, such as inquiry or problem-based tasks, collaboration, reflection, and technology-supported learning. Students were purposively selected in consultation with their teachers to capture variation in achievement and participation profiles within each case. To protect participant confidentiality, the two schools are hereafter referred to as School A and School B, and participants within each school as Teacher 1-2 and Student 1-4.

Data were collected through semi-structured interviews, non-participant classroom observations, and document analysis (lesson plans, student work, reflective materials). Interviews were conducted in Indonesian, or a mix of Indonesian and English according to preference, audio-recorded with consent, and transcribed verbatim. Teacher interviews (45 to 60 minutes) were conducted individually, while student interviews (30 to 45 minutes) were conducted in small groups. Observations focused on instructional strategies, technological learning media, interaction patterns, and indicators of deep learning such as critical questioning, collaboration, and reflection.

Data analysis followed within-case and cross-case analysis procedures (Yin, 2018). We first analyzed each case (school) individually to identify patterns in how teachers and students enacted deep learning, then synthesized across cases to identify convergent and divergent themes across the two schools. MAXQDA supported data management and coding. Case boundaries and data sufficiency were established through ongoing comparison across teachers, students, and data sources within and across cases, producing an integrated account linking teachers' experiences, pedagogical practices, contextual barriers, and students' critical engagement.

The researcher enhanced validity through triangulation across interviews, observations, and documents; member checking; peer debriefing; and an audit trail. Reflexive memoing and journaling captured the rationale behind the analysis and the researcher's positionality. The university ethical review committee granted ethical clearance. The researcher obtained informed consent from all participants and ensured confidentiality through pseudonyms.

RESULTS AND DISCUSSION

This section highlights the key issues that emerged from the analysis of the interviews, observations, and documents. Deep learning within the EFL setting was defined as a continuous process of constructing meaning through inquiry, reflection, collaboration, and using authentic language. Technology often served as an auxiliary tool in the described process; however, all participants consistently understood technology as a mediator in education. Technology created conditions for interaction, reflective practice, and engagement in learning when its use aligned with learning purposes, task demands, and feedback practices.

Technology for Authentic Interaction: Pen Pal Communication

Teachers achieved this by introducing a pen-pal program that let learners in Indonesia communicate directly with learners from other countries. This approach ensured English became a tool for practical communication, not just a course taught in the classroom through books. By exchanging messages consistently, learners could use language appropriately and tailor their messages to their audience. School A-Teacher 1 highlighted this authenticity, stating, "When my students write to peers abroad, English stops being a classroom exercise. They plan what to say, revise for clarity, and respond to real questions. This pushes them to apply vocabulary and grammar in context, and they become more motivated because communication has a real audience."

Technology for Affective Support: ChatGPT and Anxiety Reduction

ChatGPT was used as a conversation-practice tool, giving students an environment to practice English without pressure. Compared with interactions that directly involve peers or teachers, interacting with the chatbot may reduce feelings of being judged or embarrassed, which students and even teachers considered barriers to communication. Students used ChatGPT to practice their answers, seek clarification, and try alternative ways of expressing themselves, which they then used in classroom conversations. This practice increased students' willingness to communicate by reducing anxiety and giving them control over the learning process. School A-Teacher 1 explained this function clearly: "Some students choose to stay silent because they are afraid of making mistakes in front of their friends. With ChatGPT, they can practice privately, repeat questions, and try new sentences without feeling embarrassed. The immediate responses help them build confidence. After that, they become more talkative in class because their anxiety has already decreased."

Technology for Collaborative Writing: Padlet and Facebook

Teachers facilitated the use of Padlet and Facebook to create an interactive writing space where students could exchange ideas, respond to each other, and construct meaning in English. This gave students' writing a wider audience and made the writing process feel less like an assessed activity and more like a socially mediated act of communication. Students could create content together, observe different ways of expressing themselves, and improve their work by receiving feedback. School A-Teacher 2 emphasized this motivational shift, explaining, "When students post on Padlet or Facebook, they write because someone will read it, not only because I will grade it. Peer comments make them revise and add details. Even quiet students participate through short posts, and their writing gradually becomes longer and more confident."

Technology for Content-Based Engagement: YouTube and Global Innovation Topics

Teachers and students accessed recent content about global technological advances on YouTube, including innovations in transport, robotics, and drones. Using this strategy made English learning not only an activity for mastering English, but also for gaining new information. Increased student interest could be explained by the fact that the information they received was fresh and relevant. Video activities helped develop listening skills and vocabulary, as well as encourage discussions about innovations. School A-Teacher 2 explained this mechanism as follows: "When we watch YouTube videos about robots, drones, or new transportation systems, students become curious and ask more questions. They want to understand the important terms and the reasons behind these innovations. English becomes a bridge to gain new knowledge, so they listen more carefully and participate more actively." Additional evidence from the interviews further clarifies how teachers viewed technology as a bridge between the knowledge learned in class and students' everyday lives. This strengthens the "meaningful" principle in deep learning. Teachers explained that they used entertainment-oriented learning resources, such as English-language films and music on YouTube, to position English as language input used in real life, not just as material studied separately.

The teachers also used technology-based learning materials, such as videos on AI, robots in Japan, and innovation in the US in transportation, drones, and the digital industry, to make English the language through which people acquire information and knowledge about current affairs. In addition to video websites, other community and information sources such as Quora, BBC, and Reddit

help students gain insights into different aspects of society, politics, education, weather, and natural phenomena.

In addition, teachers highlighted language-learning applications such as Duolingo and Beelinguapp as tools to make practice activities more engaging and to help maintain students' effort and consistency in learning, especially when classroom learning time was limited. School A-Teacher 2 emphasized technology's function as a bridge in deep learning, stating: "Deep learning must be meaningful, meaning it connects knowledge with real life. Technology helps students and teachers build that bridge. Students watch films or listen to English-language music on YouTube for entertainment, learn about AI, robots, transportation, and drones, and explore different ideas from around the world through Quora, BBC, or Reddit. Applications like Duolingo also make practice activities more enjoyable and consistent."

From Tool Use to Pedagogical Design: Interactive and Contextual Learning Routines

Beyond using technology as a tool, teachers also described patterns of technology use related to lesson planning, implementation, and assessment. Teachers used several technologies to organize materials, create inquiry-based activities, encourage collaboration, and facilitate feedback. The technologies mentioned included learning apps like Kahoot, Wayground, and Padlet; digital platforms like Jamboard and interactive boards; several AI-powered technologies; and assistive technology for students with special educational needs. School B-Teacher 1 emphasized that using digital tools could support personalization and collaboration in learning: "By integrating digital tools such as apps, AI, and online platforms, we can create a learning experience that is not only more engaging, but also better suited to each student's needs. This helps students connect the material with deeper understanding and collaborate more effectively with their classmates." School B-Teacher 1 also emphasized the aspects of inclusivity and accessibility: "Using assistive technology for students with special needs ensures that every student can access the learning material. Digital platforms also allow direct collaboration, so students can learn from each other while working on projects and various tasks."

Overall, teachers described technology as effective when it required students to respond, explain, compare, and create through interactive quizzes, collaborative boards, and guided exploration activities (Deiniatur & Cahyono, 2024). In this way, technology was not only used to deliver material in one direction, but also as a mediator that encouraged students to think and interact actively in the learning process.

Recognizing and Supporting Deep Learners in the EFL Classroom

Teachers reported recognizing deep learners through observable behaviors, including asking "why" and "how," challenging ideas, linking content to lived experiences, persisting with complex tasks, and engaging in reflective dialogue. Teachers described deep learners as intellectually curious and willing to take risks in language production. To cultivate these dispositions, teachers described scaffolding that gradually increased cognitive demand, reflective feedback that improved work while clarifying learning processes, and structured collaboration that exposed learners to peer reasoning and alternative perspectives. School B-Teacher 2 emphasized autonomy-supportive teaching: "When I notice a student digging deeper into a topic, I try to give them open-ended questions or tasks that let them explore their own ideas. Deep learners thrive when we trust them to think independently. My role is to guide, not to control, helping them build confidence and awareness in how they learn."

Pedagogical Strategies for Fostering Deep Learning

These included student-centered teaching approaches that encourage inquiry and reflection. The teachers listed project-based learning, problem-based learning, and inquiry-based learning as the most appropriate because they included interpretive, decision-making, and justifying tasks. This was because they included authentic tasks such as debates, presentations, problem-solving activities, and reading-into-writing tasks related to issues outside the textbooks. In these cases, the language practice matched higher-order thinking, particularly in reading and writing tasks.

School B-Teacher 2 linked deep learning with authentic communication tasks and reflection supported by feedback, including the use of online chat platforms such as pen pal exchanges: "Deep learning grows when students face tasks that mirror real-life communication. I often assign projects

where they must solve problems or express opinions in English. We have utilized a pen-pal application for real practice of English communication. Through feedback, I help them reflect on what worked and what didn't. This process trains them to think critically and become aware of how their learning develops over time." Teachers also described flipped classroom routines, where basic input was shifted to independent study and classroom time was reserved for discussion, peer work, and problem solving, increasing participation and creating space for formative feedback.

Multimedia and Digital Tools to Deepen Engagement

Multimedia, along with tasks that required higher-order thinking, led to high engagement and deeper cognitive processing, according to teachers and students. Videos, podcasts, short movies, songs, and online reading materials were used to provide exposure to authentic language and multiple perspectives. Mind maps and infographics can encourage idea linking and argument structuring. Interactive applications include Kahoot, Quizlet, Wayground, Google Classroom, Padlet, and Jamboard. School B-Teacher 2 described interactive tools as pushing learners toward active application: "Incorporating interactive tools like Kahoot or Quizlet creates a sense of competition and fun, which keeps students engaged. They become more proactive in their learning, not just passively receiving information but actively applying it, which deepens their understanding."

Learners' Views of Deep Learning and Preferred Practices

Learners described deep learning as understanding that goes beyond tests and is shaped by curiosity, motivation, and real-world relevance. Deep learners were perceived as those who participate actively, seek clarification, review materials independently, and connect classroom English to personal goals. School A-Student 1 highlighted relevance as a driver of self-directed learning: "For me, deep learning happens when English feels useful beyond the classroom. I enjoy exploring topics I care about, music, culture, even social issues, and using English to express my thoughts. When I connect lessons with real life, it feels meaningful, not forced, and that keeps me motivated to learn more on my own." Learners also linked deep learning to collaboration, where peer explanation and feedback helped them refine understanding and gain confidence to speak and write. They consistently preferred interactive methods such as group discussion, role play, debates, and projects because these activities required them to justify ideas and respond to others, which felt more meaningful than lecture-driven instruction. Learners valued specific, actionable teacher feedback because it supported revision and improvement.

Constraints and Tensions in Implementing and Experiencing Deep Learning

Teachers described constraints that limited sustained implementation of deep learning practices. The most frequent challenges included large class sizes, administrative workload, exam-oriented expectations, and uneven access to resources and technology. School A-Teacher 1 noted the impact of large classes on feedback and monitoring thinking processes: "In a class with more than forty students, it's challenging to engage each student individually. I can't provide the level of personalized feedback needed for deep reflection. The class becomes more about managing the crowd than facilitating meaningful learning." School B-Teacher 1 emphasized the burden of paperwork on planning and reflection: "The pressure of completing administrative tasks leaves me with little time to prepare lessons or reflect on teaching strategies. It's difficult to foster deep learning when the focus is constantly on paperwork and meeting deadlines rather than planning for engaging, interactive lessons." Learners reported parallel barriers, including limited exposure to English outside school, difficulty sustaining self-regulated study habits, pressure to prioritize exam performance, and a digital divide involving unstable internet access and limited devices.

Cross-Case Synthesis: Technology as Supportive, Pedagogy as Decisive

Technology was not necessary for deep learning, according to another common assertion from the participants. Technology was useful for inquiry, collaboration, and reflection. By contrast, participants felt that without meaningful activities, dialogue, feedback, and learner initiative, technology was insufficient. The teachers did not see technology as replacing the teaching process, but as creating the right conditions for students to speak to authentic audiences, write to receive feedback, and engage with current knowledge through English.

Discussion

In this section, the data collected during the research are interpreted in relation to the teachers' teaching techniques and students' experiences, in relation to the theory of deep learning in English language teaching. In all cases analyzed, technology did not determine students' cognitive success. Deep learning became possible when teachers created activities that consistently stimulated students' curiosity, discussion, cooperation, and self-assessment through the feedback provided. Technology became relevant only when it helped achieve all of this. Technology acted as a catalyst rather than a determinant of deep learning. Indeed, participants repeatedly noted that technological affordances supported cognitive depth only when integrated into an intentional pedagogical process. This finding aligns with educational technology literature indicating that learning outcomes depend not on technological implementation but on learning-process design (Kirkwood & Price, 2021; Selwyn, 2022). Furthermore, TPACK and SAMR frameworks suggest that technology contributes to learning when it enables interaction, collaboration, and knowledge creation (Mishra et al., 2020; Hamilton et al., 2021). This finding also reflects the principles of design-based learning and post-digital approaches, which emphasize that learning outcomes emerge from the interplay among pedagogy, context, teachers, students, and technologies (Fawns, 2022; Laurillard, 2022).

One key contribution of technology to deep learning in Indonesian EFL classes was its ability to connect classroom-based learning to real-life contexts. Deep learning was conceptualized as meaningful learning whereby learners connected linguistic knowledge to real-life situations and contemporary issues. Technology supported this by providing authentic input and global discourses, making English a tool for engaging with current knowledge rather than just linguistic information. Entertainment and informational media, such as YouTube and technology topics, provided exposure to natural language use, cultural significance, and current global issues. Furthermore, students viewed language-learning applications as maintaining motivation through repeated, risk-free practice. Altogether, these findings suggest that technology facilitated deep learning not through novelty but by expanding contexts, audiences, and purposes of learning. Students' perceptions of deep learning as learning beyond the exam, driven by curiosity and motivation tied to reality, align well with EFL research on authentic tasks and meaningful language use (Anagnostopoulou, 2023). These findings also align with situated learning theories, in which knowledge becomes meaningful when students participate in real-life settings and communities of practice (Chang, 2021; Li, 2022). Learners benefited from collaboration, as peer discussion made reasoning transparent and open to negotiation.

Deep learning in these classes can be viewed as sustained meaning-making through inquiry, reflection, collaboration, and authentic language use. This view aligns with constructivist learning theory, which sees learning as an active process shaped by interaction with tasks, peers, and social context rather than passive absorption of information (Kirschner & Hendrick, 2020; Schunk & DiBenedetto, 2020). Consistent with recent EFL research, inquiry-oriented and collaborative pedagogies engaged learners in interpretation, reflection, and authentic communication, processes closely associated with deeper cognitive engagement (Mystakidis, 2021; Mariani et al., 2024). In this research, technology provided opportunities for interaction, access to authentic input, collaboration, and feedback loops. These elements align with the Conversational Framework described by Laurillard (2022), in which learning occurs through iterative dialogue among learners, teachers, and tasks. By contrast, when technology was used mostly for one-way communication, its contribution to learning was viewed as shallow, supporting criticism of the techno-centrism paradigm and warning against assuming technology's inherent educational benefits without pedagogical transformation (Bayne et al., 2020; Selwyn, 2022). This contrast between dialogic and one-way technology use points to interaction quality, rather than the technology itself, as the decisive, though still underexamined, factor shaping deep learning outcomes.

As for deep learners, their behaviors included asking "why" and "how", linking content to experience, and tackling difficult tasks. These features reflect Biggs' theory of deep approaches to learning, characterized by intrinsic motivation, meaning, and integration rather than simple completion (Biggs & Tang, 2011). Self-determination theory further supports this idea, suggesting that deeper engagement occurs in supportive learning environments that foster autonomy, competence, and relatedness through feedback, cooperation, and learner involvement (Ryan & Deci,

2020). The idea of teachers as guides who help control learning processes aligns with learner-centered pedagogy and the theory of formative assessment, in which feedback is used to regulate learning and foster metacognitive awareness rather than evaluate results (Carless & Winstone, 2023; Panadero et al., 2022). The strategies teachers considered effective, such as project-based, problem-based, inquiry-based, and flipped classroom approaches, align with international research indicating that student-centered and task-based instruction fosters deep learning and high-level thinking skills in EFL and general education (Huang et al., 2023; Kohnke & Moorhouse, 2022). These approaches align with experiential learning theory, which conceptualizes learning as a cyclical process of experience, reflection, conceptualization, and experimentation (Kolb, 2015).

The finding that multimedia supported deeper processing when tasks involved interpretation, comparison, and discussion fits well with the Cognitive Theory of Multimedia Learning, in which active selection, organization, and integration in working memory occur within limited capacity (Mayer, 2020, 2024). According to this theory, the same digital tool can be either deep or shallow cognitively, depending on whether the instructional design elicits generative processing. This interpretation is based on educational technology research showing that dialogic and collaborative use of media leads to better knowledge construction than one-directional information transfer (Lehtinen et al., 2023).

Nonetheless, structural barriers prevented consistent implementation of deep learning practice, namely large class sizes, work pressure, and limited time for dialogue and feedback, similar to what the literature on formative assessment and EFL learning has found (Hopfenbeck et al., 2023). Test-oriented approaches led to a washback effect and prioritized test preparation over inquiry and dialogue (Liang et al., 2025). Learners also faced challenges with self-regulation, limited experience of English beyond the classroom, and uneven access to digital resources, reflecting broader equity and digital-divide issues in technology-enabled education (UNESCO, 2023).

This study offers a new interactional perspective on deep learning in EFL, suggesting that deep learning depends on interaction between humans and computers rather than on technology per se. Although previous literature on the application of information and communication technology in language learning has discussed various benefits and drawbacks of the usage of such digital technologies in language instruction (Wang et al., 2024; Zheng & Yang, 2024), with current reviews pointing out that the level of human-computer interaction in previous literature is rather limited (Zheng & Yang, 2024), the existing knowledge about how certain interaction patterns influence cognitive involvement of learners has not been addressed in these previous studies. The results show that the same digital technologies can produce different outcomes depending on how teachers organize and manage interaction cycles within instructional activities, a factor that remains understudied in EFL technology research and applied HCI. For HCI and educational media design, the implications indicate the importance of interaction design based on dialogue, rehearsal, transparent feedback, and iteration rather than on technical aspects.

LIMITATIONS

The current study has major limitations that must be considered when evaluating the results. First, the investigation was carried out in a few senior high school settings, where the students and teachers selected to take part in the research were chosen purposefully because they engaged in technology-enhanced English language instruction. Although this method allows for detailed exploration of the interactional practices under study, it makes the generalizability of the results to other schools, regions, or educational traditions in Indonesia problematic. Second, the main data collected were qualitative and included interviews, classroom observations, and instructional documents. Although the researchers used triangulation to ensure the credibility of the findings, the lack of standardized measurement of students' achievements makes it impossible to say anything about deep learning that could be measured quantitatively. Third, the analysis focused on teachers' pedagogical designs and learner interactions with digital platforms, not the characteristics of the platforms' interfaces and systems. Therefore, this study does not evaluate interface design, accuracy, or algorithms, though these are key goals in experimental HCI studies. Contextual factors influenced teaching strategies and interaction patterns, but they were not examined as independent variables. As a result, the study offers an analysis of the situated practice of pedagogically mediated HCHI, not

an examination of the causal relationship between HCHI and DL. In sum, these limitations imply that the study provides a contextualized description of pedagogically mediated HCHI in EFL classrooms.

CONCLUSION

This study shows that deep learning in Indonesian EFL classrooms is enacted as sustained meaning construction through inquiry, reflection, collaboration, and authentic language use. Teachers and learners described deep learning as a process that becomes visible in students' questioning, persistence with complex tasks, and willingness to connect language to lived experience. Technology supported these processes by enabling interaction, access to authentic input, collaborative work, and feedback cycles. However, participants emphasized that technology was merely a facilitator, not a determinant, in the process of cognitive deepening. Indeed, purposeful pedagogical design played a critical role irrespective of the type of technology used during EFL instruction. Structural issues such as large class sizes, heavy workloads, an exam-oriented focus, and insufficient resources limited teachers' ability to scaffold inquiry and provide consistent formative feedback. In terms of theoretical contribution, this paper offers specific details on how deep learning principles can be incorporated into EFL teaching in a resource-scarce Indonesian context. In particular, it defines deep learning as a relational, design-based construct in which authentic tasks, dialogic interaction, and feedback-supported reflection become the primary mechanisms for creating depth, with technology serving as an amplifier when aligned with those mechanisms. This work offers a more nuanced and precise understanding of the constructivist approach to deep learning in EFL as a practice of joint meaning-making by students, peers, and teachers through inquiry and reflection, rather than mere exposure to material and technology. Implementation conditions in schools include appropriate class size, time for planning and reflection, and assessments that test not only rote knowledge but higher-level cognition. For policymakers and teacher education programs, these findings imply that teachers need professional development less about using tools and more about orchestrating learning, including designing tasks and providing feedback literacy. Equity is another important issue here. Reducing the digital divide and offering lower-tech alternatives are critical so that deep learning does not depend upon infrastructure inequality.

AUTHOR CONTRIBUTIONS

HMS wrote the manuscript. He also coordinated the paper's development. BYC supervised the development of the paper's framework and contributed to idea formation. ANW supervised the methodology, including instrument development and alignment. SK helped compile and organize the data collected from the study. S assisted HMS in carrying out research data collection work.

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