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Designing Adaptive Multimodal Literacy in LMS: Empowering Pre-Service Teachers through Asynchronous Learning Innovation

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A B S T R A C T

This study explores the development and implementation of an adaptive multimodal literacy module within a Learning Management System (LMS) to enhance literacy instruction in teacher education. However, previous studies have rarely integrated adaptive learning systems with multimodal literacy instruction within LMS environments to support literacy development among pre-service teachers in asynchronous learning contexts. Grounded in evidence-based literacy instruction, multimodal literacy theory, and adaptive learning pedagogy, the module was designed following the ADDIE model and implemented among 60 pre-service English teachers enrolled in a literacy course. Using a research and development design, quantitative and qualitative data were collected to evaluate participants' literacy development and learning engagement. Results revealed a statistically significant improvement in literacy competence ($t(59) = 9.67$, $p < .001$, $d = 0.92$), with notable gains in reading comprehension, vocabulary acquisition, and multimodal text interpretation. LMS data indicated increased engagement, reflected in a 92% completion rate and high mean engagement score (4.36). Qualitative findings further showed enhanced metacognitive awareness and professional reflection, as participants began to conceptualize literacy teaching through multimodal and adaptive perspectives. Despite these achievements, challenges included technical constraints and initial confusion navigating adaptive branches. Overall, the study demonstrates that adaptive multimodal literacy instruction can effectively integrate cognitive, affective, and reflective dimensions of learning in asynchronous environments. The approach not only promotes literacy mastery but also models digital pedagogy for future teachers. Findings provide valuable insights for higher education institutions seeking to design scalable, learner-centered innovations that connect adaptive technology with transformative literacy practices.

Keywords: *Adaptive Learning, Multimodal Literacy, LMS, Asynchronous Learning, Pre-Service Teacher Education*

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INTRODUCTION

The digital transformation of teacher education has accelerated the shift toward asynchronous, technology-mediated learning, offering flexibility and accessibility for pre-service teachers across diverse contexts. However, asynchronous learning environments often struggle to sustain learner engagement and provide personalized support (Wei et al., 2024). These challenges are particularly evident in literacy-based courses, where comprehension, vocabulary, and reading fluency require continuous scaffolding and interaction (Kritsotakis & Morfidi, 2024). Within Indonesia's *Program Pendidikan Profesi Guru* (PPG), literacy remains a critical competency; yet, most existing Learning Management System (LMS) modules remain static and text-centric, neglecting adaptivity and multimodality (Setiawan & Rodgers, 2024).

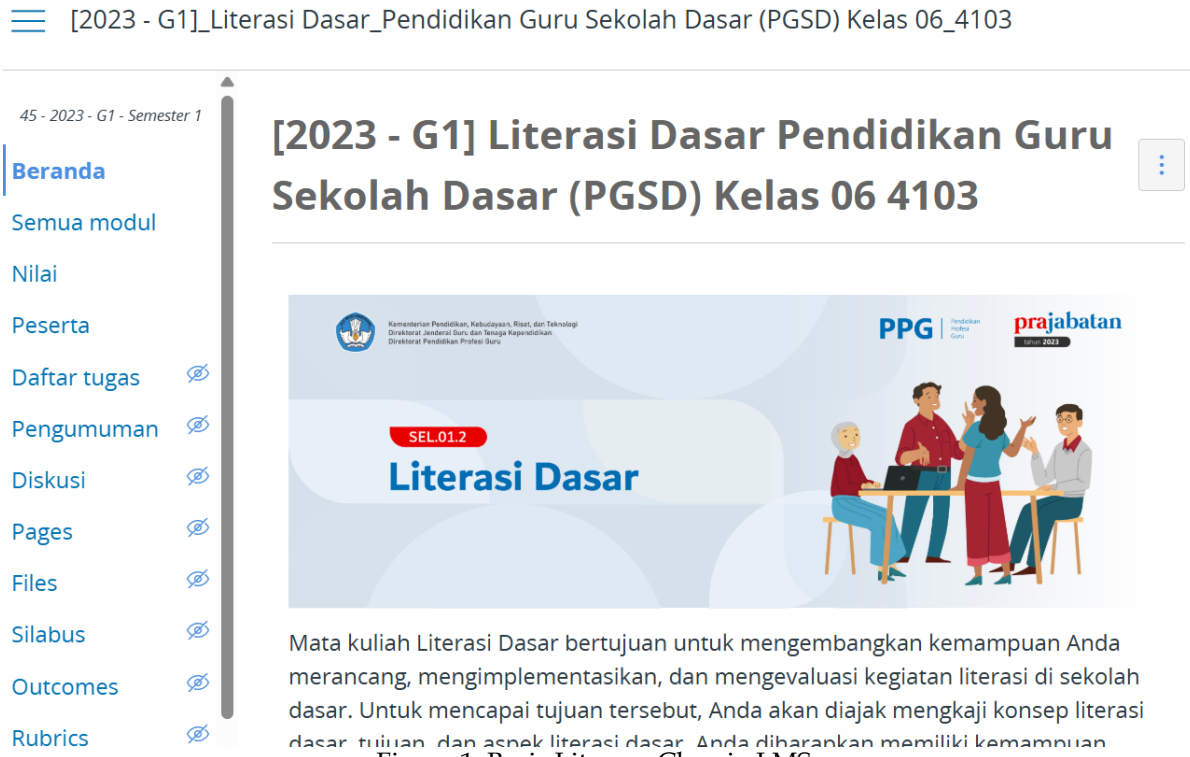

Figure 1. Basic Literacy Class in LMS

At the same time, global perspectives on literacy have evolved beyond decoding printed text to encompass the ability to construct meaning across multiple modes—textual, visual, auditory, and digital (Cope & Kalantzis, 2024; Unsworth, 2024). This paradigm, termed *multimodal literacy*, aligns closely with the communicative demands of 21st-century classrooms, where teachers must navigate hybrid and media-rich learning environments (Christian et al., 2024). Pre-service teachers, therefore, need to master not only linguistic literacy but also multimodal competence to design effective and engaging learning experiences (Sadikin et al., 2025).

Figure 2. Multimodality

Despite growing recognition of multimodality, empirical studies indicate that pre-service English teachers often lack confidence and practical strategies to integrate multimodal literacy in digital settings (Jayanti & Damayanti, 2023; Kusumaningrum et al., 2024). Moreover, literacy instruction within these platforms often remains limited to static content delivery, such as uploading reading materials, assignments, and discussion forums (Dwiputri et al., 2025). Such practices tend to replicate traditional classroom instruction rather than leveraging

the interactive and adaptive capabilities of digital learning environments. As a result, opportunities to support multimodal literacy development, learner engagement, and personalized learning pathways are frequently underutilized. These limitations highlight the need for instructional designs that integrate adaptive learning features and multimodal literacy resources within LMS environments to create more responsive and learner-centered literacy instruction.

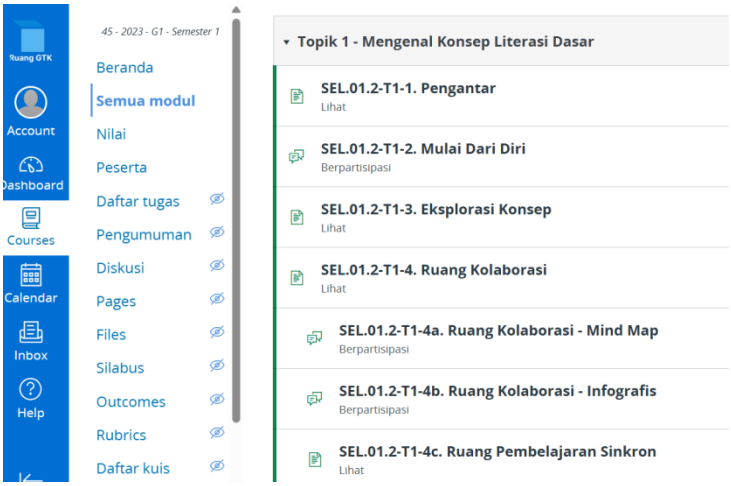

Figure 3. Module for Basic Literacy Class

The present study draws upon three interrelated theoretical foundations: evidence-based literacy instruction, multimodal literacy theory, and adaptive learning pedagogy. First, evidence-based literacy instruction identifies five fundamental components—phonemic awareness, phonics, fluency, vocabulary, and comprehension—as the core of reading development (Kritsotakis & Morfidi, 2024). Although originally designed for K–12 contexts, these principles remain essential for pre-service teachers who will later teach literacy themselves. Second, multimodal literacy emphasizes that meaning-making extends beyond linguistic text to include visual, spatial, and auditory modes (Cope & Kalantzis, 2024; Unsworth, 2024). Studies in Southeast Asian contexts show that integrating visual and auditory media enhances comprehension, particularly among learners with diverse linguistic backgrounds (Insani et al., 2024; Purba et al., 2023). Third, adaptive learning pedagogy leverages technology to tailor learning pathways, feedback, and pacing based on learner data. Research confirms that adaptive systems enhance motivation, engagement, and learning outcomes in higher education when supported by appropriate pedagogy and analytics (Contrino et al., 2024; Gligorea et al., 2023). In teacher education, adaptive learning further supports differentiation—an approach crucial for diverse cohorts of pre-service teachers with varying literacy proficiency (Nonthamand, 2024; Ulfa et al., 2018).

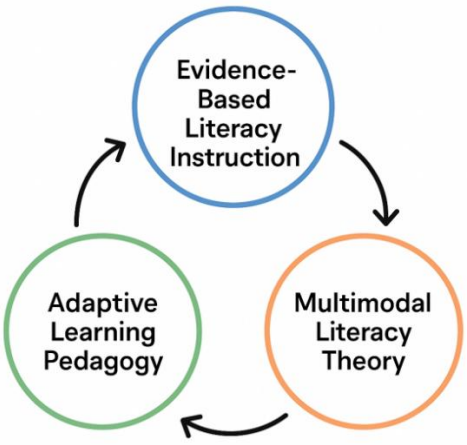

Figure 4. Theoretical Foundations

While each of these frameworks has been explored independently, few studies have combined adaptivity and multimodality to strengthen literacy foundations in teacher preparation. Previous Indonesian research largely focuses on either the design of LMS materials or multimodal literacy awareness, but not their integration within adaptive digital systems (Dwiputri et al., 2025; Setiawan & Rodgers, 2024). Consequently, the question remains how adaptive multimodal literacy instruction can be implemented effectively to support pre-service teachers' literacy development in asynchronous environments. The current study addresses this gap by developing and evaluating an adaptive multimodal literacy module embedded within an LMS environment for pre-service teachers. The module was derived from the book *Memahami Literasi* (*Understanding Literacy*) and redesigned following the Universal Design for Learning (UDL) framework (CAST, 2024) to accommodate learner diversity and promote accessibility.

Pre-service English teachers were selected as the focus of this study because they represent future educators who will be responsible for developing students' literacy competencies in increasingly digital learning environments. As literacy practices expand beyond traditional print texts to include multimodal and technology-mediated forms, teacher preparation programs must equip future teachers with the pedagogical knowledge and digital literacy skills necessary to facilitate these learning experiences. However, many pre-service teacher education programs still emphasize conventional literacy instruction and provide limited opportunities for engaging with adaptive and multimodal learning environments. Therefore, investigating how adaptive multimodal literacy modules can support the literacy development and pedagogical awareness of pre-service English teachers is particularly important for strengthening teacher readiness in contemporary classrooms.

Accordingly, the study aims to: (1) develop an adaptive multimodal literacy module that responds to individual learner profiles within an LMS; (2) examine its impact on literacy achievement, engagement, and self-regulated learning among pre-service teachers in asynchronous contexts; and (3) explore learners' perceptions of the module's adaptivity, multimodality, and pedagogical relevance for their future teaching practice. These objectives align with the broader goal of enhancing digital pedagogy and literacy instruction in teacher education. By synthesizing adaptive learning technologies and multimodal principles, this research contributes both theoretically and practically to reimagining how literacy is taught and experienced in higher education—moving, as the title suggests, *from pages to platforms*.

METHOD

This study employed a research and development (R&D) design following the ADDIE model (Analyze–Design–Develop–Implement–Evaluate) to develop and evaluate an adaptive multimodal literacy module within a Learning Management System (LMS). The design was appropriate as it allowed iterative development while collecting both quantitative outcomes and qualitative feedback (Branch, 2009; Creswell & Clark, 2023).

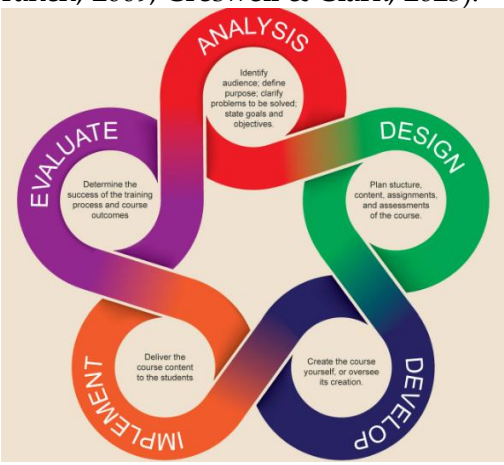

Figure 5. ADDIE Approach

Participants were 60 pre-service English teachers enrolled in the Teacher Professional Education (PPG) program at Universitas Negeri Malang. They represented diverse literacy proficiency levels based on a diagnostic pre-test. Participation was voluntary, and all ethical protocols were observed. Data were gathered through (a) expert validation rubrics for module quality, (b) literacy pre- and post-tests, (c) LMS learning analytics, (d) an online engagement questionnaire, and (e) semi-structured interviews. During the analysis phase, needs assessments and diagnostic literacy tests identified learning gaps in existing LMS modules. In the design phase, learning outcomes and adaptive logic were mapped following Universal Design for Learning (CAST, 2024). The module was then developed and uploaded to Moodle LMS with branching activities based on learner profiles. Implementation took place over eight weeks in an asynchronous format. Evaluation involved expert reviews, learner analytics, and pre/post assessments.

Quantitative data (literacy scores, engagement rates) were analyzed using descriptive statistics, paired-sample *t*-tests, and effect size calculations (*Cohen's d*). Qualitative data from interviews and reflections were analyzed thematically following Braun and Clarke's (2021) six-step framework. Triangulation of data sources ensured the validity and reliability of findings. The methodological sequence ensured systematic development, implementation, and evaluation of the adaptive multimodal literacy module. Ethical considerations, expert validation, and mixed-method triangulation were applied to ensure both rigor and educational relevance.

FINDINGS AND DISCUSSION

The adaptive multimodal literacy module was implemented over an eight-week asynchronous period through Moodle LMS. The module's content structure followed three adaptive pathways—*remedial, intermediate,* and *advanced*—based on the results of an initial diagnostic literacy assessment. Each pathway presented equivalent topics but with differentiated complexity, scaffolding, and media combinations (text, infographic, audio narration, and video explanation). The adaptive system functioned effectively: students who performed below 70% in the pre-test automatically received additional foundational reading exercises emphasizing phonemic awareness and vocabulary reinforcement. In contrast, those with higher scores were redirected to tasks involving multimodal analysis of educational texts and reflective writing. Learning analytics indicated high participation rates. Out of 60 participants, 55 (91.7%) completed the module, with an average of 7.2 logins per week and an average learning duration of 38 minutes per session, a notable increase from the baseline of 24 minutes prior to intervention. The consistent access patterns demonstrated sustained engagement throughout the course.

Literacy Performance

The pre- and post-test comparison showed a statistically significant improvement in participants' literacy competencies ($t(59) = 9.67$, $p < .001$). The mean literacy score increased from 68.2 (SD = 7.9) to 83.9 (SD = 6.4), with an effect size (Cohen's d) = 0.92, representing a large practical effect. The highest improvement was found in reading comprehension (+21 points), followed by vocabulary acquisition (+18) and multimodal text interpretation (+22). These results confirm that combining evidence-based literacy instruction with adaptive technology can significantly enhance core literacy skills among adult learners. Such outcomes mirror findings from (Contrino et al., 2024), who reported that adaptive systems in higher education improve student learning efficiency by allowing individualized progression. Similarly, Insani et al. (2024) demonstrated that multimodal materials enriched with visual and textual input improve reading comprehension among Indonesian learners. Thus, the current study provides empirical support for integrating adaptive and multimodal elements as complementary mechanisms: adaptivity ensures personalized pacing, while multimodality ensures cognitive diversity and engagement.

Table 1. Pre-test and Post-test Mean

Literacy Component	Pre-Test Mean	Post-Test Mean	Improvement (+)
Reading Comprehension	67.0	88.0	+21
Vocabulary Acquisition	70.0	88.0	+18
Multimodal Text Interpretation	67.0	89.0	+22
Overall Mean	**68.2**	**83.9**	**+15.7**

t(59) = 9.67, p < .001, Cohen's d = 0.92 (large effect)

Student Engagement and Learning Analytics

Quantitative indicators from the LMS revealed a significant enhancement in learner engagement. The module achieved a completion rate of 92%, while login frequency and task submission rates increased by 35% and 28%, respectively, compared to previous semesters. The engagement questionnaire yielded a mean score of 4.36 (SD = 0.41), classified as "high engagement." The strongest dimensions were *perceived relevance* and *self-directed learning*. These results align with Ang et al. (2024), who found that asynchronous learners exhibit greater engagement when instructional design emphasizes relevance and autonomy. Correlation analysis revealed a moderate positive relationship between engagement and literacy improvement ($r = 0.52$, $p < .01$), indicating that more engaged learners tended to gain higher literacy outcomes. This reinforces the well-established link between behavioral engagement and learning success in digital environments (Rincón-Flores et al., 2024; Brinkerhoff et al., 2024).

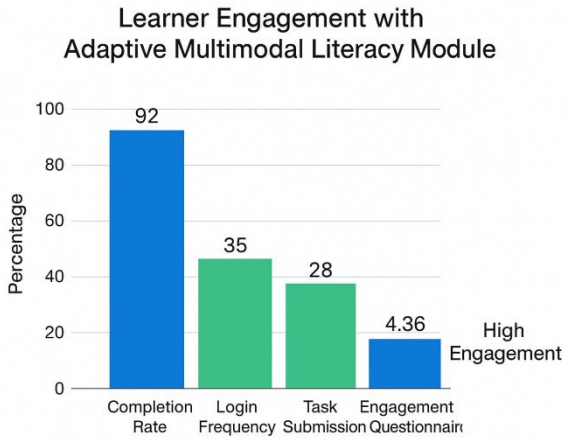

Figure 6. Learner Engagement

Learners' Reflections and Experiences

To complement the quantitative outcomes, thematic analysis of interview transcripts and reflection logs yielded three overarching themes that describe learners' lived experiences within the adaptive multimodal LMS environment.

Theme 1: "Learning at My Own Pace" — Autonomy and Flexibility

Most participants emphasized that the adaptive system empowered them to control their own learning pace without feeling left behind. They valued how the LMS recommended additional exercises when comprehension was low and allowed them to skip repetitive materials once mastery was achieved. One participant remarked, *"It felt like having a personal tutor who knew exactly what I needed to review next."* This finding echoes the concept of *self-regulated learning* in adaptive systems (Adler et al., 2025), where technology supports metacognitive control through feedback loops. Learners' comments suggest that adaptivity not only differentiated content but also enhanced agency, a vital skill for lifelong teacher development.

Theme 2: "Seeing and Hearing Helps Me Understand" – The Power of Multimodality

Learners consistently mentioned that the combination of text, visuals, and narration facilitated deeper comprehension of abstract literacy concepts. Complex topics—such as phonemic segmentation or multimodal text cohesion—were easier to grasp when accompanied by visual metaphors or short video demonstrations. These experiences substantiate Unsworth (2024) and Cope and Kalantzis (2024), who argue that multimodal representation extends cognitive processing and bridges the gap between linguistic and visual literacies. The current study adds that when multimodality is *adaptive*—triggered by learners' performance—it becomes not just decorative but pedagogically functional, supporting differentiated comprehension pathways.

Theme 3: "Reflecting Makes Me Think Like a Teacher" – Pedagogical Awareness

Beyond literacy skill improvement, students reflected on their emerging professional identity as teachers. The reflective forum activities, where they discussed classroom literacy cases and peer feedback, fostered pedagogical awareness. One student wrote, *"I started to think not only as a learner, but as a teacher—how I would explain literacy using pictures or digital texts to my students."* This transformation aligns with Contrino et al. (2024), who found that reflective practice in teacher education builds critical self-awareness and professional literacy. The adaptive multimodal approach thus acted as both content instruction and pedagogical modeling for future classroom design.

The convergence of quantitative and qualitative data confirms that the adaptive multimodal literacy module significantly enhanced both cognitive and affective dimensions of learning. The literacy test improvement demonstrates cognitive gain, while high engagement and reflective responses reveal affective and metacognitive growth. This alignment supports the *constructivist paradigm* underlying the design—learning occurs when individuals actively construct knowledge through interaction with multimodal content and feedback mechanisms (Vygotsky, 1978). In this case, the LMS acted as a mediational tool facilitating both individual reflection and social construction through discussion forums. The success of the intervention can be attributed to several design features: (1) Adaptive Differentiation – ensured content difficulty matched learner readiness, preventing overload (Gligorea et al., 2023). (2) Multimodal Reinforcement – diversified input channels, reducing monotony and sustaining motivation (Kusumaningrum et al., 2024). (3) Embedded Reflection – transformed the LMS into a dialogic space promoting critical thinking and professional growth (Jayanti & Damayanti, 2023).

Overall, the findings corroborate earlier work suggesting that digital adaptivity and multimodal integration are mutually reinforcing drivers of meaningful learning (Contrino et al., 2024; Sadikin et al., 2025).

Despite the positive outcomes, several limitations emerged. First, some participants reported technical difficulties related to internet connectivity, particularly during multimedia streaming—a challenge common in Indonesian higher education contexts (Dwiputri et al., 2025). Second, a few learners noted initial confusion navigating the adaptive branches, indicating the need for clearer orientation materials. Another consideration concerns sustainability and scalability. While the current module functioned effectively for 60 students, broader implementation would require institutional support for server capacity, instructional design training, and continuous content updating. These challenges mirror global concerns about digital equity and teacher readiness in adaptive learning adoption (Rukmini et al., 2023). Finally, emotional factors such as test anxiety and self-efficacy in asynchronous settings warrant closer examination. Research by Lu et al. (2024) on asynchronous learners' anxiety in online tests highlights the necessity of integrating affective scaffolds—such as reassurance messages and flexible deadlines—to maintain motivation and reduce dropout.

Comparatively, the present study extends previous research in three ways: (1) It contextualizes adaptive learning within *teacher literacy education*, a domain still underexplored in the Southeast Asian context, (2) It empirically demonstrates that adaptive multimodal design enhances both literacy and metacognition, not merely engagement metrics, and (3) It

bridges research and practice by showing how printed pedagogical materials (the book *Memahami Literasi*) can be successfully transformed into adaptive digital ecosystems. These contributions resonate with the ongoing global discourse on *transformative digital pedagogy* (Cope & Kalantzis, 2024; Flores et al., 2024), which advocates for learning environments that are personalized, interactive, and socially meaningful.

The alignment between the adaptive differentiation principles and literacy outcomes found in this study resonates with global evidence on the role of personalized digital environments in fostering meaningful learning. Gligorea et al. (2023), in a large-scale literature review of AI-driven adaptive learning systems, emphasized that adaptive platforms enhance learner performance when instructional sequencing and feedback loops respond dynamically to learner readiness and cognitive load. This corresponds closely with the current study's adaptive branching, which minimized cognitive overload and maintained engagement by matching content difficulty to individual proficiency levels. Similar findings were also reported by Contrino et al. (2024), who observed that adaptive content personalization in higher education improved students' motivation, time-on-task, and learning efficiency—key components of sustainable engagement in asynchronous courses.

The incorporation of multimodal reinforcement through diverse textual, visual, and auditory inputs also played a critical role in sustaining learner motivation and comprehension. Kusumaningrum et al. (2024) confirmed that multimodal text design supports differentiated meaning-making among EFL learners in Indonesian classrooms by bridging linguistic and visual literacies. Likewise, Abdullah et al. (2022) found that genre-based multimodal text analysis fosters students' communicative and interpretive competence, indicating that multimodal learning environments strengthen both cognitive and semiotic awareness. In the context of this study, the integration of visual and digital storytelling materials allowed pre-service teachers to experience literacy as a multilayered process, enriching their conceptual understanding of how multimodality supports inclusive learning.

Reflection emerged as another significant contributor to learners' affective and metacognitive development. Jayanti and Damayanti (2023) demonstrated that reflective dialogue within digital forums promotes pedagogical awareness by enabling student teachers to connect theory with classroom realities. The reflective forum activities in this research mirrored those dynamics, transforming the LMS into a dialogic learning space where learners negotiated their emerging identities as teachers. Such processes align with Chaseley and Abercrombie (2025), who argue that scaffolded reflection fosters preservice teachers' professional literacy by prompting critical self-evaluation and evidence-based reasoning about instructional design choices. These findings suggest that embedding reflection into adaptive multimodal environments not only enhances content mastery but also nurtures professional growth.

Despite these successes, infrastructural and affective limitations remain prominent. Rukmini et al. (2023) highlighted that in Indonesian higher education, digital implementation still faces barriers in connectivity, technological infrastructure, and institutional readiness—factors echoed by participants in the current study who experienced technical interruptions during multimedia streaming. Similarly, Lu et al. (2024) identified that test anxiety and emotional disengagement in asynchronous online environments can hinder self-regulated learning, underscoring the need for adaptive systems to include affective scaffolds such as flexible deadlines and reassurance messaging. These studies reinforce that successful digital pedagogy depends not only on technical functionality but also on emotional and infrastructural sustainability.

Overall, these convergent findings affirm that adaptive and multimodal learning designs operate synergistically when grounded in constructivist and reflective principles. They enable learners to move fluidly between receiving content, constructing meaning, and reflecting on professional identity—thereby aligning cognitive, affective, and social dimensions of teacher education. In sum, the adaptive multimodal literacy module developed in this study

exemplifies how technology-enhanced pedagogy can simultaneously serve as an instructional medium and a model of future-oriented teaching practice.

CONCLUSIONS

This study confirms that integrating adaptive and multimodal principles within a Learning Management System effectively enhances literacy learning for pre-service teachers. The adaptive multimodal literacy module significantly improved participants' comprehension, vocabulary, and multimodal interpretation skills while fostering reflective and professional growth. The findings suggest that when literacy instruction combines evidence-based design, multimodal representation, and adaptive technology, it strengthens both cognitive and metacognitive dimensions of learning. The adaptive LMS also functioned as a reflective space, enabling learners to connect content understanding with pedagogical thinking. Despite technical and emotional challenges—such as connectivity issues and test anxiety—the overall outcomes demonstrate that adaptive multimodal instruction can serve as a viable model for digital teacher education in Indonesia.

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