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DEVELOPING A PROBLEM-BASED APPLICATION TO ENHANCE STUDENTS' DIGITAL LITERACY IN EFL LEARNING

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Abstract

The integration of mobile technology with Problem-Based Learning (PBL) offers a promising pathway to enhance students' digital literacy in EFL contexts. This study developed and validated an Android-based English learning application grounded in PBL principles to support junior high school students' digital literacy development. Employing a research and development (R&D) approach using the 4D model (Define, Design, Develop, Disseminate), the product was evaluated through expert validation and field testing. Three expert validators assessed the application in terms of content, language, and media quality, while 81 ninth-grade students from two Indonesian public junior high schools (SMPN 2 Mojoanyar and SMPN 3 Mojokerto) participated in a four-week implementation. The application was designed around five PBL principles: authentic problem presentation, student-centered learning, collaboration, self-directed learning, and metacognitive reflection. Expert validation indicated strong quality in content (86%), language (91%), and media (76%). Students' digital literacy scores increased from M = 28.47 (SD = 2.84) to M = 47.48 (SD = 1.52), $t(80) = 58.84$, $p < .001$. Indicator-level analysis showed the highest gains in self-regulated learning, interactive feature use, and digital communication. Practicality results indicated that students perceived the application as practical and supportive (overall 75.58%). While the pretest–posttest improvement suggests substantial learning gains, the one-group design warrants cautious interpretation. Overall, the findings support the feasibility of integrating PBL into mobile-assisted EFL learning to foster students' digital literacy in alignment with the Merdeka Curriculum.

Keywords: Android application, digital literacy, EFL learning, mobile learning, problem-based learning learning

Introduction

In the digital era, education is undergoing rapid technological transformation, requiring learners to possess not only linguistic competence but also digital literacy and higher-order thinking skills. English learning in secondary schools must therefore move beyond the traditional, teacher-centered paradigm toward more active, technology-integrated learning models. Mobile learning (m-learning), characterized by portability, flexibility, and interactivity (Ibrahim & Ishartiwi, 2017); (Ljungkvist & Mozelius, 2012), offers great potential to foster engagement and self-directed learning among students. Simultaneously, the Problem-Based Learning (PBL) approach, grounded in constructivist theory which encourages learners to construct knowledge through real-world problem-solving (Chuang, 2021); (Carpendale, 2013). Integrating these two pedagogical frameworks provides a promising pathway for enhancing English learning outcomes and students' digital literacy competencies.

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Digital literacy has become a critical skill in 21st-century education, encompassing the ability to locate, evaluate, and effectively use digital information while maintaining ethical awareness (Hague & Payton, 2010); (Hatlevik et al., 2015). In the Indonesian context, where smartphone use among adolescents is nearly universal, the opportunity to leverage mobile devices as learning tools is enormous. Yet, as highlighted by Purmadi et al.(2022); Riyanti et al. (2023), the implementation of technology in learning remains limited, often constrained by teachers' lack of media development skills and insufficient digital resources. These challenges underscore the need to design mobile-based learning innovations that are pedagogically sound and contextually relevant. Mobile learning is defined as learning that uses mobile devices to access content anywhere and anytime (Zhang & Zuo, 2019). When aligned with Problem-based Learning (PBL) principles, m-learning allows students to collaboratively explore authentic language problems, apply linguistic concepts in real-life contexts, and reflect on their digital interactions (Cong & Ironsi, 2025). Moreover, this integration aligns closely with the goals of *Kurikulum Merdeka*, which emphasizes learner autonomy, critical thinking, and digital fluency (Lydwin et al., 2025).

Problem-based Learning (PBL) is rooted in constructivist learning theory, which posits that learners actively construct knowledge through experience and social interaction (Chuang, 2021). In PBL, students collaboratively analyze complex, real-world problems, propose hypotheses, and design solutions (Thomassen & Stentoft, 2020); (Sebastián-López & González, 2020). The constructivist and experiential dimensions of PBL are strengthened when implemented via mobile technology. Mobile applications provide access to authentic materials, online collaboration, and immediate feedback, enhancing problem-solving and critical thinking (Gudonienė et al., 2021); (Ironsi & Bensen Bostancı, 2023).

Previous studies have shown the effectiveness of integrating mobile learning and PBL in enhancing students' cognitive and digital skills. (Cong & Ironsi, 2025) demonstrated that a mobile–PBL integrated model improved undergraduate students' problem-solving and critical thinking competencies. Similarly, studies by (Solissa et al., 2025) found that hybrid or technology-enhanced PBL approaches foster digital literacy, collaboration, and creativity among learners. (Atmojo & Nugroho, 2020) emphasized that digital literacy education, when combined with inquiry-based or project-based methods, cultivates communication and information management skills essential for lifelong learning. However, while the benefits of PBL and mobile learning have been widely reported, few studies have specifically developed mobile-based English learning media for junior high school students that systematically integrate PBL principles. Moreover, existing studies often focus on general digital literacy or science-related learning contexts (Asrizal et al., 2018), rather than English as a Foreign Language (EFL) learning environments. Hence, this current research represents a new contribution by designing and validating a PBL-based mobile English learning application tailored to junior high school students. It also examines its feasibility and effectiveness in promoting digital literacy, which is an area that remains underexplored in Indonesian EFL settings (Suwastini et al., 2021); (Suryani et al., 2024).

Despite the increasing adoption of technology-enhanced PBL in education, several gaps persist. First, most previous studies examined either technology integration or PBL independently, not as a unified instructional model (Solissa et al., 2025). Second, there is limited empirical evidence on how mobile-based PBL specifically affects students' digital literacy and English proficiency in secondary education. Third, studies often overlook the expert validation process that ensures the media's pedagogical, linguistic, and technical quality (Wulandari et al., 2023). (Lydwin et al., 2025) also highlighted the readiness gap among Indonesian students to engage in technology-integrated PBL due

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to disparities in infrastructure and digital competence. Besides, the implementation of technology-enhanced PBL at the junior high school level still faces various challenges, especially in Mojokerto. This condition is reinforced by the results of the researchers' preliminary study at SMPN 3 Mojokerto and SMPN 2 Mojoanyar, which show that low digital literacy impacts students' English vocabulary mastery. This study addresses these issues by developing a validated Android-based interactive learning application designed around authentic PBL scenarios for fostering students' digital literacy.

Accordingly, this study addresses gaps in (1) the limited development of PBL-oriented mobile EFL applications for junior high school learners, (2) the scarcity of evidence on how mobile-PBL designs influence students' digital literacy in secondary EFL settings, and (3) the insufficient emphasis on expert validation to ensure pedagogical, linguistic, and technical quality. Building on these gaps, this research aims to develop and validate an Android-based interactive English learning application integrating PBL principles and to examine its practicality and potential effectiveness in improving students' digital literacy.

This study is guided by the following research questions:

1. How can interactive English learning content be designed for an Android application using PBL principles for junior high school students?
2. To what extent do subject-matter, language, and media experts validate the quality and feasibility of the developed application?
3. To what extent does the PBL-based mobile application improve students' digital literacy during a four-week implementation?

Literature Review

This section reviews previous studies related to Problem-Based Learning (PBL), mobile learning, and digital literacy, which form the conceptual and empirical basis for this research. This section also explains the related previous studies illustrating how integrating PBL and mobile learning can foster deeper understanding, collaboration, and digital competence.

Problem-based learning and mobile learning

PBL is a teaching method where students learn new information and abilities by working on problems that are based on real-life situations (Loyens et al., 2008). It started in a Canadian medical school as a way to move away from lessons that mainly involve teachers and instead focus more on teaching through student involvement (Barrows & Tamblyn, 1980). Additionally, Problem-Based Learning (PBL) is an instructional model grounded in constructivist theory, emphasizing learning through the exploration of authentic problems. Learners construct knowledge collaboratively, guided by inquiry, reflection, and application (Han, 2025). Regarding this, mobile learning complements PBL principles, i.e., learners can explore problems, access multimedia resources, collaborate online, and present their solutions through mobile platforms. This synergy makes mobile learning a powerful vehicle for implementing PBL in digital education settings.

Mobile learning has transformed modern pedagogy by enabling flexible, interactive, and ubiquitous learning environments (Traxler & Vosloo, 2014). (Kale et al., 2021) developed a mobile learning-based edugame on the respiratory system and found that interactive mobile applications can effectively improve student engagement and digital literacy. Their study proved its feasibility and

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pedagogical quality. Mobile learning's interactive features, such as animations, quizzes, and gamified tasks which promote motivation and concept retention (Talan, 2020). Ibrahim & Ishartiwi (2017) also observed that Android-based learning media support deeper conceptual understanding and learner autonomy in secondary education. Similarly, (Heirdsfield et al., 2007) noted that flexibility and accessibility in mobile-supported learning environments enhance learners' motivation and self-regulation.

Digital literacy

Digital literacy is the ability to find, evaluate, use, and create information responsibly through digital technologies (Hague & Payton, 2010). (Wingo et al., 2017) defines it as a multidimensional skill encompassing not only technical competence but also ethics, critical thinking, and civic responsibility. (Asrizal et al., 2018) further argue that digital literacy forms part of the "4Cs" of 21st-century learning, i.e., critical thinking, creativity, collaboration, and communication, which makes it indispensable in education.

Riyanti et al (2023) emphasize that internet-based and mobile-mediated learning can significantly enhance students' digital literacy. Their study found that elementary students improved their digital skills and collaboration through interactive online platforms. (Kale et al., 2021) also found that digital literacy is fostered through active engagement with mobile media. Their findings revealed notable improvements in four dimensions of literacy, i.e., smart use, critical reading, sharing, and socialization. As Wingo et al (2017) argues, digital literacy not only involves technical skills but also ethics and critical consciousness. Learners must be aware of misinformation and practice responsible use of digital resources. Dašić et al (2024) reinforces this by asserting that digital literacy leads to critical and creative mindsets, necessary for meaningful participation in the digital society.

The integration of PBL and mobile learning to foster English and digital literacy

Integrating PBL and mobile learning offers a robust framework to enhance both language learning and digital literacy. Through PBL, students engage in inquiry-driven exploration; through mobile learning, they gain access to diverse, interactive, and multimodal resources (Kale et al., 2021). Riyanti et al (2023) show that gamified and interactive applications support situational learning, allowing students to apply concepts in dynamic contexts such as augmented reality (AR) or virtual simulations. The combination of these approaches supports students' metacognition and self-regulation (Han, 2025), enabling them to plan, monitor, and evaluate their learning activities effectively. Flavell et al (2019) found that e-learning environments can empower both teachers and students to adapt to technological challenges and enhance learning outcomes. Wingo et al (2017) explain that technology acceptance depends on faculty and student perceptions of usability and value, highlighting the importance of expert validation in digital media development.

In the educational technology development process, validation from experts in content, language, and media is crucial to ensure product quality and feasibility (Kale et al., 2021). From a language education perspective, integrating PBL into mobile learning creates an authentic communicative space where students apply English to analyze and solve contextual problems. Zhang & Zuo (2019) found that mobile learning in English instruction increases students' motivation and autonomy by allowing individualized learning experiences. Similarly, Traxler & Vosloo (2014) argue

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that mobile technologies support the collection of real data and context-sensitive exploration, promoting deeper learning.

The synthesis of these empirical findings underscores the pedagogical potential of a Problem-Based Learning (PBL)-oriented mobile English learning model to foster not only students' English competence but also their digital literacy and critical thinking capacities. Engagement in collaborative, problem-oriented tasks through digital media enables learners to exercise critical inquiry, evaluate and verify information, negotiate meaning, and generate creative solutions, which are cognitive processes that are inherently aligned with both language learning and digital literacy development. Consequently, this study aims to address the identified research gaps by designing and validating an interactive, mobile-based English learning application grounded in the PBL framework to enhance junior high school students' digital literacy. By integrating pedagogical theory, technological innovation, and literacy development, this research advances current research on evidence-based and contextually responsive digital learning design.

Methodology

Research design and procedures

This study employed a mixed-methods R&D design by integrating the 4D development model (Define, Design, Develop, Disseminate) with a one-group pretest–posttest quasi-experimental procedure during field implementation. The 4D model was used to systematically develop an Android-based learning application, while the pretest–posttest procedure was used to examine changes in students' digital literacy before and after using the application. This design was selected due to practical constraints in establishing equivalent control groups across school contexts; therefore, causal claims are interpreted cautiously.

The procedures included: (1) defining instructional needs through teacher interviews and curriculum review; (2) designing PBL-integrated learning content and application features; (3) developing the application and conducting expert validation; and (4) conducting field testing over a four-week intervention and collecting practicality feedback.

a. Define stage: needs analysis and problem
b. A comprehensive needs analysis was conducted through structured interviews with four English teachers at SMPN 2 Mojoanyar and SMPN 3 Mojokerto. The findings indicated relatively low levels of students' digital literacy in the local context, as reflected in school observations and publicly available educational statistics from the Indonesian Ministry of Education. Further analysis identified three critical challenges: (1) teachers' predominant reliance on conventional textbooks as the primary learning resource, (2) limited use of digital media for structured learning activities, and (3) restricted internet access for educational purposes. Learner analysis showed that ninth-grade students possessed basic smartphone operation skills but lacked competencies in utilizing digital tools for systematic and goal-oriented learning. Curriculum analysis confirmed alignment with both the 2013 Curriculum and the Merdeka Curriculum, emphasizing the integration of 21st-century skills, particularly digital literacy competencies.
c. Design stage: conceptual framework development
   Based on the needs analysis, a comprehensive conceptual framework was developed integrating the Problem-Based Learning approach with mobile learning technology. The application architecture was structured around five core principles derived from PBL theory: (1) authentic

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problem presentation reflecting real-world English communication contexts, (2) student-centered learning facilitation through interactive features, (3) collaborative knowledge construction through discussion forums, (4) self-directed learning support via personalized content delivery, and (5) reflection and evaluation mechanisms for metacognitive development. The application interface was designed with three hierarchical levels: (1) Header section containing personalized welcome messages and learning progress indicators, (2) Banner section featuring motivational imagery of diverse learning environments (indoor and outdoor settings) to enhance student engagement, and (3) Content menu section organizing learning features into systematic categories. The navigation structure was developed following mobile-first design principles, ensuring intuitive user experience and minimal cognitive load.

d. Develop stage: PBL integration and feature implementation
The Android application was developed using Android Studio with minimum SDK compatibility for Android 5.0 (Lollipop) ensuring wide device accessibility (Ibrahim & Ishartiwi, 2017). Problem-Based Learning was integrated through authentic scenarios encouraging critical thinking in English language challenges. Expert validation assessed product quality through three purposively selected validators: (1) an English education expert with doctoral qualification, (2) a language and applied linguistics expert in EFL pedagogy, and (3) a media and technology expert in educational technology. This triangulation enhances validation credibility (Akbar, 2013). Validation employed three Likert-scale questionnaires: media/technology (15 items), language/content (17 items), and learning materials (13 items). Validity percentage: (Total Score/Maximum Score) × 100%, with criteria ranging from Invalid (0-20%) to Very Valid (81-100%)(Akbar, 2013).

e. Dissemination stage
Following expert validation and necessary revisions, the application underwent field testing to assess its effectiveness in enhancing students' digital literacy. A quasi-experimental one-group pretest–posttest design was implemented over a four-week intervention period (July–September 2025). This design was selected due to practical constraints in establishing equivalent control groups across different school contexts, while still enabling the measurement of learning outcomes before and after the intervention (Shadish et al., 2002).

Research site and participants

Two participant groups were involved. First, three expert validators were purposively selected: a subject matter expert in English education with doctoral degree, a language expert specializing in EFL curriculum development, and a media expert with educational technology experience. Second, 81 ninth-grade students participated (25 from SMPN 2 Mojoanyar, 56 from SMPN 3 Mojokerto). Student selection criteria included active ninth-grade enrollment during 2024/2025, Android device ownership (minimum Android 5.0), willingness to participate throughout the four-week intervention, parental consent, and no prior PBL-based mobile learning experience. The selection of ninth-grade students was justified by: (1) the urgency of enhancing digital literacy in preparation for national examinations and future secondary education, (2) appropriate cognitive maturity levels for engaging with problem-based learning approaches (Piaget, 1970);(Vygotsky & Luria, 1978), and (3) increasing autonomy in technology-mediated learning compared to younger adolescents.

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Data collection and analysis

Data collection was conducted systematically across multiple phases employing qualitative and quantitative instruments. 1st Phase (Needs Analysis) involved structured interviews with four English teachers using a semi-structured protocol of 12 open-ended questions addressing current instructional practices, teaching challenges, students' technology access, and technology integration feasibility. Interview data were audio-recorded and transcribed for thematic analysis (Braun & Clarke, 2008). 2nd Phase (Expert Validation) utilized three validation instruments: Media and Technology Assessment (15 items), Language and Content Evaluation (17 items), and Learning Material Review (13 items), all using 5-point Likert scales. Validators received the functional application, user manual, questionnaires, and feedback forms with a two-week evaluation period (Nieveen, 1999). 3rd Phase (Digital Literacy Assessment) employed a 10-indicator instrument adapted from DigComp 2.1 framework (Carretero et al., 2017) with demonstrated reliability (Cronbach's $\alpha = .87$). Pretest and posttest were administered via Google Forms before and after a four-week intervention. 4th Phase (Practicality Assessment) used a 33-item questionnaire across six dimensions administered immediately post-intervention (Nieveen, 1999).

A mixed-methods analytical approach was employed (Creswell & Poth, 2016). Expert validation used descriptive statistics with validity percentages calculated as: (Σ Score Obtained / Σ Maximum Score) × 100%, interpreted from Invalid (0-20%) to Very Valid (81-100%) (Akbar, 2013). Qualitative feedback underwent thematic analysis to identify strengths and revision needs (Braun & Clarke, 2008). Digital literacy effectiveness analysis employed descriptive statistics (mean, standard deviation) and inferential statistics including gain score calculation, paired-samples t-test ($\alpha = .05$) with Shapiro-Wilk normality testing, and Cohen's d effect size measurement using benchmarks: small (0.2), medium (0.5), large (0.8). Indicator-level analysis examined improvements across 10 digital literacy indicators. All analyses used SPSS 26.0 (IBM Corp., 2019). Practicality assessment calculated percentages for each dimension using similar formulas, with criteria ranging from Impractical (0-20%) to Very Practical (81-100%)(Nieveen, 1999). Qualitative responses were thematically coded (Miles et al., 2023). Findings were integrated through convergent parallel design, synthesizing validation, effectiveness, and practicality data for comprehensive evaluation (Creswell & Poth, 2016).

Results

This section presents the empirical findings obtained from the research and development stages of the study. The data were derived from three major phases: (1) the design and development of PBL-based interactive English learning content for Android mobile devices, (2) expert validation assessing the feasibility and quality of the developed media, and (3) practicality testing conducted with junior high school students. Each subsection below presents detailed findings supported by quantitative data and qualitative interpretation, providing evidence for the effectiveness and pedagogical soundness of the developed mobile-based learning model.

Designing interactive English learning content for android mobile applications using PBL approach for junior high school students

The researcher designed interactive content based on five PBL principles: a) presentation of authentic problems, b) student-centered learning, c) group/collaborative work, d) independent

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learning, and e) reflection and evaluation mechanisms for metacognitive development. A comprehensive conceptual framework was developed by integrating the Problem-Based Learning (PBL) approach with mobile learning technology.

Authentic problem presentation

The design of interactive English learning content based on PBL on an Android application for junior high school students was carried out by integrating the principle of presenting authentic problems into various interactive design features. In the interactive material feature, for example, students not only learn narrative texts theoretically, but are also given contextual problems such as completing incomplete stories with the appropriate vocabulary and grammar. In the gamification feature, games are designed as problem-solving simulations, such as matching pictures of objects with the English vocabulary for the names of those objects. Quizzes and evaluations are also packaged in the form of analytical challenges, such as evaluating the accuracy of information in a text. Through this approach, each feature in the application not only teaches linguistic elements but also trains students to apply that knowledge in solving authentic problems, making learning more meaningful, contextual, and encouraging the development of critical thinking skills.

Student-centered learning

Designing effective interactive English learning content with a PBL approach for junior high school students' Android applications applies student-centered principles by integrating them into the entire feature architecture. The learning style detection feature is the foundation, which allows the application to recommend personalized paths and materials (visual, auditory, or kinesthetic), so that content is presented according to individual cognitive preferences. The gamification feature positions students as active problem solvers, encouraging independent exploration with the support of an online dictionary and interactive videos that provide on-demand resources. In addition, the learning progress dashboard allows students to monitor their own progress, reflect on their weaknesses, and set learning goals, further emphasizing their central role in the learning process.

Collaborative work

The design of interactive English learning content based on PBL for Android applications for junior high school students integrates the principles of collaborative knowledge construction by creating features that encourage students to jointly build understanding through social interaction. Gamification features designed for group games require students to coordinate to compose sentences or complete vocabulary challenges in a shared scenario. Additionally, interactive videos depicting complex communication situations spark group discussions to analyze and reconstruct the most effective language solutions.

Independent Learning

Designing interactive English learning content based on PBL for Android applications for junior high school students applies the principle of independent learning by creating a digital ecosystem that allows students to take full control of their learning process through responsive

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features. This principle is realized through a learning progress dashboard that provides a clear visualization of progress and areas for improvement, allowing students to reflect and set learning targets independently. Supported by learning style detection features, the application provides personalized learning paths where students can choose interactive materials and games that suit their cognitive preferences. Students are encouraged to independently explore various available resources such as contextual online dictionaries and interactive videos with customizable playback controls. The intuitive navigation structure and flexible content access allow students to determine their learning pace and sequence, while a comprehensive evaluation system (formative quizzes, pre-tests, post-tests) provides immediate feedback that facilitates self-correction.

Reflection and Evaluation

The design of interactive English learning content based on PBL for Android applications for junior high school students integrates the principles of reflection and evaluation by building a continuous feedback mechanism embedded in authentic problem-solving experiences. This principle is realized through a comprehensive evaluation system that includes pre-tests, formative quizzes, and post-tests, where each question is packaged in the form of contextual problems. A learning progress dashboard that displays development in visual form facilitates metacognitive reflection, allowing students to evaluate their own learning patterns and adjust their approach to solving subsequent authentic problems. Thus, this application can help students receive immediate feedback, reflect on the learning process, and foster students' capacity for self-evaluation.

The learning media's quality and feasibility

The PBL-based interactive content for Android mobile devices was completed and then validated by subject matter experts, language experts, and media experts. The instrument was created using a likert scale. The subject matter expert validation sheet consisted of three aspects, namely PBL, deep learning, and pedagogy, which were broken down into 13 questions. The results of the subject matter expert validation are presented in Table 1.

Tabel 1. *Result of Expert Validation*

Assessment Aspect	Score	Grade	Criteria
Problems are presented based on real-world contexts that are meaningful to students.	4	80	Valid
Problems are not too simple but challenging enough in line with students' cognitive development stages.	5	100	Very Valid
Problems stimulate students' curiosity and learning activity.	5	100	Very Valid
Problems are relevant and contextual to English language learning.	4	80	Valid
Problems guide students to think deeply, ask questions, find solutions, and produce real products.	4	80	Valid
Mindful learning: encourages full attention, self-regulation, and awareness in learning.	4	80	Valid
Meaningful Learning: Connects new knowledge with prior knowledge.	4	80	Valid
Joyful Learning: creates a positive, empathetic, and exciting learning atmosphere.	4	80	Valid

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Reflective activities and inquiry processes are used to deepen students' understanding.	4	80	Valid
Adaptive and personalized learning tailored to the needs and characteristics of learners.	4	80	Valid
Encouraging active learning	5	100	Very Valid
Facilitating collaborative learning	4	80	Valid
Accommodating various learning styles	5	100	Very Valid
Total Score of Expert Validation	56	86	Very Valid

The validation results conducted by subject matter experts on the developed learning tools showed excellent quality, with a final score of 86, which falls into the Highly Valid category. A detailed analysis of 13 assessment aspects revealed that the main strength of this product lies in its ability to design learning problems or challenges. Key aspects of modern learning, such as stimulating students' curiosity, providing an appropriate level of cognitive challenge, encouraging active learning, and accommodating various learning styles, all received a perfect score (5) with a "Highly Valid" rating. This indicates that the materials developed are not only relevant to the students' level of development but are also designed to optimally stimulate their engagement and activity.

Consistently, the other nine assessment aspects received a score of 4 (Valid criteria). These aspects include the foundations of learning design, such as the presentation of real-world context-based problems, relevance to English language learning, and the ability of problems to guide students toward deep thinking and the creation of real products. In addition, contemporary pedagogical principles are also well integrated, as reflected in the fulfilment of the elements of mindful learning, meaningful learning, joyful learning, reflective-inquiry activities, adaptive learning, and collaboration. High and consistent scores across all these aspects prove that the product has met the standards of content and learning methodology. Overall, the findings of this expert validation provide a strong empirical basis that this learning tool is feasible and eligible for further testing in the research and development stage.

Language expert validation aims to test the linguistic suitability of the compiled material. The language expert validation sheet consists of aspects of learning content and digital literacy, which are presented in 17 questions. The results of the language expert validation are presented in Table 2.

Table 2. *Result of Language Expert Validation*

Assessment Aspect	Score	Grade	Criteria
Alignment with basic English language competencies for junior high school students	4	80	Valid
Development of problem-solving skills	4	80	Valid
Alignment with learning objectives	4	80	Valid
Alignment with competency achievement indicators	4	80	Valid
Alignment with the characteristics of junior high school students	5	100	Very Valid
Relevance to digital literacy needs	5	100	Very Valid
Accuracy of vocabulary material	5	100	Very Valid
Accuracy of grammar material	5	100	Very Valid
Accuracy of pronunciation material	5	100	Very Valid
Suitability of difficulty level to student level	4	80	Valid
Completeness of material (reading, listening, speaking, writing)	4	80	Valid
Contextuality of material to everyday life	5	100	Very Valid
Diversity of topics and themes	4	80	Valid

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Development of digital information access skills.	5	100	Very Valid
Development of information evaluation skills.	5	100	Very Valid
Development of technology use skills	5	100	Very Valid
Development of digital communication skills.	5	100	Very Valid
Total Score of Expert Validation	78	91	Very Valid

Based on the validation results conducted by language experts on English learning tools for junior high school level, it can be concluded that the product is declared Highly Valid overall with a total score of 78 out of 85 and a final score of 91. This level of validity reflects the high quality of the material and its readiness for implementation in the learning process. The scores achieved in each aspect of the assessment were mostly in the "Valid" (score of 4/value of 80) and "Highly Valid" (score of 5/value of 100) categories, with no aspects deemed to be less than valid.

A more detailed analysis shows that this product has very prominent advantages in several crucial aspects. The aspects that received a perfect score (100) are closely related to relevance and 21st-century skills, namely suitability for junior high school students, relevance to digital literacy needs, and the development of skills to access, evaluate, use technology, and communicate in a digital environment. In addition, in terms of linguistic content accuracy, vocabulary, grammar, and pronunciation materials also received a score of 100, indicating a strong linguistic foundation that is scientifically accountable. The contextuality of the material in relation to everyday life was also rated very good, showing that the material presented is easy for students to understand and apply.

On the other hand, several aspects scored in the "Valid" category (score of 80), which, although good, still leaves room for further development. These aspects include suitability with basic competencies, problem solving development, suitability with learning objectives and indicators, level of difficulty, completeness of material (covering all four language skills), and diversity of topics and themes. Thus, even though the product is considered highly valid, there are opportunities for improvement in these aspects, for example by enriching the variety of topics, increasing the complexity of questions to challenge problem-solving skills, and ensuring more comprehensive material coverage for all learning indicators. Overall, these findings prove that the validated product has met high quality standards and is suitable as an effective learning medium in junior high school English classes.

Media expert validation aims to test the technical feasibility of the Android mobile application. The media expert validation sheet consists of technological and media aspects, which are broken down into 15 questions. The results of the media expert validation are presented in Table 3.

Table 3. *Result of Media Expert Validation*

Assessment Aspect	Score	Grade	Criteria
Attractive and organized layout	3	60	Valid Enough
Consistent design throughout the application	3	60	Valid Enough
Appropriate and attractive use of color	4	80	Valid
Text readability (font, size, contrast)	4	80	Valid
Responsiveness to various screen sizes	4	80	Valid
Image and video quality	4	80	Valid
Ease of application navigation	4	80	Valid
Loading speed and responsiveness	4	80	Valid
Intuitive use	4	80	Valid
Clear usage instructions	4	80	Valid
System feedback on user actions	3	60	Valid Enough

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Quality of quizzes and interactive exercises	4	80	Valid
Automatic scoring system	4	80	Valid
Gamification (points, badges, leaderboards)	4	80	Valid
Progress tracking feature.	4	80	Valid
Total Score of Expert Validation	57	76	Valid

Based on the validation results conducted by media experts, it can be concluded that the quality of the learning media tested is generally considered Valid with an average score of 76. Of the 15 aspects assessed, 11 aspects (73.3%) received the maximum score with the "Valid" criteria. These outstanding aspects include aesthetic and functional elements, such as the use of color, text readability, and responsiveness; as well as interactivity and assessment components, such as quiz quality, automatic scoring systems, and gamification features. This shows that the media has met good standards of eligibility in terms of user interface and core learning mechanisms.

However, this evaluation also identified several areas that need improvement. Three aspects, namely attractive and organized layout, design consistency, and system feedback on user actions, still scored in the "Sufficiently Valid" category (score of 60). These findings indicate that although the overall rating is valid, there is room for improvement in terms of visual layout, consistency of design elements throughout the application, and clarity of feedback provided by the system to users. Improvements in these three aspects are expected to enhance the user experience and overall media capabilities.

How PBL-based mobile applications improve junior high school students' digital and English literacy

After the validation test, an empirical assessment was conducted involving 81 ninth-grade students from SMPN 2 Mojoanyar (25 students) and SMPN 3 Mojokerto (56 students). The assessment employed a one-group pre-test- posttest design to measure changes in students' digital literacy competencies following the implementation of the PBL- based mobile application. A digital literacy assessment instrument consisting of 10 indicators was administered before (pretest) and after (posttest) the invention period of four weeks.

Pretest- Posttest result

The descriptive statistics of students' digital literacy scores before and after the intervention are presented in Table 4.

Table 4. *Descriptive Statistics of Digital Literacy Assessment*

Measurement	*N*	Mean Score	*SD*	*Min*	*Max*	Total Possible Score
Pretest	81	28.47	2.84	22	34	50
Posttest	81	47.48	1.52	42	50	50
Gain Score	81	19.01	2.91	14	22	-

Note: Maximum score per indicator = 5, Total Maximum score = 50

The result indicates a substantial increase in students' digital literacy competencies following the intervention. The mean pretest score was 28.47 (56.94% of maximum score) which increases to 47.48 (94.96% of maximum score) in the posttest, yielding a mean gain score of 19.01 points. This represents

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a 66.75% improvement in digital literacy performance. The standard deviation decreased from 2.84 to 1.52, suggesting greater consistency in students' digital literacy abilities after using the application.

Analysis by digital literacy indicators

A detailed analysis of each digital literacy indicators revealed varying degrees of improvement across different competency areas (Table 5).

Table 5. *Pretest-Posttest comparison by digital literacy indicators*

Indicators	Pretest Mean	Posttest Mean	Gain Score	Improvement (%)	Category
Mobile application usage for learning	2.98	4.98	2.00	67.11%	High
Information search and evaluation	2.94	4.98	2.04	69.39%	High
Interactive features utilization	2.78	4.98	2.20	79.14%	High
Digital communication and collaboration	2.42	4.27	1.85	76.45%	High
Digital content creation	2.36	3.86	1.50	63.56%	Moderate
Independent problem-solving	2.93	4.98	2.05	69.97%	High
Digital material organization	2.79	4.88	2.09	74.91%	High
Digital security awareness	2.86	4.98	2.12	74.13%	High
Critical evaluation of content	2.70	4.60	1.90	70.37%	High
Self-regulated learning with technology	2.72	4.98	2.26	83.09%	High
Overall Mean	2.75	4.75	2.00	72.81%	High

The data demonstrate significant improvements across all ten indicators of digital literacy. The highest gains were observed in self-regulated learning with technology (83.09%), interactive feature utilization (79.14%), and digital communication and collaboration (76.45%). These findings suggest that the PBL-based mobile application was particularly effective in fostering autonomous learning behaviors and interactive engagement with digital learning tools.

Moderate improvement was noted in digital content creation (63.56%), which remained the lowest-performing indicator in both pretest and posttest. This suggest that while student' receptive digital literacy skills (accessing, evaluating, organizing information), improved substantially, productive digital literacy skills (creating original digital content in English) require extend practice and scaffolding.

Statistical significance testing

To determine whether the observed improvements were statistically significant, a paired-samples t-test was conducted comparing pretest and posttest scores (Table 6).

Table 6. *Paired-Sample t-Test result*

Comparison	Mean Difference	SD	t-value	df	Sig. (2-tailed)	Effect Size (Cohen's d)
Posttest- Pretest	19.01	2.91	58.84	80	<.001***	8.13

*p<.001

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Although the effect size estimate (Cohen's d) appears exceptionally large, this value should be interpreted with caution because the posttest scores approached the maximum scale (ceiling effect) and the posttest standard deviation was relatively small. Under such conditions, standardized mean differences can be inflated. Therefore, the improvement is best interpreted as a substantial increase in performance within the measured scale rather than as an exact magnitude that can be generalized across instruments and contexts.

In addition, the one-group pretest–posttest design does not fully rule out alternative explanations (e.g., maturation or concurrent learning experiences). Future studies should incorporate control/comparison groups and longer follow-up measurements to strengthen causal inference and examine sustainability of the gains.

Practicality assessment

In addition to the pretest-posttest assessment, a practicality evaluation was conducted through a post- intervention questionnaire administered via Google Form. The questionnaire assessed six dimensions of application usability and perceived effectiveness with 33 items. Result from 81 respondents are presented in Table 7

Table 7. *Practicality assessment results*

Assessment Dimension	Total Score (f)	N	Percentage (P)	Category
Technology Usage Experience	597	81	73.83%	Practical
Application Effective	636	81	78.52%	Practical
Learning Content Quality	618	81	76.30%	Practical
PBL Method Implementation	589	81	72.72%	Practical
Adaptive Learning Features	472	81	77.78%	Practical
Perceived Learning Support	1656	81	74.32%	Practical
Overall Mean	-	-	**75.58%**	**Practical**

The practicality assessment confirmed that students perceived the application as user-friendly and effective across all evaluated dimensions, with practicality percentages ranging from 72.72% to 78.52%. The highest rating was given to Application Effectiveness (78.52%), indicating students' confidence in the application's capacity to support their learning process. The Learning Content Quality (76.30%) and Adaptive Learning Features (77.78%) also received favorable ratings, suggesting that the PBL-based content and personalized learning pathways were well-received by students.

The relatively lower rating in PBL Method Implementation (72.72%) suggests that while students appreciated the problem-based approach, they may have encountered challenges in adapting to inquiry-based learning after years of conventional instruction. This indicates the need for additional scaffolding and teacher guidance in the initial stages of PBL implementation.

Integration of Quantitative Findings

The convergence of pretest-posttest gain scores and practicality assessment data provides robust evidence that the PBL-based mobile application effectively enhanced students' digital literacy competencies. The substantial gain scores (mean = 19.01, 66.75% improvement) demonstrate measurable skill development, while the high practicality ratings (mean = 75.58%) confirm that

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students found the application accessible and beneficial. These complementary findings validate both the pedagogical effectiveness and practical usability of the developed learning model.

The significant improvements observed across multiple digital literacy dimensions—particularly in self-regulated learning, interactive engagement, and critical evaluation—align with the theoretical framework of Problem-Based Learning, which emphasizes learner autonomy, authentic problem-solving, and metacognitive reflection. The application's design, which integrated these PBL principles through gamification, adaptive pathways, and progress monitoring features, successfully operationalized constructivist learning theory in a mobile-mediated environment.

Furthermore, the exceptionally large effect size (Cohen's d = 8.13) and statistical significance ($p < .001$) of the pretest-posttest differences provide compelling empirical evidence that technology-integrated PBL can substantially transform students' digital literacy development. This finding extends previous research on mobile learning and PBL by demonstrating not merely correlation but measurable improvement in specific, operationalized digital competency indicators relevant to 21st-century learning demands.

Discussion

The findings of this study provide compelling evidence that the integration of Problem-Based Learning (PBL) principles into mobile-assisted English learning can effectively enhance both students' English and digital literacy. This aligns with prior research asserting that PBL and mobile learning synergistically foster active, contextualized, and technology-enhanced learning environments (Cong & Ironsi, 2025); (Gudonienė et al., 2021). The discussion below elaborates on how each result supports and extends existing theoretical and empirical insights.

The development process of the Android-based application adhered to five key PBL principles—authentic problems, student-centeredness, collaboration, independent learning, and reflection—which were operationalized through the app's main features such as gamification, learning-style detection, progress dashboards, and interactive videos. These design choices reflect the constructivist framework articulated by (Chuang, 2021) and (Carpendale, 2013), in which learning occurs through active engagement with contextual problems and social negotiation of meaning. The authentic problem-based design was particularly instrumental in fostering critical thinking and meaningful learning. By embedding tasks that required students to analyze incomplete stories, match visual cues to vocabulary, and evaluate textual accuracy, the application simulated real communicative contexts. This finding corroborates (Thomassen & Stentoft, 2020) argument that problem contextualization enhances learners' ability to transfer linguistic knowledge to novel situations. Furthermore, the gamification elements that required cooperative play illustrate how digital media can support collaborative construction of knowledge, as emphasized in previous mobile-PBL integrations (Han, 2025); (Riyanti et al., 2023).

In addition, the student-centered and adaptive features, particularly the learning-style detection and dashboard, demonstrate alignment with the principles of autonomy and personalization highlighted by (Ibrahim & Ishartiwi, 2017). These features empowered learners to monitor progress, set goals, and self-regulate, thus operationalizing the "self-directed learning" dimension identified by (Loyens et al., 2008). This design element also aligns with *Kurikulum Merdeka*'s emphasis on learner agency and individualized learning pathways (Lydwin et al., 2025). The validation phase confirmed the feasibility and quality of the developed application, with experts rating the subject matter, linguistic accuracy, and media design as *Highly Valid* (average scores between 86 and 91) and *Valid* (average

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score 76) respectively. The high scores in pedagogical and linguistic domains indicate that the PBL framework was successfully translated into digital instructional design.

Subject matter validation results affirm that the app's problem design was developmentally appropriate, stimulating curiosity, and effectively fostering active and reflective learning. These findings are consistent with Solissa et al. (2025), who found that hybrid PBL models cultivate engagement and deep learning. Similarly, language expert validation revealed outstanding results in contextuality, vocabulary accuracy, and digital literacy alignment—dimensions critical for EFL learning as proposed by Zhang & Zuo (2019). This suggests that the integration of linguistic and digital competencies can occur synergistically when language tasks are embedded within authentic, technology-mediated contexts.

However, the media validation results (average score of 76) revealed that while core technical aspects such as readability, interactivity, and responsiveness met valid standards, improvements were needed in design consistency and feedback mechanisms. This echoes findings by Wingo et al. (2017), who noted that usability and interface coherence significantly influence technology acceptance among learners. Addressing these minor limitations would further enhance the application's pedagogical affordances and user experience.

Based on the empirical assessment of 81 ninth-grade students, the PBL-based mobile application demonstrated substantial effectiveness in enhancing digital literacy competencies. The intervention yielded a significant mean gain score of 19.01 points, representing a 66.75% improvement from pretest to posttest. Statistical analysis confirmed the intervention's impact with an exceptionally large effect size (Cohen's $d = 8.13$, $p < .001$), indicating profound practical significance. All ten digital literacy indicators showed considerable improvement, with self-regulated learning (83.09%), interactive feature utilization (79.14%), and digital communication (76.45%) achieving the highest gains. The practicality assessment further validated the application's usability, with an overall rating of 75.58%. This outcome aligns with prior studies highlighting that digital problem-solving environments promote higher-order thinking and active language use (Cong & Ironsi, 2025). The students' positive responses also confirm that digital literacy dimensions, such as accessing, evaluating, and communicating information, were effectively strengthened. This reinforces (Riyanti et al., 2023), who emphasized that digital literacy extends beyond technical skill to include critical and ethical awareness. This observation aligns with Lydwin et al., (2025), who noted that learner readiness and infrastructure conditions remain contextual challenges in Indonesian secondary education.

The convergence of these findings contributes both theoretically and practically. Theoretically, this study extends the constructivist and PBL literature by empirically demonstrating how mobile technology can mediate authentic, inquiry-driven English learning experiences that simultaneously foster digital literacy. It validates the proposition of Suwastini et al., (2021) that 21st-century skills can be effectively nurtured when pedagogical design and technological affordances are intentionally aligned. Practically, the study offers a validated, contextually appropriate instructional model that can be implemented in Indonesian junior high schools. The app's design can serve as a prototype for teachers seeking to integrate PBL into mobile-based EFL instruction, in line with Kurikulum Merdeka's vision of independent, critical, and digitally fluent learners. Furthermore, the structured validation process ensures that the model meets pedagogical, linguistic, and technical standards, addressing the common gap of insufficient media quality assurance identified by Purmadi et al. (2022).

Conclusion and Recommendations

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This study developed and validated an Android-based English learning application integrating Problem-Based Learning (PBL) to support junior high school students' digital literacy in EFL learning. Expert validation indicated that the application met pedagogical, linguistic, and media feasibility criteria (content = 86%; language = 91%; media = 76%). Field implementation with 81 ninth-grade students over four weeks showed substantial improvement in measured digital literacy, with the strongest gains in self-regulated learning, interactive engagement, and digital communication. Students also perceived the application as practical and supportive (overall practicality = 75.58%).

Despite these promising results, interpretations should be cautious due to the one-group design and potential ceiling effects in posttest scores. Future studies should employ controlled experimental designs, larger and more diverse samples, and longitudinal follow-ups to evaluate the sustainability of learning gains and to examine impacts on English proficiency outcomes more directly. Product refinement should prioritize interface consistency and clearer system feedback to enhance user experience and learning guidance.

Disclosure statement

No potential conflict of interest was reported by the author.

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