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Development of Interactive Mobile Learning Based on Problem-Based Learning for Computational Thinking Material in High School

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Abstract

This research was motivated by students' low interest and motivation in learning computational thinking. Computational thinking material is still presented in the form of theory and is not based on case studies so that students find it difficult to understand its implementation in everyday life. This study aimed to develop KompuThink, a Problem-Based Learning (PBL)-based mobile learning application for computational thinking instruction. Research and Development using the ADDIE model, through the stages of analysis, design, development, implementation, and evaluation. The research subjects were 35 class X students of SMA Negeri 6 Malang who were taking informatics subjects. Data were collected using expert validation questionnaires and user testing instruments and analyzed using descriptive quantitative methods. The results showed that media expert validation yielded an average feasibility score of 88% and material expert validation yielded 86%, both categorized as very feasible. Classroom trials resulted in an average student acceptance score of 92.27%, also categorized as very feasible. The novelty of this study lies in the development and feasibility evaluation of a PBL-based mobile learning application that explicitly targets core computational thinking topics (searching, sorting, stack, and queue) within the Indonesian high school context, a combination that has been rarely addressed in previous studies. These findings indicate that KompuThink is a highly feasible and well-accepted interactive mobile learning medium for computational thinking and can serve as a reference for future research and development in informatics education technology.

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INTRODUCTION

Information and Communication Technology (ICT) can make learning more interesting, interactive, and relevant to students' needs in the digital era (Sirimathep et al., 2022). Students at SMA Negeri 6 Malang have wide access to mobile devices, such as smartphones, which offer a great opportunity to use mobile platforms as effective and efficient learning media. Preliminary observations and discussions with teachers at this school indicated that computational thinking has been included in the curriculum, but learning is still dominated by conventional, teacher-centered methods and limited digital learning resources. Students often struggle to understand Computational Thinking (CT) concepts and exhibit low learning motivation during CT lessons. In addition, SMA Negeri 6 Malang is a typical public high school in Malang that represents the characteristics of many Indonesian schools. These conditions make SMA Negeri 6 Malang a relevant site for developing and implementing an interactive mobile learning application to support CT learning.

Computational thinking, one of the important competencies in the education curriculum, serves to improve students' critical thinking (Murniatiningtyas et al., 2024). This competency is also an important basis for facing the demands of globalization and technological development (Wulansari et al., 2023). However, conventional approaches are often less effective at engaging students' interest in learning, which poses a challenge in teaching this material (Dita et al., 2023). Previous research shows that problem-based learning (PBL) can improve student engagement and concept understanding (Wang et al., 2024). In addition, PBL-based mobile learning offers high flexibility and accessibility, facilitating active learning through solving real problems (Martínez-Gómez & Nicolalde, 2025). Therefore, the development of PBL-based interactive mobile learning represents a strategic approach to enhancing the effectiveness of computational thinking instruction at the high school level.

Mobile learning has emerged as an innovative approach in education, particularly in the digital era. It is widely regarded as having the potential to enhance student participation and learning motivation, especially when designed using engaging and learner-centered approaches (Yuliana et al., 2024). Students can learn at any time and from any location using mobile devices like smartphones, making the learning experience more adaptable and engaging (Hidayat et al., 2020). Most high school students already have smartphones with sufficient specifications to support modern learning applications, including multimedia-based and interactive applications.

Prior research has shown how mobile learning can enhance the quality of education at the high school level. For example, a recent meta-analysis found that school-aged pupils' science achievement is greatly improved by mobile learning (Dong et al., 2024). In addition, research has shown that interactive mobile learning can increase students' motivation and interest in learning mathematics (Efendi & Qodr, 2023). These results show that incorporating mobile in secondary education is not only pertinent but also positively correlated with better learning outcomes. However, studies that integrate interactive mobile learning with a PBL approach specifically for computational thinking materials at the high school level are still limited, especially in the context of Indonesian schools. Most existing mobile applications do not explicitly target CT competencies or are not designed based on a systematic PBL model. Therefore, there is a need to develop an interactive mobile learning application based on PBL that is specifically designed to support high school students' computational thinking.

This application is anticipated to produce an interesting, dynamic, and successful learning environment for teaching computational thinking by utilizing mobile technologies and cutting-edge teaching strategies (Coelho et al., 2023; Romadani et al., 2024). Mobile learning supports flexible, accessible, and engaging learning environments, while PBL effectively promotes active learning and real-world problem-solving, making their integration appropriate for addressing the identified problem (Benlaghrissi & Ouahidi, 2024). Specifically, this research aims to develop KompuThink, a mobile learning application based on PBL for computational thinking materials at the high school level. The manuscript focuses on describing KompuThink's development process and its main features, aligned with CT competencies and the stages of PBL.

RESEARCH METHODS

The ADDIE methodology, which comprises the Analysis, Design, Development, Implementation, and Evaluation phases as depicted in Figure 1, is used to construct the KompuThink application.

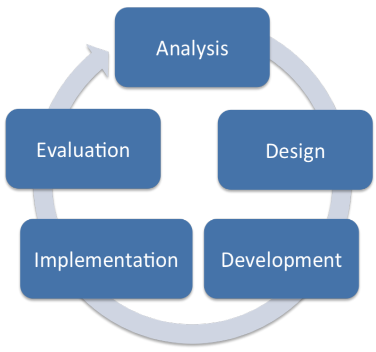

Figure 1. ADDIE model development flow

This method was chosen because it is structured and suitable for developing learning products (Yaniawati et al., 2023). The following stages are carried out.

A. Analysis

This phase seeks to determine the characteristics of the students and their learning needs (Garzón et al., 2024). Activities include: (a) Needs analysis: investigating the requirements of educators and learners concerning the acquisition of PBL-based computational thinking resources (Liu & Correia, 2021); (b) Literature study: understanding the concept of PBL and mobile learning development; and (c) User characteristic analysis: analyzing the profile of high school students who are the target users to ensure the application suits their needs (Naveed et al., 2023).

Referring to the Grade X Informatics curriculum and supported by the results of the needs analysis with teachers and students, the computational thinking content in KompuThink was structured around four core topics: searching, sorting, stack, and queue. These topics were selected to align with the expected learning outcomes of the curriculum, namely enabling students to understand fundamental data processing concepts, explain them using everyday examples, and apply simple algorithmic procedures to solve contextual problems. The searching topic addresses competencies related to problem identification and strategy selection by guiding students to recognize the elements of a search problem (search space, target, and criteria) and to compare search strategies in familiar contexts such as locating physical or digital objects. The sorting topic targets algorithmic thinking competencies by requiring students to understand the purpose of ordering data, trace the procedural steps of basic sorting algorithms (e.g., insertion sort and selection sort), and explain how these steps transform unordered data into an ordered form. The stack and queue topic focuses on data structure concepts and process modeling by emphasizing LIFO and FIFO principles through real-life analogies and by engaging students in modeling basic operations, including push, pop, enqueue, and dequeue. In addition, the media requirements identified through the needs analysis were incorporated to support curriculum-aligned learning activities and to ensure consistency with the stages of Problem-Based Learning (PBL).

B. Design

This stage involves designing the application and its content: (a) UI/UX design; (b) Application feature blueprint: determining the main features of the app such as interactive learning modules, simulations, and quizzes (Ramli et al., 2024); and (c) Learning content planning: developing computational thinking materials with a flow that supports the PBL approach, including problems that students will solve (Fang et al., 2025).

The results of the analysis phase were used to create the material and media design of KompuThink. The four topics (searching, sorting, stack, and queue) were each designed as self-contained learning units following the phases of Problem-Based Learning (PBL): problem orientation, information gathering, solution development, presentation, and reflection. The searching unit introduces contextual problems and game-based activities to support understanding of search space and strategies; the sorting unit uses everyday analogies and step-by-step visualizations of insertion and selection sort; and the stack and queue unit employs visual metaphors and simple animations to illustrate LIFO and FIFO operations. At the media level, each unit consists of problem introduction, concept explanation, interactive activities, formative quizzes, and reflection, supported by a consistent UI/UX design to ensure usability for high school students.

C. Development

The development stage includes implementing the design into a real product using Unity (Sapundzhi et al., 2023): (a) Digital content creation: integrating learning materials into the application with interactive multimedia; (b) Application coding: using scripts in Unity to build the main features of the app ; (c) Alpha testing: internal testing to check basic functionality and initial improvements.

D. Implementation

Implementation involves testing the app on a class of high school (Liu & Correia, 2021): (a) Usage simulation: the app was introduced to students in a classroom setting to test the user experience first-hand; and (b) Feedback collection: through observation and questionnaires, data was collected to assess student engagement and the effectiveness of the app in supporting PBL learning.

E. Evaluation

Evaluation is conducted after implementation to evaluate student acceptance of the use of KompuThink in learning. Data from student feedback is used to assess the success of the product.

Table 1. Indicator of Media Validation

No	Aspect	Number of Items
1	Application Design	1
2	User Interaction	2
3	Accessibility	2
4	Reusability	1

The research subjects were 35 grade X students from one intact informatics class at SMA Negeri 6 Malang. The class was selected using purposive sampling in collaboration with the subject teacher, based on its availability in the school schedule and the teacher's willingness to integrate KompuThink into regular lessons. This study is preliminary research focusing on feasibility and user acceptance rather than statistical effectiveness testing with a one-class sample and is intended to provide initial evidence of the application's practicality in a real classroom context.

Table 2. Indicator of Material Validation

No	Aspect	Number of Items
1	Learning Objectives	2
2	Learning Materials	9
3	Learning Methods	1
4	Learning Resources	2
5	Learning Activities	7

The students used KompuThink as a medium for learning computational thinking in one instructional sequence that included an introductory activity, exploration of the materials, completion of PBL-based case studies, and a closing reflection. Pre- and post-tests were administered as part of the learning flow designed by the teacher; however, in this study, these test scores were not analyzed. The data reported in this manuscript focuses only on expert validation and student acceptance of the application as a learning medium supporting the PBL-based learning process.

The validation instruments consisted of material experts, media experts, and a student response questionnaire. Each instrument was structured into several aspects and items as summarized in Tables 1-3. The media expert instrument included 6 items (Table 1), the material expert instrument contained 21 items (Table 2), and the student response instrument comprised 16 items (Table 3). The validation instruments employed a four-point Likert scale, while the student response questionnaire used a five-point Likert scale.

Table 3. Indicator of Student Response

No	Aspect	Number of Items
1	Software	6
2	Learning	5
3	Visual Communication	5

Expert validation involved two media experts and two material experts. The media experts were lecturers in computer science education with a minimum of eight years of experience in developing digital learning media. The material experts were certified informatics teachers who had taught computational thinking or related subjects for at least five years. All experts were selected through purposive sampling based on their academic qualifications and practical experience in their respective fields. Each expert evaluated the KompuThink application using a structured validation questionnaire tailored to their area of expertise.

Table 4. Feasibility Score

Score (%)	Criteria
0% ≤ Score < 20%	very unfit
20% ≤ Score < 40%	not feasible
40% ≤ Score < 60%	moderately feasible
60% ≤ Score < 80%	feasible
80% ≤ Score ≤ 100%	very feasible

In the application testing process, both tests on media experts, material experts, and testing on students used the formula (Ambarita et al., 2022). The results of the calculation are then compared with the score interpretation in Table 4.

Percentage of feasibility (%) =

$$\frac{\text{total score obtained } x \text{ } 100}{\text{maximum score}}$$

RESULT AND DISCUSSION

A. Result

The KompuThink application is designed as a mobile-based interactive learning medium to support high school students in understanding CT concepts. This application is developed using Unity, a cross-platform game and application development platform that allows the creation of applications with attractive appearances, stable performance, and high compatibility with various devices. KompuThink is equipped with various features, such as interactive learning modules, video tutorials, algorithm simulations, and evaluation quizzes. The materials presented include basic concepts of computational thinking, such as decomposition, abstraction, an algorithmic mindset, and an introduction to searching, sorting, stacks, and queues, which are aligned with the high school curriculum (Varghese & Renumol, 2024). Learning evaluations are available in the form of interactive quizzes and scenario-based exercises, designed to measure students' overall understanding (Gundersen & Lampropoulos, 2025).

In accordance with the research and development design described in the methods section, this results section presents (1) the final form of the KompuThink application as the product of the development phase and (2) the findings from the expert validation and student acceptance as part of the evaluation phase. From the stages of research that have been carried out, the results are obtained in the form of Komputhink applications, which have several features.

1. Login Page for Students and Teachers

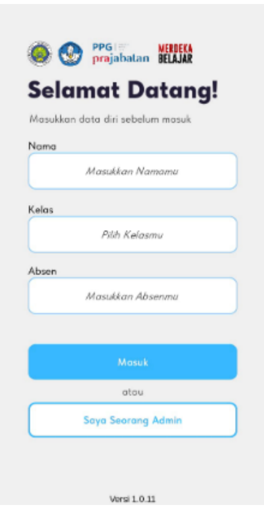

Figure 2. Login page

On this login page (Figure 2), if the user is a student, they must enter their name, class, and attendance to access the application's dashboard. If the student has not registered, they can confirm with the teacher to register first. On the other hand, if the person logging in is a teacher, they will enter their username and password, then go to the teacher's dashboard.

2. KompuThink Dashboard Page

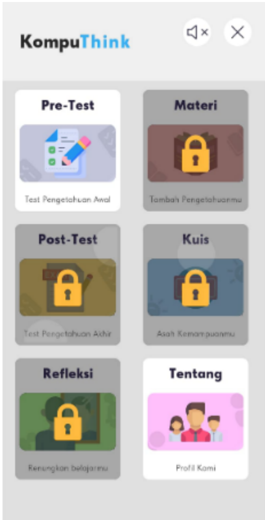

Figure 3. Dashboard page

On this dashboard (Figure 3), if users log in as a student, the main menu options of this application will be displayed, starting with the pretest. Then, if users have, they can continue to open the material on the computational thinking chapter. In this material section, students must read all the content to continue or to move to another menu page. Then, if users log in as a teacher, the dashboard that appears is a page for monitoring student grades and collecting student assignments, and there is also a menu for managing (adding or deleting) new classes.

3. KompuThink Assessment Page

On the KompuThink assessment page, as shown in Figure 4, there are three parts, namely the pretest pages, post-test pages, and quiz pages. On the pretest page, a pretest question is displayed to find out the students' initial understanding; besides that, this page is also a requirement to access the material page, because the material page will be locked and cannot be accessed if the pretest page has not been completed. On the post-test page, students will do a post-test where the post-test questions include all the material they have learned.

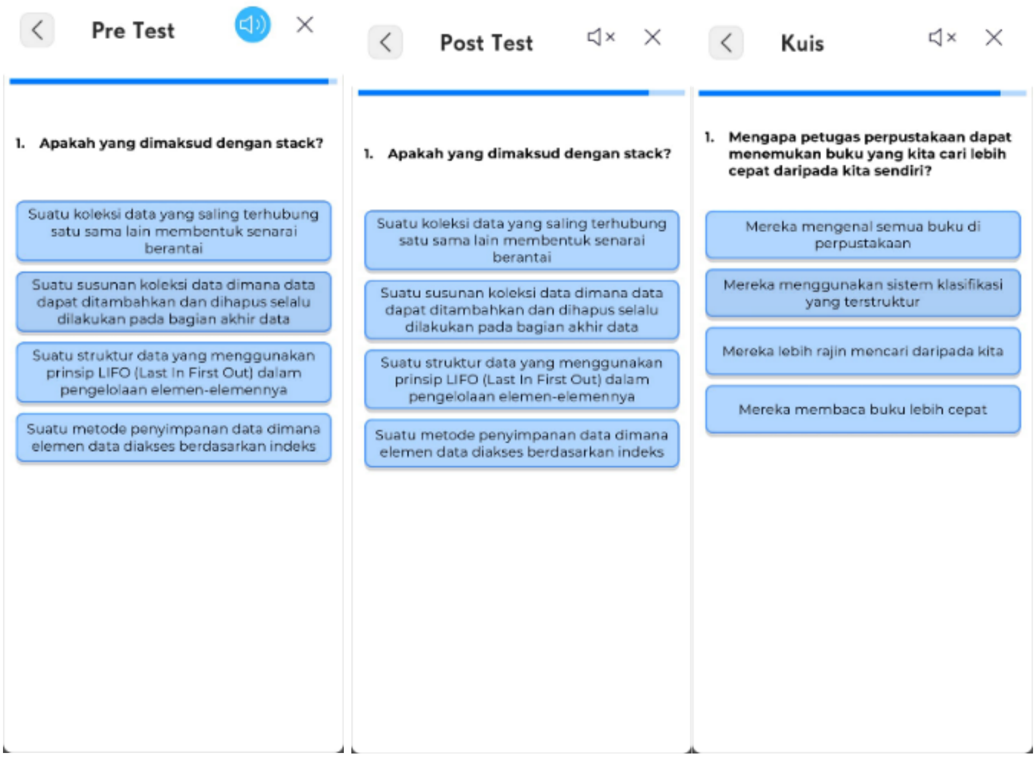

Figure 4. KompuThink assessment page

The KompuThink application integrates several interactive features that distinguish it from static digital materials. Students must actively respond to pre-test, quiz, and post-test items, and the application provides immediate feedback on their answers. Access to subsequent sub-chapters and menus depends on completing previous activities, so user actions directly control the learning flow. In each computational thinking unit, students work on scenario-based exercises and tasks within the application, and they record their reflections on the learning process through the reflection page. These elements are the basis for categorizing KompuThink as interactive mobile learning media.

4. Material Page

On this material page (Figure 5), students will be presented with material about the computational thinking chapter. The material section consists of two material presentations, namely in the form of reading and in the form of audiovisuals, which can be seen by students as a choice of how they learn. On this material page also applies that students must complete learning one sub chapter to move to the next sub chapter and open the next menu.

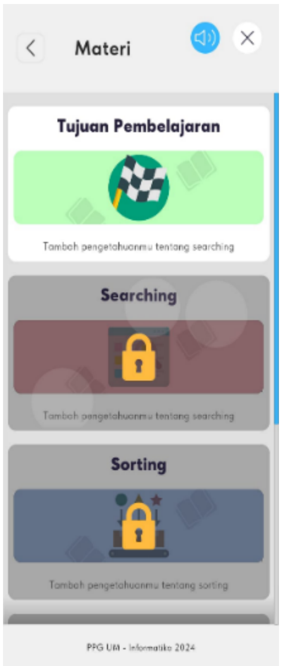

Figure 5. Material page

The final version of KompuThink integrates four core computational thinking topics into structured learning units. Each unit starts with a contextual problem scenario, which is followed by concept explanations, worked examples, and practice exercises that correspond to the PBL phases outlined in the Methods section. For example, the sorting unit uses recognisable contexts and step-by-step algorithm traces to solve ordering problems, while the searching section presents common search scenarios and helps students formalise search tactics using text, images, and brief exercises. To demonstrate LIFO and FIFO operations, the stack and queue units use examples from everyday life, such as heaps of plates and lines of people. According to the elements assessed by the material experts, these learning units are supported by suitable learning materials, PBL-oriented techniques, and structured learning activities.

5. Reflection Page

On the reflection page, as shown in Figure 6, students will be invited to provide feedback on the learning process using this "Komputhink" learning media.

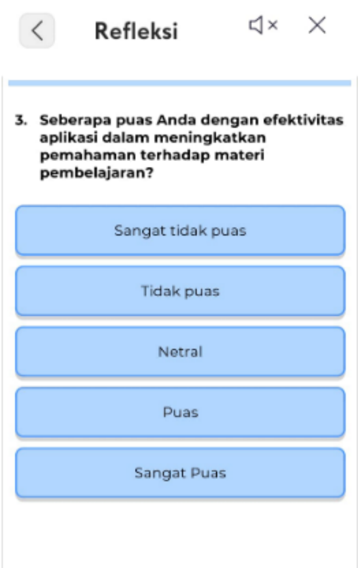

Figure 6. Reflection page

In summary, the developed KompuThink application integrates several interactive features that distinguish it from static digital materials. Students actively interact with the media by (1) completing pre-tests and quizzes that provide immediate feedback, (2) navigating through sub-chapters that unlock only after a previous sub-chapter is completed, (3) engaging with audiovisual explanations and scenario-based exercises, and (4) providing reflections and responses directly in the application. Teachers can also interact with the system by monitoring students and managing classes. These elements of user control, feedback, branching, and activity-based tasks indicate that KompuThink can be categorized as interactive mobile learning media for computational thinking.

Furthermore, after the development phase, the application was assessed by material and media specialists to ascertain the appropriateness of the instructional content and learning media. Tables 5 and 6 show the validation results from the media and material specialists, respectively.

Table 5. Results of Media Expert Assessment

Aspects	%	Category
Application Design	85%	very feasible
User Interaction	90%	very feasible
Accessibility	90%	very feasible
Reusability	85%	very feasible
Average	88%	very feasible

Based on Table 5, the results of media expert testing, which included providing applications and testing validation questionnaires, show an average of 88% in each aspect. It can be concluded that the KompuThink application shows good effectiveness in terms of design, accessibility, interaction, and reuse, with an average value above 85%.

Table 6. Result of Material Expert Assessment

Aspects	%	Category
Learning Objectives	83	very feasible
Learning Materials	87	very feasible
Learning Methods	88	very feasible
Learning Resources	80	very feasible
Learning Activities	93	very feasible
Average	86	Very Feasible

Based on Table 6, the results of material experts by providing applications and testing validation questionnaires, the average total score is 86% in each aspect. Therefore, it can be said that KompuThink supports computational thinking effectively, with most assessment aspects exceeding 80%. The application may provide students with engagement, as evidenced by the high score of 93% on the learning activities aspect. Well-organised educational resources create a positive learning environment for pupils, increasing their acceptability.

Table 7 shows that the KompuThink application received very high ratings across all assessed aspects. In the software aspect (average = 90.80%), the application proved to be stable, easy to use, error-free, and compatible with various devices. The learning aspect (average = 94%) showed that the app increased students' understanding, enthusiasm, and knowledge, and was relevant to the computational thinking material. In terms of visual communication (average = 92%), the app has an attractive design with appropriate colors, fonts, and navigation. Overall, KompuThink is an innovative, interesting, and effective interactive learning media.

Table 7. Result of Student Acceptance

Aspects	%	Category
Software Aspect		
KompuThink application is easy to use without difficulty	90.5	very feasible
KompuThink application is convenient to use	93	very feasible
Komputhink application does not crash easily	90	very feasible
KompuThink application has no errors when used	88	very feasible
The KompuThink app can be used on other smartphones	91	very feasible
The KompuThink application can be installed on other smartphones	92	very feasible
Learning Aspect		
KompuThink app is easy to understand	97	very feasible
The KompuThink application adds enthusiasm to learning	93	very feasible
KompuThink application provides a new atmosphere in learning	93	very feasible
The KompuThink app increases knowledge	93	very feasible
KompuThink application is suitable for computational thinking subject matter	94	very feasible
Visual Communication Aspect		
The appearance of the KompuThink application is attractive	91	very feasible
The color combination of the KompuThink application is appropriate	92	very feasible
The typeface used in the KompuThink application is clearly legible	94	very feasible
The sound in the KompuThink application is interesting	89	very feasible
Buttons in the KompuThink application are easy to understand.	92	very feasible
Average	92.27	very feasible

B. Discussion

The results demonstrate that the KompuThink application received "very feasible" evaluations from both the media expert (88%) and the material expert (86%). Additionally, student responses produced an overall average score of 92.27%, which fell into the "very feasible" category. The software, learning, and visual communication aspects were rated well. These results show that KompuThink is a mobile learning application for computational thinking in high school that is suitable both technically and pedagogically.

These results directly address the research gap mentioned in the introduction, which is the scarcity of interactive mobile learning applications that specifically combine computational thinking content with a PBL approach at the high school level, especially in Indonesia. KompuThink was judged "very feasible" by media and material experts, meaning that the design and content satisfy pedagogical and technical requirements for classroom application. KompuThink incorporates four fundamental CT subjects (searching, sorting, stack, and queue) into PBL-based learning units. Such a PBL-based mobile application is widely recognised and seen as beneficial for learning, as evidenced by the extremely positive student reactions. Thus, this study not only demonstrates the feasibility of a CT-focused, PBL-based mobile learning design but also provides an example of how such an application can be implemented and accepted in a real secondary school context.

It has been demonstrated that using mobile devices in the classroom improves student comprehension and engagement. Sadikin & Hamidah (2020) reported that technology-based learning increases learning effectiveness by providing more interactive and engaging learning experiences. Based on these results, the KompuThink app was created to help high school students learn computational thinking using a PBL method.

Numerous studies that highlight the substantial advantages of the learning process also promote the usage of mobile learning technologies. According to (Lazaro & Duart, 2023) mobile learning not only offers flexibility of time and place but also increases students' learning independence. Their study indicates PBL-based mobile learning can improve learning outcomes by up to 88% in exact subjects (Cong & Ironsi, 2025). Additionally, it has been discovered that incorporating mobile technology with interactive components increases students' enthusiasm to study by 75%, particularly in PBL (Yu et al., 2023).

Previous studies have shown that mobile learning outperforms traditional teaching methods in terms of comprehension and mastery because it enables students to learn at their own pace and adapt course materials to suit their individual needs (Gumbheer et al., 2022). The KompuThink application is made to facilitate this flexibility by offering learning resources that are accessible anytime and anywhere, enabling students to participate in autonomous learning without being limited by time or space.

At SMA Negeri 6 Malang, the latest innovation in informatics learning through interactive media is being introduced. This application was developed using Unity software to contain informatics materials integrated with the math syllabus and adopt the concept of computational thinking, an important skill in today's technological era (Agbo et al., 2023). Packaged as a mobile-based learning application, this application is designed to be easily accessible through Android devices with a minimum version of 10 (Android Q), with a size of less than 10MB, making it lightweight and storage-efficient (Johannsen et al., 2023). Key features, such as the learning material menu and interactive exercise menu, aim to enhance learners' understanding through an engaging and efficient approach (Troussas et al., 2022)

From a technical perspective, application stability and compatibility across devices are critical factors in the successful implementation of mobile learning (Lazaro & Duart, 2023). Previous research has shown that lightweight, stable, and user-friendly applications tend to achieve higher adoption rates, particularly among high school students (Açıkgül & Şad, 2021). These findings are consistent with the evaluation results of *KompuThink*, which received positive user responses attributed to its intuitive interface design and efficient file size of less than 10 MB.

The feasibility test results showed that the KompuThink application received a very decent assessment from the material expert with a score of 86% and from the media expert with a score of 87%. This feasibility value indicates that the application has met the criteria as a relevant, interesting, and useful learning media. Learning media that are rated as highly feasible not only have good interactive features but also strong stability in their technical operations, which minimizes interference and facilitates use (Chand & Kumar, 2025).

In the experimental class test results, the learning and visual communication aspects of the KompuThink application also received very positive responses from students, with an average score above 90% on each aspect tested, including ease of use, convenience, and attractive graphic quality. These findings indicate that the application effectively meets students' needs and expectations for modern learning media, which is likely to support students' motivation and interest in learning. Previous research has emphasized that attractive visual design and an intuitive interface play a crucial role in sustaining student motivation when using mobile-based learning applications (Ahmad Faudzi et al., 2023).

In the context of the KompuThink app, features such as an interactive interface, intuitive navigation, and digital-based evaluation are designed to maximize these benefits. The app has also been designed to solve various challenges that students face in understanding the concepts of abstraction and algorithms, two important elements in computational thinking. Previous studies have shown that mobile learning media integrating the Problem-Based Learning (PBL) approach can enhance students' critical thinking skills (Irawati et al., 2022). Supported by this empirical evidence, the *KompuThink* application functions not only as a learning medium but also has the potential to improve the quality of education in the digital era.

Compared with previous studies, this study's contribution is the integration of multiple components that are rarely found in a single intervention. Numerous earlier studies have investigated mobile learning for science and maths courses or have used PBL in in-person or online settings. Some have also included computational thinking using conventional or non-mobile learning materials. KompuThink, on the other hand, was created especially as an interactive mobile application that (1) focuses on fundamental computational thinking skills, (2) organizes learning activities in accordance with PBL phases, and (3) is created and assessed in a standard Indonesian public high school. Research on mobile learning, PBL, and computational thinking has been extended by the positive feasibility and acceptance results, which indicate that this integrated design is workable and acceptable in the secondary school setting.

The trial results concluded that the KompuThink application is highly feasible and well accepted as a mobile learning that implements the PBL approach. Its effectiveness in increasing student motivation and engagement shows that KompuThink can not only help students in understanding the concept of computational thinking but also increase their interest in exploring further. Thus, this application becomes one of the relevant innovations to support education in the digital era and help high school students prepare relevant skills to face future challenges. Although the study is supported by previous evidence on mobile learning and PBL, the conclusions drawn here are based primarily on feasibility and acceptance data rather than on measured learning gains.

CONCLUSION

This study concludes that KompuThink, a mobile learning application based on Problem-Based Learning (PBL), is highly feasible for supporting computational thinking instruction at the high school level. The application offers a range of features, including interactive learning modules, video tutorials, and assessment components, which are designed to facilitate student engagement and conceptual understanding. Expert validation results indicate that both the material and media aspects of KompuThink fall into the "very feasible" category, reflecting strong alignment with curricular and instructional requirements. The integration of interactive mobile technology with PBL principles supports effective classroom implementation, particularly through well-designed software functionality, learning structure, and visual communication. Student responses further demonstrate strong acceptance of the application, especially in terms of ease of use, convenience, and visual appeal. These findings suggest that the suitability of the application to students' learning needs and available facilities plays a crucial role in its acceptance, thereby confirming the relevance of the initial needs analysis to the quality and usability of the final product.

However, this study is still limited to testing the application on users, so future research should employ a quasi-experimental or mixed-method design, for example, by comparing an experimental class using KompuThink with a control class using conventional media, and measuring both computational thinking skills and learning motivation using validated instruments, complemented with interviews or focus group discussions.

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