

Effectiveness of Mobile Devices-Based Problem Based Learning on Students' Computational Thinking Skills in Informatics Learning

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Abstract: This study aims to develop and examine the effectiveness of a Mobile Devices-based learning medium integrated with Problem Based Learning (PBL) to improve students' Computational Thinking Skills (CTS) in Informatics learning at SMP Negeri 21 Padang. The development followed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). This research used a quantitative approach with a Quasi-Experimental Pretest-Posttest Control Group Design, involving 60 grade IX students (30 in the experimental class and 30 in the control class) selected through cluster random sampling. Data were collected using media and material validation sheets, teacher and student practicality questionnaires, and a Computational Thinking Skills test. The results showed that media expert validation obtained an Aiken's V of 0.886 (88.61%) and material expert validation obtained 0.882 (88.20%), both in the Very Valid category. The practicality test showed 90.00% (teacher) and 93.80% (student) responses, both in the Very Practical category. The Independent Sample t-Test on posttest scores showed $t_{\text{count}} = 10.864 > t_{\text{table}} = 2.002$ ($p < 0.05$), indicating a significant difference between the experimental and control classes. The N-Gain score of the experimental class (0.680, moderate category) was higher than that of the control class (0.265, low category). Thus, the Mobile Devices-based learning medium integrated with PBL is valid, practical, and effective in improving students' Computational Thinking Skills in Informatics learning.

Keywords: Computational thinking skills; Effectiveness; Informatics learning; Mobile devices-based; Problem based learning

Introduction

Computational Thinking Skills (CTS) is one of the core competencies that students must possess in Informatics learning at the Junior High School (SMP) level. CTS encompasses logical, systematic, and structured thinking through decomposition, pattern recognition, abstraction, and algorithm design in solving problems (Dewantara et al., 2026). This ability is not only important in the field of computing but also helps students understand complex problems in daily life rationally and effectively (Ekayana et al., 2025).

Informatics learning at SMP Negeri 21 Padang has been conducted mainly through teacher presentations

using an LCD projector, followed by worksheet-based exercises and practical tasks in the computer laboratory, where one computer is shared by two students (Desky et al., 2026b). This condition is insufficient for students to complete independent practical tasks. Teachers have attempted alternative solutions such as assigning homework through the Quizizz application accessed via Android devices; however, students who do not own an Android device are unable to complete these assignments. Consequently, Informatics learning at the school has not been fully interactive, and students' CTS has not developed optimally, as reflected in students' limited ability to understand problems systematically,

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design logical solutions, and connect learning concepts with real situations (Desky et al., 2026a).

Twenty-first century education demands the mastery of Higher Order Thinking Skills, problem-solving ability, creativity, collaboration, and digital literacy. In line with this, the Kurikulum Merdeka positions Informatics as a subject to develop students' computational thinking through technology-based problem solving. Therefore, the learning process needs to be redesigned innovatively to provide a meaningful learning experience and encourage students' active involvement (Ghifari et al., 2024).

Based on school data for the 2025/2026 academic year, SMP Negeri 21 Padang has 877 students, consisting of 254 grade VII, 302 grade VIII, and 321 grade IX students. A preliminary measurement of CTS was conducted on these students using four main indicators: decomposition, pattern recognition, abstraction, and algorithmic thinking. The results are presented in Table 1.

Table 1. Baseline computational thinking skills achievement per indicator

Indicator	Grade VII	Grade IX	Grade IX
Decomposition	52	60	66
Pattern Recognition	50	58	64
Abstraction	54	62	68
Algorithmic Thinking	48	56	62
Mean	51	59	65

Source: SMP Negeri 21 Padang (2025).

The results show that CTS at every grade level is still in the fairly low category, with the algorithmic-thinking indicator consistently the lowest. Furthermore, an analysis of the learning mastery criteria (KKTP = 80) shows that most students have not yet reached the mastery level, as shown in Table 2.

Table 2. Learning mastery of computational thinking skills (%)

Category	Grade VII	Grade IX	Grade IX
Mastered	13	19	30
Not Mastered	87	81	70

Source: SMP Negeri 21 Padang (2025).

At the national level, the Ministry of Education, Culture, Research, and Technology has continued to strengthen digital literacy and computational thinking as part of the Informatics curriculum, positioning technology-assisted problem solving as a central competency for junior high school graduates. This policy direction reinforces the relevance of designing learning media that combine devices students already own with instructional models proven to develop higher-order

thinking, rather than treating technology integration and pedagogical design as separate efforts.

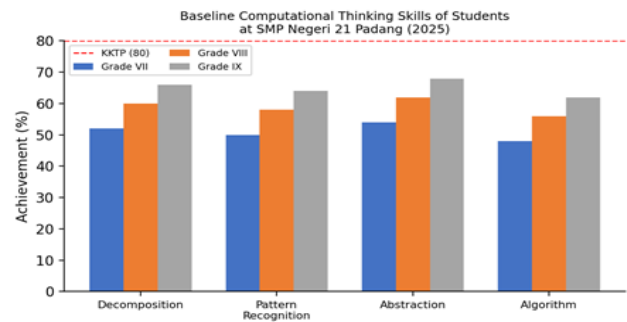


Figure 1. Baseline computational thinking skills of students at SMP Negeri 21 Padang (2025)

Almost all students at SMP Negeri 21 Padang already own an Android-based smartphone, but these devices are mostly used for communication and entertainment rather than for learning. Mobile Devices offer flexibility, ease of access to digital learning resources, and support for more interactive and collaborative learning (Desky et al., 2025b). Meanwhile, Problem Based Learning (PBL) is a student-centered model that engages learners in authentic problem solving, investigation, collaboration, and reflection, which is considered effective in developing higher-order thinking skills (Mardawati et al., 2022).

Previous studies have shown that the use of Mobile Devices in learning can improve engagement and learning outcomes, and that PBL contributes to the improvement of computational thinking (Septiantoko et al., 2025; Junaidi, 2025). However, studies that specifically examine the effectiveness of Mobile Devices integrated with PBL on Computational Thinking Skills of junior high school students in Informatics learning remain limited. This gap constitutes the novelty of the present study, which not only develops a valid and practical learning medium but also empirically tests its effectiveness in improving students' computational thinking (Sari et al., 2026).

Several relevant previous studies further support the direction of this research, as summarized in Table 3.

These studies confirm that PBL and Mobile Devices each contribute positively to computational thinking and learning outcomes; however, studies that specifically combine both variables to measure their effect on CTS among SMP students in Informatics learning remain limited, which underlines the novelty of the present study (Arwizet et al., 2026).

Based on the problems described above, this study aims to develop a Mobile Devices-based learning medium integrated with Problem Based Learning and to examine its validity, practicality, and effectiveness in

improving students' Computational Thinking Skills in Informatics learning at SMP Negeri 21 Padang.

Table 3. Summary of relevant previous studies

Author(s)/Year	Focus	Key Finding
Pulungan & Khairuna (2023)	PBL, collaboration, CT	PBL positively affects collaboration and CT skills of SMP students
Safitri et al. (2025)	Mobile-based PBL media, Informatics	Mobile-based PBL media improves the effectiveness of Informatics learning
Ekayana et al. (2025)	Interactive mobile learning, CT	Interactive mobile learning improves CT and achievement in digital-systems courses
Grover & Pea (2013)	CT in K-12 education	CT is a foundational competency that needs to be integrated into the K-12 curriculum
Hsu et al. (2018)	Problem-based learning, CT	Problem-based learning improves students' computational thinking
Sung et al. (2016)	Mobile devices, learning outcomes	Mobile devices significantly improve learning outcomes, motivation, and engagement

Source: Synthesized from related literature (2013–2025).

Method

This study used a quantitative approach with a Quasi-Experimental design, specifically the Pretest-Posttest Control Group Design (Creswell, 2024; Cohen et al., 2023). This design was chosen because full control over all extraneous variables was not possible, while the effect of the treatment on the dependent variable could still be observed by comparing an experimental group and a control group (Table 4).

Table 4. Research design (pretest-posttest control group design)

Group	Pretest	Treatment	Posttest
Experimental	O1	X (Mobile Devices + PBL)	O2
Control	O3	Conventional learning	O4

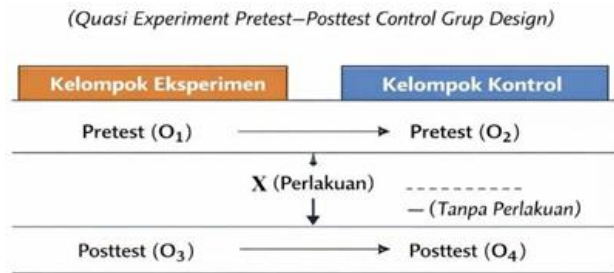


Figure 2. Diagram of the quasi-experimental pretest-posttest control group design
Population and Sample

The population of this study was all grade IX students of SMP Negeri 21 Padang in the 2025/2026 academic year, totaling 321 students. The sample consisted of 60 students, 30 in the experimental class and 30 in the control class, selected using Cluster Random Sampling, in which classes rather than individual students were randomly selected as clusters to avoid disrupting the ongoing learning process and to prevent treatment contamination between groups (Vaesar et al., 2026; Mardiana et al., 2026).

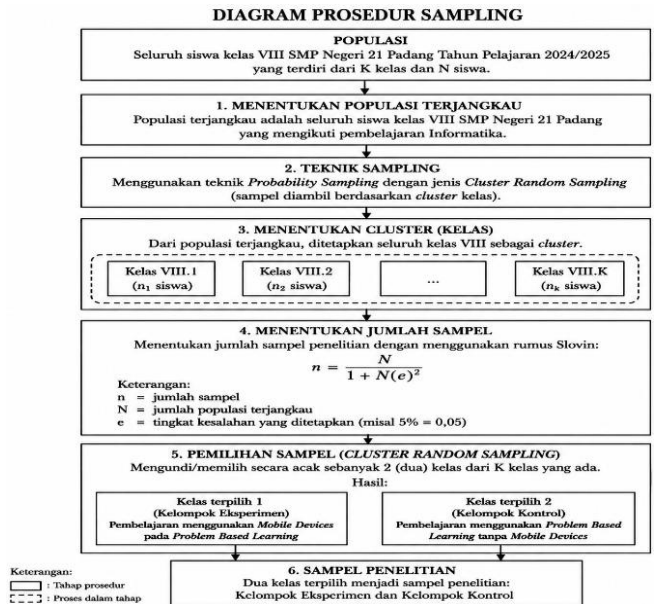


Figure 3. Cluster random sampling procedure

The sampling procedure followed several steps: determining the reachable population (all grade IX students), applying probability sampling with a cluster random sampling type, treating each existing class as a cluster, calculating the required sample size using the Slovin formula, and then randomly drawing two classes from the available clusters. The two selected classes were then randomly assigned as the experimental class, which received the Mobile Devices-based PBL treatment, and the control class, which received conventional learning. Both classes subsequently completed the pretest and, after the treatment period, the posttest, the results of which were compared to determine the effect of the treatment given (Sudianti et al., 2025).

Research Procedure

The research procedure followed the ADDIE development model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation (Ningsih et al., 2025). The Analysis stage identified learning needs, student characteristics, curriculum, and learning materials. The Design stage produced the lesson design, the Mobile Devices media design, and the

research instruments. The Development stage produced the media and instruments, followed by expert validation. The Implementation stage applied the pretest, the PBL-based treatment using Mobile Devices, and the posttest. The Evaluation stage analyzed the pretest-posttest data descriptively and inferentially to draw conclusions regarding the effectiveness of the developed medium.



Figure 4. ADDIE development model applied in this study

Data Collection Instruments

Table 5. Grid of the media validation instrument

Aspect	Number of Items
Display	3
Usability	3
Functionality	4
Language	10
Total	20

Table 6. G grid of the media validation instrument

Aspect	Number of Items
Suitability with Learning Objectives	9
Content Accuracy	3
Content Currency	3
Supporting Presentation	2
Learning Presentation	6
Content Completeness	7
Language	5
Total	35

Source: Adapted from Arsyad (2020).

Four types of instruments were used: a media validation sheet assessing display, usability, functionality, and language aspects; a material validation sheet assessing content suitability, accuracy, currency, presentation, completeness, and language;

teacher and student practicality questionnaires assessing technical, effectiveness, design, interpretability, and equivalence aspects; and a Computational Thinking Skills objective test used for the pretest and posttest. The validation and practicality instruments used a five-point Likert scale (5 = Very Good to 1 = Very Poor).

Table 7. Grid of the practicality instrument (teacher and student)

Aspect	Number of Items
Technical	3
Effectiveness	1
Design	4
Interpretability	4
Equivalence	3
Total	15

Source: Adapted from Nieveen (1999), Tessmer (1998), Sugiyono (2023), and Arsyad (2020).

Table 8. Summary of research instrument design

Instrument Group	Type	Purpose	Respondent
Validation	Media validation sheet	Assess feasibility of the Mobile Devices media	Media experts
Validation	Material validation sheet	Assess feasibility of the learning content	Material experts
Practicality	Teacher questionnaire	Assess ease of use and benefit for teachers	Informatics teacher
Practicality	Student questionnaire	Assess ease of use and benefit for students	Students
Effectiveness	CTS objective test	Measure Computational Thinking Skills (pretest/posttest)	Students

Source: Adapted from the research instrument design (2026).

Data Analysis Technique

Content validity of the media and material was analyzed using Aiken's V index, categorized as valid when $V \geq 0.666$ (Desky et al., 2025a; Agbo et al., 2023) the validity level criteria are presented later in Table 7. Practicality data from teachers and students were analyzed using percentage technique and categorized descriptively following the criteria in Table 9.

Table 9. Practicality level criteria

Value (%)	Criteria
0-20	Not Practical
21-40	Less Practical
41-60	Fairly Practical
61-80	Practical
81-100	Very Practical

Effectiveness was analyzed through a series of prerequisite and inferential statistical tests: normality using the Liliefors test, homogeneity using the F-test, and hypothesis testing using the Independent Sample t-Test at a 5% significance level. In addition, the Normalized Gain (N-Gain) score was calculated using the formula $g = (S_{\text{post}} - S_{\text{pre}}) / (100 - S_{\text{pre}})$, where S_{post} and S_{pre} denote the posttest and pretest scores respectively, to determine the level of improvement in CTS. The N-Gain score was categorized as high, moderate, or low following the criteria in Table 10 (Fang et al., 2025; Shin et al., 2021).

Table 10. N-Gain score interpretation

N-Gain Score	Interpretation
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Moderate
$g < 0.30$	Low

A Mobile Devices-based interactive learning medium is considered effective when it obtains an N-Gain score of at least the moderate category, and when the experimental class shows a significantly higher improvement in learning outcomes than the control class based on the Independent Sample t-Test (Deviana et al., 2025).

Result and Discussion

Analysis and Design Stage

The learning-needs analysis showed that Informatics learning was still dominated by lectures, simple discussions, and worksheet-based assignments, with students given limited opportunity for independent exploration, investigation, and problem solving. This condition caused students' learning activities to remain passive so that the process did not yet fully support the development of higher-order thinking skills. In addition, the school's computer laboratory facilities were still limited, so not all students could use a computer individually, whereas almost all students already owned an Android-based smartphone that was mostly used for communication and entertainment rather than for learning. The needs analysis further confirmed that students still had difficulty identifying problems, decomposing them into smaller parts, recognizing patterns, performing abstraction, and composing systematic problem-solving steps, all of which are key competencies that need to be developed through problem-based learning.

The learner characteristics analysis was conducted to describe the initial condition of the grade IX students who were the subjects of the study. The results showed that students' academic ability varied, as reflected in the number of students who had not yet reached the

learning-mastery criteria. In terms of learning preference, students showed strong interest in learning that involves digital media, group discussion, information exploration through the internet, and problem solving related to daily life, indicating that an active, collaborative, and contextual model such as Mobile Devices-based PBL is suitable to their needs.

The curriculum analysis confirmed that Informatics learning at SMP Negeri 21 Padang refers to the Kurikulum Merdeka, so that the developed learning tools were aligned with the applicable Learning Outcomes (Capaian Pembelajaran/CP), Learning Objectives (Tujuan Pembelajaran/TP), and Learning Objective Flow (Alur Tujuan Pembelajaran/ATP). The Informatics subject under the Kurikulum Merdeka does not only emphasize technology skills but also the development of logical, critical, creative, and collaborative thinking through Computational Thinking, so that the integration of Mobile Devices with PBL was considered relevant to the characteristics of the curriculum (Fiona et al., 2025).

The material analysis was carried out to determine the learning content that matched the research objectives and the characteristics of PBL. The chosen content required students to identify problems, analyze information, formulate solutions, and make decisions systematically, in line with the CTS indicators of decomposition, pattern recognition, abstraction, and algorithmic thinking, while also considering ease of integration with the Mobile Devices medium (Ermawalis et al., 2025).

Based on this analysis, the learning medium was designed as an Android-accessible application containing a home/login page, teaching materials, PBL-based project/task pages, and quizzes, as illustrated in Figure 5 (initial display design) and Figure 6 (main menu design).

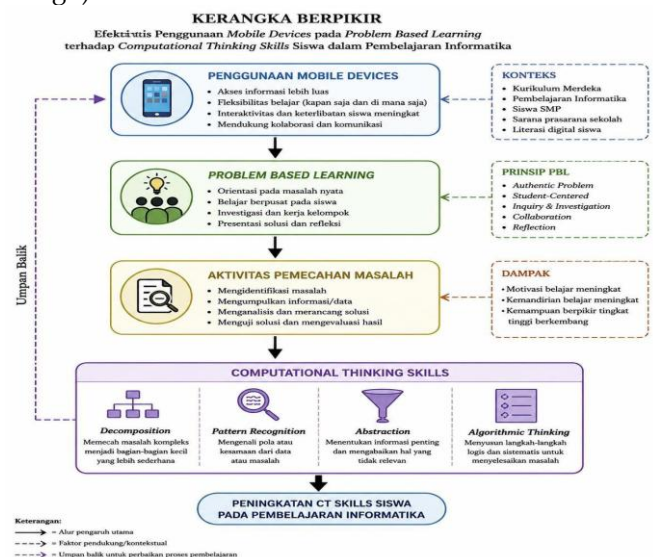


Figure 5. Conceptual framework linking

Development Stage

The developed media were validated by three media experts and material experts using the validation instrument prepared in the Design stage. The recapitulation of the media validation results is presented in Table 11.

Table 11. Media expert validation results

Aspect	Items	Aiken's V	(%)	Category
Display	3	0.89	88.89	Very Valid
Usability	3	0.89	88.89	Very Valid
Functionality	4	0.89	88.89	Very Valid
Language	10	0.88	87.78	Very Valid
Mean	20	0.89	88.61	Very Valid

Source: Research data analysis (2026)

All aspects obtained an Aiken's V above 0.80, placing the media in the Very Valid category, with an overall mean of 0.886 (88.61%). Table 12 presents the material expert validation results.

Table 12. Material expert validation results

Aspect	Aiken's V	(%)	Category
Content suitability with LO	0.889	88.89	Very Valid
Content accuracy	0.889	88.89	Very Valid
Content currency	0.833	83.33	Very Valid
Supporting presentation	0.917	91.67	Very Valid
Learning presentation	0.889	88.89	Very Valid
Content completeness	0.857	85.71	Very Valid
Language	0.900	90.00	Very Valid
Mean	0.882	88.20	Very Valid

Table 13. Validity level category (Irsyadunas et al., 2021)

Achievement Level	Category
0 – 0.666	Invalid
≥ 0.666	Valid

The media were then tested for practicality by teachers and students. Table 13 and Table 14 present the recapitulations (Irfan et al., 2025).

Table 14. Teacher practicality results

Aspect	(%)	Category
Technical	87.5	Very Practical
Effectiveness	100.0	Very Practical
Design	93.8	Very Practical
Interpretability	87.5	Very Practical
Equivalence	87.5	Very Practical
Mean	90.0	Very Practical

Both teachers and students rated the medium as Very Practical, indicating that it is easy to operate, has clear navigation, and supports the implementation of PBL in Informatics learning.

Table 15. Student practicality results

Aspect	(%)	Category
Technical	95.1	Very Practical
Effectiveness	92.9	Very Practical
Design	91.7	Very Practical
Interpretability	92.7	Very Practical
Equivalence	96.9	Very Practical
Mean	93.8	Very Practical

Source: Research data analysis (2026).

Product Revision

All suggestions given by the media and material validators were followed up through a revision process before the medium was implemented. A summary of the main revisions is presented in Table 16.

Table 16. Summary of product revisions based on validators' suggestions

Aspect	Validator Suggestion	Follow-up Revision
Display	Improve interface layout consistency	Layout was made more consistent and systematic across pages
Usability	Add a more detailed user guide	A user-guide page was added before the material page
Functionality	Align features with PBL syntax	Features were adjusted to each stage of PBL
Language	Standardize technical terms and spelling	Terms were standardized and edited following PUEBI
Content suitability	Align content with the latest Learning Objectives	Content was updated according to the CP, TP, and ATP of the Kurikulum Merdeka
Content accuracy	Add up-to-date scientific references	References were updated with current literature

Source: Media and material expert validation results (2026).

After the revision process, the final product was an Android-accessible Mobile Devices learning medium containing a home page, teaching materials, PBL-based project tasks, and quizzes, which was subsequently implemented in the experimental class.

Implementation Stage

The Implementation stage was carried out after the learning medium had been declared valid and practical. Both groups received the same learning content but different treatments: the experimental class used the Mobile Devices-based medium integrated with PBL, while the control class followed the teacher's conventional teaching method. Implementation followed the designed learning syntax, beginning with a pretest, followed by several meetings of PBL-based

learning assisted by Mobile Devices for the experimental class, and concluded with a posttest for both classes. During implementation, students in the experimental class were observed to be actively involved in identifying problems, gathering information, discussing, formulating solutions, and presenting the results of their problem solving, while also being able to access digital learning resources and complete tasks independently or collaboratively through their own smartphones (Safitri et al., 2025).

During each meeting, the experimental class followed the standard PBL syntax: orienting students to the problem, organizing students for study, guiding individual and group investigation, developing and presenting the results of problem solving, and analyzing and evaluating the problem-solving process (Aksakal & Kucuk, 2025). Within this syntax, Mobile Devices were used to present the problem scenario, provide access to supplementary digital materials, support group discussion and information gathering, and allow students to submit and review their project-based tasks and quizzes directly through the application, so that the four Computational Thinking indicators of decomposition, pattern recognition, abstraction, and algorithmic thinking were practiced repeatedly across sessions.

The medium was implemented on 60 grade IX students, consisting of 30 in the control class and 30 in the experimental class, as shown in Table 17.

Table 17. Sample description

Group	N
Control Class	30
Experimental Class	30
Total	60

Before treatment, both groups were given a pretest to determine their initial CTS. Table 18 presents the descriptive statistics of the pretest scores.

Table 18. Descriptive statistics of pretest scores

Group	N	Mean	Median	SD	Min	Max
Control	30	38.87	37.00	9.05	20	58
Experimental	30	39.20	39.00	7.84	23	54

Source: Research data analysis (2026).

The pretest results indicate that the initial CTS of both groups was relatively equivalent. After the treatment, a posttest was conducted, and the results are shown in Table 19.

Table 19. Descriptive statistics of posttest scores

Group	N	Mean	Median	SD	Min	Max
Control	30	55.47	54.00	8.97	33	74
Experimental	30	80.40	83.50	8.81	60	91

Source: Research data analysis (2026).

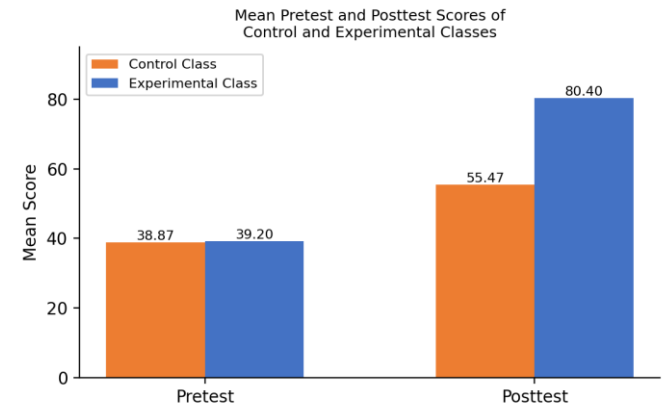


Figure 6. Mean pretest and posttest scores of the control and experimental classes

The mean posttest score of the experimental class increased substantially from 39.20 to 80.40, while the control class increased from 38.87 to 55.47. This descriptive difference was further examined through inferential statistical analysis.

Evaluation Stage

The Evaluation stage was carried out to assess both the quality of the developed product and the implementation of the learning process. Product evaluation showed that the Mobile Devices-based medium met the Very Valid criterion based on the media and material expert validation, and the Very Practical criterion based on the teacher and student practicality results, after all validators' suggestions had been followed up through revision. Learning evaluation showed that the PBL syntax assisted by Mobile Devices could be implemented systematically, with the teacher able to carry out each learning stage as designed and students demonstrating active involvement from problem identification to the presentation of solutions. Taken together, the results of the product and learning evaluations indicate that the developed medium fulfilled Nieveen (1999) quality criteria of validity and practicality and was ready to be examined for its effectiveness through the following statistical analysis.

Statistical Analysis

The normality test using the Liliefors method showed that all data groups were normally distributed, as presented in Table 20.

Table 20. Normality test results (Liliefors)

Group	N	L _{count}	L _{table}	Conclusion
Pretest Control	30	0.124	0.162	Normal
Pretest Experimental	30	0.061	0.162	Normal
Posttest Control	30	0.143	0.162	Normal
Posttest Experimental	30	0.116	0.162	Normal

The homogeneity test using the F-test showed that the variances of both groups were homogeneous (Table 21), so the requirements for the Independent Sample t-Test were fulfilled.

Table 21. Homogeneity test results

Data	F _{count}	F _{table}	Conclusion
Pretest	1.334	1.861	Homogeneous

The equivalence of the initial ability (pretest) and the difference in the final ability (posttest) between groups were examined using the Independent Sample t-Test, as shown in Table 22.

Table 22. Hypothesis test results (independent sample t-test)

Statistic	Pretest	Posttest
t _{count}	0.153	10.864
t _{table}	2.002	2.002
p-value	0.879	0.000
Decision	H0 accepted	H0 rejected

Source: Research data analysis (2026).

The pretest result ($t_{\text{count}} = 0.153 < t_{\text{table}} = 2.002$; $p = 0.879 > 0.05$) confirms that both groups had equivalent initial ability. The posttest result ($t_{\text{count}} = 10.864 > t_{\text{table}} = 2.002$; $p < 0.05$) indicates a significant difference between the experimental and control classes after treatment, so the alternative hypothesis is accepted: the use of Mobile Devices in Problem Based Learning significantly affects students' Computational Thinking Skills.

The level of improvement in CTS was further examined using the N-Gain score, as presented in Table 23 and Figure 7.

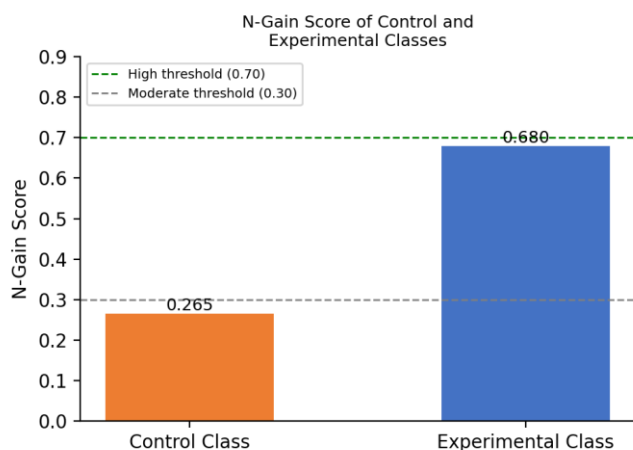


Figure 7. N-Gain score of the control and experimental classes

The experimental class obtained a mean N-Gain of 0.680 (moderate category), considerably higher than the control class at 0.265 (low category), reinforcing the

result of the hypothesis test that the Mobile Devices-based PBL medium is more effective in improving students' Computational Thinking Skills than conventional learning.

Table 23. N-Gain test results

Statistic	Control	Experimental
N	30	30
Mean N-Gain	0.265	0.680
SD	0.145	0.130
Max	0.518	0.850
Min	-0.048	0.385
Category	Low	Moderate

Source: Research data analysis (2026).

Discussion

Validity of Mobile Devices on Problem Based Learning. The developed medium obtained a Very Valid category from both media experts (0.886; 88.61%) and material experts (0.882; 88.20%). This finding is consistent with Nieveen (1999), who states that a developed product is considered valid when it demonstrates consistency between learning objectives, content, user characteristics, and instructional design. It also supports Branch (2009), who emphasizes that expert validation is a crucial stage of the ADDIE model to ensure product quality before implementation.

From the media perspective, the highest-rated aspects were display, usability, and functionality, each reaching 88.89%, indicating that the interface, navigation, and instructional functions of the application were well received by the validators. From the material perspective, the supporting-presentation aspect achieved the highest score (91.67%), suggesting that the examples, illustrations, and supporting content embedded in the medium were considered particularly strong in aiding students' understanding of Computational Thinking concepts. Meanwhile, the content-currency aspect obtained the comparatively lowest, though still Very Valid, score (83.33%), indicating an area that can be further strengthened in future iterations of the medium by incorporating more recent references and examples.

Practicality of Mobile Devices on Problem Based Learning. Both teachers (90.00%) and students (93.80%) rated the medium as Very Practical. This result is in line with Lai et al. (2021), who defines practicality as the ease with which a product can be used by its target users according to the intended purpose, and with Arsyad (2020), who states that a good instructional medium should be easy to use, attractive, interactive, and able to increase students' learning motivation.

The slightly higher practicality score reported by students compared with teachers suggests that the medium was particularly well received by its primary

end users, likely because students were already familiar with operating Android-based smartphones in daily life, which reduced the technical barrier to using the medium for learning purposes. Teachers, meanwhile, still noted a need for clearer usage guidance and a wider variety of practice items, both of which were addressed during the product-revision process described above. This pattern indicates that practicality should be examined from multiple user perspectives, since teachers and students may value different aspects of an instructional medium, such as classroom manageability for teachers versus ease of independent use for students.

Effectiveness of Mobile Devices on Problem Based Learning toward Computational Thinking Skills. The Independent Sample t-Test ($t_{\text{count}} = 10.864$; $p < 0.05$) and the N-Gain results (experimental 0.680 vs. control 0.265) indicate that the Mobile Devices-based PBL medium is effective in improving students' CTS. This finding supports (Wu et al., 2026), who defines Computational Thinking as encompassing decomposition, pattern recognition, abstraction, and algorithmic thinking, abilities that can be developed through learning that provides opportunities for systematic problem solving. It is also consistent with Fitriyah et al. (2025) who explains that PBL improves higher-order thinking because students actively construct knowledge through authentic problem solving, and with Desky et al. (2026a) and Desky et al. (2026b), who state that Mobile Devices provide learning flexibility, wider access to digital resources, and support for collaborative, student-centered learning.

Beyond the statistical significance, the magnitude of the difference is also noteworthy from a practical standpoint: the experimental class moved from a low initial mean score (39.20) to a posttest mean within the passing range (80.40), whereas the control class, although also improving, remained below the mastery criterion (55.47 against a KKTP of 80). This gap suggests that conventional instruction alone, even with the same content and time allocation, may not be sufficient to bring the majority of students to the required mastery level, and that a deliberately designed combination of accessible technology and authentic problem solving is what drives the additional gain observed in the experimental class.

Compared with previous studies discussed in the literature review, these findings reinforce the notion that the integration of Mobile Devices with Problem Based Learning contributes positively to learning outcomes and thinking skills. As summarized in Table 2a, Tananda et al. (2026) found that PBL positively affects collaboration and CT skills, Taali et al. (2024) showed that mobile-based PBL media improve the effectiveness of Informatics learning, and Desky et al. (2025a) demonstrated that interactive mobile learning improves

CT and achievement in technology-related courses. The present study is consistent with these findings while extending them by providing quantitative evidence, through validity, practicality, and effectiveness testing within a single ADDIE-based development cycle, that a Mobile Devices-based PBL medium can significantly improve CTS among junior high school students in Informatics learning specifically. The novelty of this study therefore lies in its specific focus on testing the effectiveness of Mobile Devices-based PBL on Computational Thinking Skills of junior high school students in Informatics learning, providing empirical evidence that goes beyond product development to demonstrate a significant improvement in students' computational thinking ability.

Research Limitations

This study has several limitations that should be considered when interpreting the results. First, the research was conducted at only one school, SMP Negeri 21 Padang, so the findings describe the condition of students at that school and cannot yet be broadly generalized to schools with different student characteristics, facilities, and learning environments. Second, the research subjects were limited to 60 students (30 experimental and 30 control), and although this sample size met the requirements of experimental research, a larger sample involving several schools would provide a higher degree of generalization. Third, the developed medium was focused on Informatics content determined by the applicable Learning Outcomes, Learning Objectives, and Learning Objective Flow, so its effectiveness on other subjects or materials remains unknown.

Fourth, this study only measured the effect of Mobile Devices on CTS through pretest and posttest scores and did not examine other aspects such as motivation, creativity, collaboration, or communication skills. Fifth, implementation was carried out within a relatively limited time in accordance with the school schedule, so the long-term impact of the medium on the development of CTS could not be observed. Sixth, the use of the Mobile Devices-based medium was still influenced by the condition of students' devices, such as smartphone specifications, memory capacity, internet connection stability, and school infrastructure readiness. Seventh, the development of the medium used the ADDIE model and did not compare its effectiveness with other development models such as 4D, Borg and Gall, or Dick and Carey, leaving room for further research.

Implications

Theoretically, this study reinforces the notion that the integration of digital technology with a student-

centered learning model can improve the quality of learning. The use of Mobile Devices combined with Problem Based Learning has been shown to support the development of Computational Thinking Skills through problem-solving-oriented learning activities, reinforcing the concept of 21st-century learning that positions technology as a means to develop higher-order thinking skills. Practically, this study provides an alternative Mobile Devices-based instructional medium that teachers can use to support Informatics learning, particularly to increase student engagement and to train computational thinking through authentic problem-solving tasks that can be accessed flexibly through students' own smartphones.

Conclusion

Based on the research findings, it can be concluded that the Mobile Devices-based learning medium integrated with Problem Based Learning, developed through the ADDIE model, is Very Valid (media 88.61%; material 88.20%), Very Practical (teacher 90.00%; student 93.80%), and Effective in improving students' Computational Thinking Skills, as shown by a significant difference between the experimental and control classes ($t_{\text{count}} = 10.864$; $p < 0.05$) and a higher N-Gain in the experimental class (0.680, moderate) compared to the control class (0.265, low). These three findings confirm that the developed medium fulfils the main criteria of educational development research, namely validity, practicality, and effectiveness, and is therefore suitable as a complementary instructional medium for Informatics learning that aims to develop students' computational thinking.

Recommendations

Based on these conclusions, several recommendations are proposed. For teachers, it is recommended to utilize Mobile Devices as a learning medium combined with Problem Based Learning, since it has been shown to improve students' Computational Thinking Skills, while also designing more contextual learning activities so that students use their mobile devices not merely for communication but also as a learning tool. For schools, it is recommended to support the implementation of technology-based learning by providing adequate internet access, clear policies on the use of digital devices on campus, and training for teachers in developing Mobile Devices-based instructional media. For students, it is recommended to use Mobile Devices more wisely as a learning tool to improve computational thinking, broaden access to digital learning resources, and strengthen learning independence. For future researchers, it is recommended to extend the use of Mobile Devices to broader Informatics content or other subjects, involve larger samples and multiple schools, and integrate more advanced technologies such as Artificial Intelligence, Augmented Reality, or Virtual Reality to

further enhance the quality of learning and the development of students' 21st-century skills.

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Conflicts of Interest

There is no conflict of interest.

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