

Research Article

Development of a Coding-Integrated Project-Based Learning (PJBL) Module to Enhance Digital Literacy Among Elementary School Students

Anggita Silvi Zahrotus Jannah^{1*}, Faridahtul Jannah², Shofia Hattarina³, Ribut Prastiwi Sriwijayanti⁴

¹Panca Marga University, Indonesia; e-mail : anggitasilvi136@gmail.com

²Panca Marga University, Indonesia; e-mail : faridahtul@upm.ac.id

³Panca Marga University, Indonesia; e-mail : shofiahattarina@gmail.com

⁴Panca Marga University, Indonesia; e-mail : ributprastiwi@upm.ac.id

*Corresponding Author : anggitasilvi136@gmail.com

Abstract: This study aimed to (1) develop a Project-Based Learning (PjBL) model integrated with coding activities that aligns with the learning characteristics of elementary school students, (2) examine the validity of the developed model through expert evaluations, and (3) investigate its effectiveness in improving students' digital literacy. The research employed a Research and Development (R&D) approach using the ADDIE framework, consisting of Analysis, Design, Development, Implementation, and Evaluation phases. The study was conducted in a fifth-grade classroom at SDN Ambulu II. Data were collected through classroom observations, interviews, expert validation sheets, student response questionnaires, and pre-test and post-test assessments. Descriptive quantitative analysis was used to interpret the data, while the N-Gain index measured improvements in students' digital literacy. The results indicated that the coding-integrated PjBL model was highly feasible, with validity scores of 95% from material experts and 95.8% from media experts. Practitioners rated the model's practicality at 95%, while student responses reached 99%, indicating high acceptance. The effectiveness analysis produced an N-Gain score of 0.76, categorized as high, demonstrating a significant improvement in students' digital literacy. These findings suggest that the coding-integrated Project-Based Learning model is valid, practical, and effective for supporting elementary school IPAS learning and enhancing students' digital literacy.

Keywords: Coding; Digital literacy; Elementary school; Project-Based Learning; Research and Development.

1. Introduction

The rapid advancement of information technology has made digital literacy one of the essential competencies that elementary school students need to acquire. Digital literacy extends beyond the ability to operate technological devices; it also encompasses the ability to search for, understand, evaluate, create, and utilize digital information critically, ethically, and responsibly in both learning activities and everyday life (Naila et al., 2021). Developing digital literacy from the elementary education level is essential for fostering effective learning habits while enhancing critical thinking, creativity, problem-solving skills, and students' readiness to face the challenges of twenty-first-century learning.

Although digital devices and internet access have become increasingly accessible, elementary school students' digital literacy skills still face various challenges. These challenges are attributed to the limited integration of digital literacy into classroom instruction, teachers' insufficient competence in integrating technology into teaching and learning activities, and the lack of instructional models capable of providing meaningful digital learning experiences. Furthermore, students' understanding of ethical and responsible technology use still requires considerable improvement to ensure that they utilize digital technology safely, wisely, and responsibly.

One strategy to improve students' digital literacy is through coding instruction. Coding instruction is not merely intended to develop programming skills but also serves as a means of fostering computational thinking, logical reasoning, creativity, and problem-solving

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abilities. Through coding activities, students gain an understanding of how digital technology works while creating simple digital products that contribute to the development of broader digital literacy competencies.

The implementation of coding instruction requires a learning approach that actively engages students throughout the learning process. One appropriate approach is the Project-Based Learning (PjBL) model, as it provides students with opportunities to learn through project completion that requires critical thinking, collaboration, communication, creativity, and the effective use of technology (Maulida et al., 2024). Previous studies have demonstrated that PjBL effectively enhances students' digital literacy, creativity, learning motivation, and twenty-first-century skills (Silitubun et al., 2020). In addition, integrating technology into PjBL has been shown to improve students' critical thinking abilities and digital literacy competencies (Ismail, 2025; European Commission, 2022).

Nevertheless, studies focusing specifically on the development of a Project-Based Learning-based coding instruction model to improve elementary school students' digital literacy remain relatively limited. Most previous studies have examined either the implementation of PjBL or digital literacy independently, without integrating coding instruction as the primary component evaluated through empirical research (Qurin et al., 2024). Therefore, there is a need to develop an instructional model that systematically integrates coding activities with the syntax of Project-Based Learning to improve elementary school students' digital literacy (Voogt et al., 2022; Yadav et al., 2021).

The importance of this study is further supported by the implementation of the School Literacy Movement (Gerakan Literasi Sekolah/GLS), which indicates that digital literacy practices in elementary schools have progressed but have not yet been implemented optimally. Consequently, more contextual, innovative, and sustainable instructional models are still needed (Jannah & Hattarina, 2022). Other studies have also revealed that the Project-Based Learning model effectively improves various aspects of literacy through structured project activities designed around authentic problem-solving (Jannah & Wardana, 2025).

Based on classroom observations, interviews with teachers, and an analysis of instructional practices at SD Negeri Ambulu 2, several major issues were identified. These include students' low level of digital literacy, the lack of integrated coding instruction within classroom learning, teacher-centered instructional practices, limited coding instructional modules and learning resources, teachers' inadequate competence in implementing project-based and technology-integrated learning, and the absence of a Project-Based Learning-based coding instruction model that has been validated in terms of validity, practicality, and effectiveness. Therefore, this study aims to develop a Project-Based Learning (PjBL)-based coding instruction model that is valid, practical, and effective in improving elementary school students' digital literacy while contributing to the development of innovative instructional practices that are aligned with the demands of the digital era (Azzahra et al., 2024; OECD, 2021; UNESCO, 2023).

2. Research Methods

This research adopted a Research and Development (R&D) approach to produce a coding learning model based on the Project-Based Learning (PjBL) framework aimed at strengthening digital literacy among elementary school students. The instructional model was developed by following the ADDIE framework, which includes five interconnected stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE framework was chosen because it offers a structured and iterative process that supports the planning, creation, application, and continuous refinement of educational products, ensuring that the developed learning model meets instructional objectives and learners' needs.

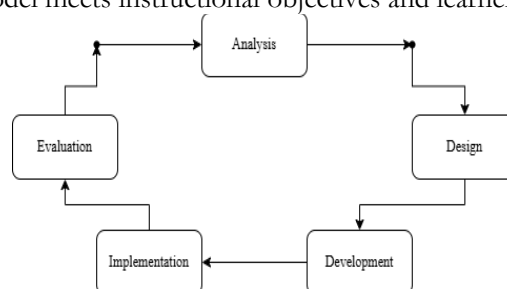


Figure 1. Stages of the ADDIE Development Model
Source: Compiled by the Author (2026).

The Analysis phase began with classroom observations, interviews, and a needs analysis to identify students' characteristics, existing learning conditions, and digital literacy issues encountered at SD Negeri Ambulu II. The findings from this phase served as the foundation for designing an instructional product that addressed the school's educational needs. During the Design phase, a Project-Based Learning (PjBL)-based coding learning model was designed. This stage involved preparing instructional materials, developing learning tools, designing project storyboards, and creating instructional media and teaching materials aligned with the Merdeka Curriculum.

The Development phase focused on producing the instructional model by integrating coding activities into the Science and Social Studies (IPAS) topic "Harmony in the Ecosystem." The completed product was subsequently validated by subject matter experts, media experts, and educational practitioners to obtain constructive feedback for product refinement. The Implementation phase involved conducting field trials with fifth-grade students at SD Negeri Ambulu II. A pre-test–post-test research design was employed to evaluate the effectiveness of the developed learning model in improving students' digital literacy.

Finally, the Evaluation phase was conducted through both formative and summative evaluation. The evaluation was based on the results of expert validation, classroom observations, assessment tests, and user responses to identify areas for improvement and to refine the developed instructional model (Ulannidha & Agustina, 2025).

This study involved both expert validators and student participants. The expert panel comprised specialists in learning materials, instructional media, and classroom practice, whereas the target users were fifth-grade students at SD Negeri Ambulu II. The evaluation of the developed product began with a preliminary trial involving 10 students and was subsequently expanded to a larger implementation with 32 students to obtain comprehensive feedback on the learning model.

This research employed two types of data to evaluate the developed learning model. Numerical evidence was generated from expert validation assessments, questionnaire responses completed by teachers and students, and comparisons of students' pre-test and post-test digital literacy scores. In addition, descriptive evidence was collected through observation activities together with suggestions, comments, and evaluative feedback from validators, classroom teachers, and students to support the refinement of the product during its development and application.

Several instruments were utilized to collect the research data, including expert evaluation forms, teacher and student questionnaires, observation checklists, and digital literacy tests administered before and after the implementation of the learning model. The collected data were examined using both qualitative and quantitative analysis techniques. Qualitative findings were processed through data reduction, classification, and descriptive interpretation to identify necessary improvements to the developed product. Quantitative findings were analyzed by calculating percentage scores to assess the model's validity and practicality. In addition, the effectiveness of the developed learning model was determined by applying the N-Gain index to compare students' performance before and after the intervention. The outcomes of these analyses provided evidence regarding the validity, practicality, and effectiveness of the Project-Based Learning (PjBL)-based coding learning model.

3. Results and Discussion

The main outcome of this research was the development of a coding-integrated Project-Based Learning (PjBL) model intended to strengthen the digital literacy of fifth-grade students at SD Negeri Ambulu II. The development process followed the ADDIE instructional design framework, encompassing the phases of Analysis, Design, Development, Implementation, and Evaluation. The preliminary investigation indicated several challenges in classroom practice. Learning activities were largely dominated by teacher-centered instruction, digital technology had not been effectively incorporated into the teaching process, and students demonstrated limited digital literacy skills. In response to these findings, a learning model was designed by embedding basic coding activities into project-based learning within the IPAS topic, *Harmony in the Ecosystem*, to create a more interactive and technology-supported learning experience. During the Development stage, several instructional components were produced, including a teaching module, Project-Based Student Worksheets (LKPD), AI-assisted instructional videos, a digital educational game entitled "Tug of War," basic coding activities, and learning media utilizing an Interactive Flat Panel (IFP). The developed products were

subsequently validated by subject matter experts, media experts, and educational practitioners to evaluate their validity and to obtain recommendations for further refinement and improvement.

Product Validation Results

To determine the quality of the developed coding-integrated Project-Based Learning (PjBL) model, a validation process was carried out involving specialists in subject content, instructional media, and classroom practice. The evaluation results indicated that the proposed learning model satisfied the established feasibility criteria and received highly positive assessments from all validators. A detailed summary of the validation outcomes is provided in Table 1.

Table 1. Summary of Expert Validation Results

Validator	Obtained Score	Maximum Score	Percentage (%)	Category
Subject Matter Expert	57	60	95.0	Excellent
Media Expert	46	48	95.8	Excellent
Educational Practitioner	57	60	95.0	Excellent
Average	160	168	95.3	Excellent

As shown in Table 1, the average validation percentage reached **95.3%**, placing the developed instructional model in the excellent category. This result confirms that the model satisfies the criteria for content validity, media quality, and instructional practicality required for classroom implementation. The subject matter expert assigned a score of **95.0%**, indicating that the instructional materials, coding activities, and project-based learning components were appropriately aligned with the Grade V Science and Social Studies (IPAS) curriculum objectives. The media expert awarded the highest score (**95.8%**), reflecting the quality, interactivity, and usability of the instructional media, including AI-assisted learning videos, Google Sheets, the "Tug of War" digital game, and the Interactive Flat Panel (IFP). Likewise, the educational practitioner provided a 95.0% rating, suggesting that the instructional model is practical to apply in classroom settings and effectively encourages active student participation during the learning process.

These results support earlier research indicating that Project-Based Learning (PjBL) provides authentic and meaningful learning experiences by engaging students in project-oriented activities closely connected to real-life contexts. In addition, integrating digital technologies into classroom instruction has been reported to enhance student engagement while fostering essential twenty-first-century competencies, including digital literacy, creativity, communication, and collaboration (Maulida et al., 2024).

Product Trial Results

A preliminary product trial was implemented with a sample of 10 fifth-grade students to examine the practicality of the developed learning model. The questionnaire results revealed an approval rating of 97%, reflecting a very high level of practicality and student acceptance. During the implementation, students demonstrated enthusiastic participation and strong engagement while using AI-assisted learning videos, the digital educational game *Tug of War*, introductory coding activities, and project-based tasks, including the creation of pop-up books and food chain dioramas.

Following the preliminary trial, the developed learning model was applied to a larger group consisting of 32 fifth-grade students. Its effectiveness was assessed by measuring changes in students' digital literacy performance before and after the learning intervention. The mean score increased from **47.66** on the pre-test to **81.09** on the post-test. Furthermore, the N-Gain analysis produced a value of **0.67**, which falls within the moderate-to-high improvement category. These results suggest that integrating coding activities into the Project-Based Learning (PjBL) model contributed significantly to enhancing the digital literacy skills of elementary school students.

Table 2. Pre-test, Post-test, and N-Gain Results of Students' Digital Literacy

Number of Students	Mean Pre-test	Mean Post-test	N-Gain
32	4766	81,09	0,67

The increase in students' achievement suggests that the implementation of the developed instructional model enabled learners to gain a deeper understanding of digital technologies while strengthening their critical thinking and problem-solving abilities. Through collaborative project activities, students were encouraged to search for relevant information, analyze and organize data, exchange ideas with peers, and create meaningful project outputs that reflected their learning.

The results of this study are consistent with previous findings demonstrating that Project-Based Learning (PjBL) contributes to improvements in digital literacy, creativity, and critical thinking by engaging students in authentic, problem-oriented projects (Murid & Dasar, 2025). Similarly, research conducted by Ismail reported that integrating digital technology into project-based instruction significantly enhances both digital literacy and higher-order thinking skills among students (Indonesia & Terbuka, 2025).

Moreover, incorporating basic coding activities into classroom instruction provided students with opportunities to participate in active, inquiry-based learning. By following structured problem-solving processes, students developed computational thinking skills, which represent a key component of digital literacy. These findings reinforce the perspective that coding education at the elementary level should extend beyond introducing programming concepts to fostering logical reasoning, creativity, and systematic approaches to solving real-world problems (Naila et al., 2021).

Overall, the evidence obtained from expert validation, student feedback, and the improvement in digital literacy test scores indicates that the developed Project-Based Learning (PjBL)-based coding learning model fulfills the criteria of validity, practicality, and effectiveness. Therefore, the model is considered appropriate for improving the digital literacy of fifth-grade students at SD Negeri Ambulu II.

4. Conclusion

This research resulted in the development of a Project-Based Learning (PjBL)-integrated coding instructional model designed to strengthen the digital literacy of elementary school students. The instructional model was developed by following the ADDIE framework, comprising the stages of Analysis, Design, Development, Implementation, and Evaluation. The final product consisted of several instructional components, including a teacher's module, project-based student worksheets (LKPD), AI-supported learning videos, a digital educational game called "Tug of War," project assignments involving the construction of pop-up books and food chain dioramas, and basic coding activities embedded within the Grade V Science and Social Studies (IPAS) topic Harmony in Ecosystems.

The evaluation findings confirmed that the instructional model achieved a high level of quality and suitability for classroom application. Assessments conducted by subject matter experts, media experts, and educational practitioners consistently rated the product as highly appropriate for instructional use. In addition, both the pilot implementation with a small group of students and the wider classroom trial generated favorable responses, indicating that the learning activities were engaging and practical to implement. The effectiveness analysis further demonstrated a substantial improvement in students' digital literacy, with an N-Gain score of 0.76, classified as high. These findings indicate that the developed Project-Based Learning (PjBL)-based coding instructional model is a valid, practical, and effective instructional approach for improving the digital literacy of fifth-grade students at SD Negeri Ambulu II.

The Project-Based Learning (PjBL)-based coding instructional model developed in this study has the potential to be adopted as an innovative approach for strengthening digital literacy among elementary school students. Future research is encouraged to adapt and evaluate this model in different academic subjects and educational contexts, involve broader and more diverse participant groups, and incorporate additional digital technologies to enrich the learning experience and improve instructional outcomes.

Moreover, subsequent studies should investigate the impact of the proposed model on other essential twenty-first-century competencies. In particular, researchers are encouraged to examine its contribution to the development of creativity, collaboration, communication, and critical thinking skills, thereby providing a more comprehensive understanding of the model's educational value across various learning environments.

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