

DEVELOPMENT OF THE ADAPTIVE E-MODULE “SCRATCHVENTURE” BASED ON ADVENTURE-BASE LEARNING TO ACCELERATE JUNIOR HIGH SCHOOL STUDENTS’ COMPUTATIONAL THINKING SKILLS

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ABSTRACT

Computational Thinking (CT) is a fundamental competency in 21st-century education, which has been formally integrated as one of the main pillars within Indonesia’s Merdeka Curriculum to foster the development of the Pancasila Student Profile. Despite this policy integration, its implementation in classroom settings remains constrained by a persistent misalignment between intended curricular outcomes and actual classroom practices. This discrepancy is primarily attributed to two interrelated challenges: teachers’ limited pedagogical readiness and instructional capacity to effectively facilitate CT learning, and the heterogeneity in students’ CT proficiency at the junior high school level. This literature-based study aims to develop a conceptual framework for “ScratchVenture,” an innovative e-module designed to address these challenges. ScratchVenture is conceptualized as an adaptive e-module integrating three theoretical foundations: (1) Adventure-Based Learning (ABL) which provides an experiential and reflective pedagogical structure that enhances student engagement and meaningful learning; (2) the Scratch Visual programming environment as a creative platform for operationalizing CT practices; and (3) a personalization mechanism based on Item Response Theory (IRT) to dynamically tailor learning tasks and challenges according to individual students’ ability levels. The proposed model seeks to establish a personalized, engaging, and reflective learning environment to support the effective and equitable development of computational thinking competencies among junior high school students.

Keywords: Computational Thinking, Adventure-Based Learning, Scratch, E-Modul.

1) INTRODUCTION

Entering the digital era of the 21st century, the landscape of competencies required by individuals has fundamentally changed. Among these competencies, Computational Thinking (CT) has been widely acknowledged as an essential skill,

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not only for computer scientists but also for learners across various fields. (Pramudhita et al., 2022) CT is commonly defined as a cognitive process involved in formulating problems and solutions that can be effectively executed by information-processing agents, whether human or machine. 4 It represents a problem-solving approach applicable across a wide range of contexts, supporting the development of logical, structured, and creative thinking. (Pramudhita et al., 2022)

Recognizing its growing importance, many countries have formally integrated CT into their K-12 education systems. (Marifah et al., 2022) Indonesia, through the Merdeka Curriculum policy, has similarly positioned CT as a core competency to be taught in schools. The integration of CT within the Merdeka Curriculum is not merely a reflection of global trends, but a deliberate effort to strengthen students' fundamental competencies and holistic understanding. (Sutojo et al., 2023) It aims to prepare and cultivate a generation that is creative, innovative, and capable of solving complex problems, in alignment with the vision of developing high-quality Indonesian human resources through the Pancasila Student Profile. Therefore, the successful implementation of CT is a key indicator of progress toward current national education reform goals.

Although curricular objectives have been clearly defined, the effective implementation of Computational Thinking (CT) at the junior high school level in Indonesia continues to face complex and multifaceted challenges. A clear gap persists between the ideal expectations of the curriculum and the realities of classroom practice. This gap can be understood through three main dimensions: challenges related to teachers, students, and the availability of relevant learning media. First, teacher-related challenges represent the most fundamental barrier. Many teachers lack sufficient background knowledge, training, and skills to effectively teach CT concepts. (Pramudhita et al., 2022) Teachers' perceptions of CT also vary considerably, with many still unfamiliar with its terminology and pedagogical approaches. (Hakim et al., 2024) These difficulties are further intensified by limited educational resources and the lack of structured professional development programs. As a result, teachers often struggle to design curricula and instructional materials that systematically integrate CT concepts in ways that are

appropriate to students' developmental levels. (Rohman et al., 2024). Implementing CT requires a shift in mindset—from merely using information technology to guiding students to think like computer scientists—a transition that is far from straightforward (Pramudhita et al., 2022).

Second, student-related challenges are equally significant. Studies indicate substantial variability in CT proficiency among students within the same classroom (Yanita et al., 2024). A large proportion of students remain at relatively low levels of CT proficiency, particularly in higher-order thinking aspects such as abstraction and algorithmic thinking. (Salsabila et al., 2024) They often experience difficulties in identifying the core of a problem and applying logical and structured problem-solving strategies, which are fundamental to CT. (Hakim et al., 2024) This condition creates a pedagogical dilemma for teachers: materials that are too difficult may lead to frustration and anxiety among lower-performing students, while materials that are too simple may result in boredom and a lack of challenge for higher-performing students. Third, challenges related to learning media also play a critical role. The lack of instructional materials capable of bridging teachers' pedagogical limitations while accommodating diverse student abilities has become a crucial issue. Although unplugged approaches (without computers) have been developed as an alternative for schools with limited technological infrastructure (Sutojo et al., 2023), there remains an urgent need for more advanced, engaging, and adaptive digital learning media in technology-enabled environments. Existing learning materials are often static and unable to provide personalized learning experiences.

To address these systemic challenges, an innovative solution is required—one that goes beyond content delivery to incorporate effective pedagogy and personalization. This study proposes the development of a conceptual framework for 'ScratchVenture,' an adaptive e-module specifically designed to accelerate junior high school students' computational thinking skills.

2) METHODS

This study employs a systematic literature review methodology. This approach was selected as the study aims to develop a new conceptual framework by synthesizing findings

from existing research across multiple domains, rather than collecting new empirical data. The research process was conducted in three main stages:

- a. Identification and Data Collection: The study began with the collection of a corpus of relevant literature from selected sources. These sources included peer-reviewed journal articles, conference proceedings, and research reports focusing on four main pillars of the study: (a) the implementation of Computational Thinking (CT) in educational contexts in Indonesia, particularly within the Merdeka Curriculum; (b) the use of Scratch as a platform for CT development; (c) the Adventure-Based Learning (ABL) instructional model; and (d) adaptive learning technologies, particularly Computerized Adaptive Testing (CAT) and Item Response Theory (IRT).
- b. Screening and Selection: The collected corpus of literature was then carefully screened. The primary inclusion criteria were the direct relevance of the articles to at least one of the four research pillars and their focus on primary and secondary education levels, particularly junior high school. Articles that were purely descriptive without in-depth analysis or that fell outside the K–12 educational context were excluded. This process ensured that the selected literature was of high quality and relevant to addressing the research objectives.
- c. Synthesis and Analysis: Following this, a creative synthesis process was conducted, in which insights from these different domains were integrated to develop a well-structured and innovative conceptual framework for the ScratchVenture e-module. The primary focus of the analysis was to explore how the strengths of one approach can address the limitations of others, thereby forming a more robust and integrated model that extends beyond the contributions of individual components.

3) RESULTS AND DISCUSSION

The result of this literature review are the development of an integrated conceptual framework for the “ScratchVenture” e-module. This framework is not merely a combination of discrete components, but rather a synthesis that unifies pedagogy, content, and technology into a cohesive learning ecosystem. The most fundamental innovation of this model is the

reconceptualization of the ‘item’ within the Item Response Theory (IRT) framework. Instead of relying on traditional multiple-choice questions that are detached from the learning process, ScratchVenture defines each performance-based programming challenge in Scratch as an “item” in itself. As a result, the learning process (working on challenges) and the assessment process (measuring students’ abilities) become closely interconnected, operating simultaneously as an integrated process. The integration matrix presented below outlines the conceptual framework of ScratchVenture, illustrating how each component of the module is based on established theory, implemented in practical terms, and designed to address the specific challenges identified in this study.

Based on the synthesis of findings from various literature sources, the use of Scratch is known to enhance students’ motivation, engagement, and learning outcomes (Mardian & Surjono, 2025). Interactive modules based on Scratch also offer flexibility in terms of time and place, as they can be accessed online through digital devices such as laptops or tablets. The learning process supported by this e-module is self-directed and adaptive, allowing students to learn at their own learning pace and review materials they have not yet fully understood. The interactivity embedded within the e-module further promotes an exploratory learning process, aligning with the constructivist approach, in which learners actively construct their own knowledge through direct experience.

Computational thinking skills, which constitute the primary objective of this e-module development, include four core dimensions: decomposition, abstraction, pattern recognition, and algorithmic thinking. The Scratch-based e-module facilitates these dimensions through project-based activities that require students to break down complex problems into smaller components, identify patterns, construct logical sequences, and turn them into code blocks that can be executed by the program. These activities implicitly help develop students’ systematic and logical thinking skills, which are essential for solving problems in the digital era (Aziz & Zakir, 2022; Shefira et al., 2024)

Valverde-Berrocso et al. (2021) found that the use of visual programming-based tools such as Scratch in primary and secondary education can improve students’ critical and

computational thinking skills. Their findings indicate that the integration of Scratch into the learning process led to a 28% improvement in cognitive learning outcomes and demonstrated a significant impact on student engagement and motivation. These findings highlight that platforms like Scratch function not simply as visual aids, but also as tools that support the development of algorithmic and logical thinking at an early stage of learning. Consequently, interactive e-modules based on these principles serve as strategic media for delivering programming content to junior high school students.

Furthermore, Yusup et al. (2022) found that the development of Scratch-based interactive e-modules led to improvements in students' computational thinking skills and creativity, with increases of 31% and 34%, respectively (Santiago, 2022). The module in this study was designed using a project-based learning approach, which aligns with the learning structure embedded in Scratch. Students completed a series of tasks involving the creation of simple animations, educational games, and interactive simulations, supported by step-by-step guidance provided within the module. As a result, students showed higher levels of engagement and creativity, along with a stronger conceptual understanding of programming logic.

The improvement in students' creativity observed in the synthesis is also influenced by the creative freedom enabled by Scratch. Students are able to design their own characters, determine storylines, control program responses, and customize graphical elements based on their ideas (Sukmawati & Tarmizi, 2022). This aspect is important as it enables students to express their ideas and integrate them into digital forms, which also contributes to the development of digital literacy skills. Within the context of the e-module, this feature is utilized by providing open-ended project scenarios, where students, rather than simply following step-by-step instructions, are encouraged to develop unique solutions.

Interactive e-modules have also been shown to be effective in supporting differentiated learning, which refers to the adaptation of instruction based on students' learning styles and abilities. Through the use of simulations, video tutorials, textual guidance, and interactive exercises, students with different learning preferences (visual, auditory, and kinesthetic) can be

effectively supported. The intuitive and visually clear interface also makes the e-module more inclusive, allowing students with different levels of technological proficiency to learn independently. These findings suggest that Scratch-based e-modules are not only suitable for students who are already familiar with technology, but also for those who are just beginning to explore the fundamentals of programming.

In terms of assessment, the e-module provides automated evaluation and reflection features, allowing students to monitor their progress in real time. The evaluation process not only measures conceptual understanding, but also assesses students' thinking processes in constructing algorithms and their creativity in completing projects. Teachers can also utilize this data to provide formative feedback and make adjustments to subsequent instructional strategies.

Taken together, the findings indicate that the development of Scratch-based interactive e-modules makes a significant contribution to the development of 21st-century skills, particularly computational thinking and creativity. This e-module not only functions as a learning support tool, but also as an exploratory medium that positions students as active participants in the learning process.

Table 1. Integration Matrix of the ScratchVenture E-Module Conceptual Framework

Module Component	Theoretical Basic	Implementation in ScratchVenture	Problems Addressed
Learning Flow & Narrative	<i>Adventure Based Learning</i> (ABL)	Students follow a compelling adventure storyline. Each learning unit is designed as a 'mission' or 'stage' within a journey, providing clear context and objectives for each challenge	Low student engagement and motivation (Pane et al., 2024). Learning often feels fragmented and lacks meaningful context.
Content Activities	CT Framework (Brennan & Resnick, 2012) & Scratch Platform	Each mission consists of Scratch-based programming challenges designed to train one or more CT concepts (e.g., loops,	Lack of structured CT learning materials. Students experience difficulties in understanding abstract CT concepts.

		conditionals) through practical activities such as remixing and debugging (Salsabila et al., 2024).	
Assessment & Personalization	<i>Item Response Theory (IRT) & Computerized Adaptive Test (CAT)</i>	A set of Scratch challenges consists of hundreds of tasks calibrated using Item Response Theory (IRT), particularly in terms of difficulty (b). The system automatically evaluates students' solutions, updates their ability estimates (θ), and assigns subsequent missions that best match their current level of proficiency.	Wide variation in student abilities within a single class. High-achieving students may feel underchallenged, while lower-achieving students may struggle.
Reflection & Learning Transfer	Debriefing Model ("What? So What? Now What?")	After completing a mission, the system automatically initiates a debriefing session. Students are guided through reflective prompts to examine their problem-solving processes and consider how the strategies they used can be applied beyond the Scratch context.	Students often experience difficulty transferring learned knowledge to different contexts. Learning tends to focus on coding tasks without deeper conceptual understanding (Stuhr, n.d.).

In practice, the learning cycle within a single ScratchVenture unit is structured as follows:

- a. Briefing: The module presents a narrative segment to introduce the context. For example, students are given a scenario such as a spaceship running out of energy and needing to land on Planet X to collect energy crystals. They are then tasked with designing a Scratch program to control an exploration robot, avoid obstacles, and

- collect a specified number of crystals. The challenge is implicitly designed to train specific CT concepts, such as loops and conditionals.
- b. **Experiential Activity:** Students enter the Scratch environment integrated within the e-module and begin working on the challenge. The learning process is iterative and exploratory, with students encouraged to experiment, encounter errors, perform debugging, and, where possible, collaborate with peers. This stage reflects the incremental nature of CT practices.
 - c. **Adaptive Assessment (Background Process):** Once students consider their solution complete and submit their work, the system automatically evaluates the Scratch project through a series of predefined tests. If all tests are passed, the response is recorded as correct. Based on this result and the difficulty level of the completed challenge, the IRT engine updates the student's ability estimate (θ). It then assigns the next challenge that best aligns with the student's current level of proficiency.
 - d. **Debriefing:** Before proceeding to the next challenge, the module presents a reflection screen. Students are guided by prompts such as "What strategies were most effective in helping your robot avoid obstacles?" (What?) and "How can this step-by-step reasoning be applied to solve problems in mathematics?" (Now What?). This stage encourages learning beyond technical execution and supports the development of metacognitive awareness.

4) CONCLUSION

The integration of Computational Thinking (CT) within the Merdeka Curriculum represents an important step in preparing Indonesian students to face the challenges of the 21st century. However, its successful implementation is constrained by complex systemic challenges, particularly gaps in teachers' pedagogical competencies and the significant diversity in students' ability levels. Addressing these issues requires an intervention that goes beyond content delivery, focusing instead on how learning is experienced and personalized.

This literature-based study has developed and substantiated a conceptual framework for 'ScratchVenture,' a next-generation adaptive e-module. The framework is built upon a strong

synthesis of three key theoretical pillars: the narrative and reflective pedagogy of Adventure-Based Learning (ABL), the creative and accessible CT practice environment offered by the Scratch platform, and the advanced personalization mechanism enabled by Item Response Theory (IRT). This integration results in a learning model that simultaneously enhances student engagement, provides personalized learning pathways, supports teachers' pedagogical practices, and facilitates the transfer of skills. The ScratchVenture conceptual framework presented in this study offers a detailed and theoretically grounded blueprint for the development of innovative CT learning media. The model holds strong potential to significantly accelerate the development of CT skills among junior high school students in a more effective, efficient, and equitable manner.

As a next step, this conceptual framework needs to be translated into a tangible product. Future research should focus on: (1) developing a prototype of the ScratchVenture e-module based on the proposed architecture; (2) constructing and calibrating a bank of performance-based tasks (Scratch challenges) using IRT methodology to determine the parameters of each task; and (3) conducting rigorous field trials in real junior high school classroom settings to evaluate the effectiveness, usability, and impact of the ScratchVenture e-module on students' computational thinking skills.

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