Development of a Computational Thinking-Based Learning Module Aligned with the Merdeka Curriculum for Primary

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Abstract

This study aims to develop a computational thinking learning module tailored to the Merdeka Curriculum for primary school students. The Merdeka Curriculum, which emphasizes 21st-century skills, provides a flexible and adaptive framework for education; however, integrating computational thinking remains a challenge in many schools. Through a research and development (R&D) approach, this study identifies the needs, designs, and tests an innovative learning module. The development process begins with a needs analysis conducted through surveys and interviews with teachers and students in primary schools implementing the Merdeka Curriculum. Based on these findings, the learning module is designed to include various interactive activities and exercises aimed at developing computational thinking skills in children. The module is then validated by educational experts and piloted in several primary schools. The trial results indicate that the developed learning module is effective in enhancing students' understanding of computational thinking concepts. Feedback from teachers and students also suggests that the module is engaging, easy to understand, and supports active learning in the classroom. Nevertheless, challenges such as limited time and school facilities need to be addressed for broader implementation. This study makes a significant contribution by providing educational resources that support the development of computational thinking skills in primary schools, in line with the principles of the Merdeka Curriculum. Recommendations for further research and field implementation are also presented to strengthen the outcomes obtained.

Keywords: Computational Thinking; Merdeka Curriculum; Primary School; Module Development.

Introduction

Education is a critical component of sustainable societal development, especially in the era of the Fourth Industrial Revolution, characterized by the rapid advancement of information and communication technology (ICT). These changes necessitate adaptations in educational curricula to prepare students with the 21st-century skills required to compete in an increasingly competitive global job market. One essential skill that has emerged from this need is Computational Thinking (CT), a mental process that involves systematic problem-solving, system design, and understanding human behavior through the fundamental concepts of computer science (Aydeniz, 2018). The application of CT in primary education has gained increasing attention worldwide due to its potential to enhance students' analytical skills, problem-solving abilities, and mastery of essential concepts in STEM (Science, Technology, Engineering, and Mathematics) fields (Kakavas & Ugolini, 2019). In Indonesia, efforts to integrate CT into primary education have been accelerated through the development of the Merdeka Curriculum. This curriculum offers

flexibility for schools to design educational programs that align with students' needs and potentials, focusing on character development and 21st-century skills.

However, implementing CT in Indonesian primary schools still faces many challenges. One of the primary challenges is the lack of understanding and preparedness among educators to effectively teach CT concepts. Research indicates that integrating CT into the curriculum requires strong support in terms of teacher training, the development of appropriate learning modules, and the provision of adequate resources in schools (Garvin *et al*., 2019). The Merdeka Curriculum, with its flexible and adaptive orientation, offers significant opportunities to address these challenges. However, to fully optimize these opportunities, a more structured effort is needed to develop CT learning modules that align with the characteristics and needs of primary school students. These modules should be designed not only to teach CT concepts theoretically but also to engage students in interactive activities that can facilitate a practical understanding of how CT can be applied in everyday life and various fields of study (Dagienė *et al*., 2022).

Moreover, developing effective learning modules must take into account various aspects, including teaching strategies, the technology tools used, and the assessment methods applied. Studies show that project-based approaches, which combine CT with other subjects such as mathematics and science, can increase students' motivation and participation in the learning process (Yeni *et al*., 2023). However, the success of this approach heavily depends on teachers' competency in integrating CT concepts into lessons, highlighting the importance of ongoing teacher training. This research aims to address these challenges by developing a CT learning module tailored to the principles of the Merdeka Curriculum. The module development process begins with a thorough needs analysis conducted through surveys and interviews with teachers and students in several primary schools. This step is crucial to ensure that the developed module is relevant and can be effectively applied within the existing learning context. After the module is designed, the next step is validation by educational experts and pilot testing in several primary schools to measure the module's effectiveness in enhancing students' understanding of CT (Bocconi *et al*., 2016).

The results of these trials are expected to provide empirical evidence regarding the module's effectiveness in improving students' computational thinking skills. Additionally, feedback from teachers and students during the trials will be used to refine and perfect the module before broader implementation. Thus, this research not only aims to develop an innovative learning module but also to make a meaningful contribution to improving the quality of primary education in Indonesia through the integration of CT in the primary school curriculum. In the long term, the development and implementation of this CT learning module are expected to equip students with the necessary skills to face future challenges, both academically and in everyday life. Therefore, this research is not only relevant in the context of curriculum development in Indonesia but also has the potential to contribute to the global literature on the application of CT in primary education (Waterman *et al*., 2019).

Literature Review

Computational thinking (CT) is understood as a set of skills and attitudes that include problem decomposition, pattern recognition, abstraction, and algorithms. CT has received significant attention due to its potential in improving students' ability to think logically and systematically, and to solve complex problems in a structured manner (Aydeniz, 2018). In Indonesia, the Merdeka Curriculum is considered a progressive step in education that gives schools the freedom to design learning programs that suit students' needs and potential. This curriculum emphasizes the importance of character development and 21st-century skills, including CT, as part of holistic learning (Garvin *et al*., 2019). Previous studies have shown that the integration of CT into the elementary school curriculum has a positive impact on students' analytical and problem-solving abilities. The implementation of CT in elementary schools allows students to develop skills that are essential in today's digital world, such as the ability to analyze data, understand algorithms, and solve problems in innovative ways (Yeni *et al*., 2023). In addition, project-based approaches that integrate CT with other subjects such as mathematics and science have been shown to increase students' motivation and engagement in the learning process (Waterman *et al*., 2019).

Despite the abundant evidence supporting the integration of CT in primary education, significant challenges remain in its implementation. One of the main challenges is the lack of adequate training for teachers to teach CT concepts effectively. Studies have shown that the success of CT implementation is highly dependent on teachers' competence in integrating these concepts into the existing curriculum (Dagienė *et al*., 2022). Therefore, the development of appropriate learning modules, as well as ongoing training for teachers, is crucial. In the context of education in Indonesia, several initiatives have been undertaken to support the development of CT skills through training and workshops. For example, the Learning Workshops conducted by Elfiadi *et al*. (2023) and Wali *et al*. (2023) have focused on improving the quality of teaching with a student-centered approach and the application of CT in various subjects. These workshops aim to equip teachers with the knowledge and skills needed to implement more effective and innovative teaching methods (Elfiadi *et al*., 2023; Wali *et al*., 2023). Furthermore, the literature shows that the development of learning modules specifically designed to teach CT can improve students' understanding of complex computing concepts. These modules often include interactive activities that not only reinforce theoretical understanding but also provide opportunities for students to apply their knowledge in real-world situations (Bocconi *et al*., 2016). The book "Education for All" by Anggreni *et al*. (2023) also emphasizes the importance of inclusive solutions in the learning environment, which is relevant to efforts to integrate CT into the elementary school curriculum. The book discusses strategies to ensure that all students, regardless of their background, can access and benefit from high-quality education, including CT learning (Anggreni *et al*., 2023). The development and implementation of comprehensive CT modules, as well as the importance of ongoing teacher training to ensure that students can fully utilize the potential offered by CT in basic education. These efforts will not only improve the quality of education, but also prepare students to face future challenges in a world increasingly dominated by digital technology.

Methodology

This research employs a Research and Development (R&D) approach, which aims to produce an educational product that is valid, practical, and effective. The R&D approach was chosen because it allows for the development of a product tailored to the specific needs of users, in this case, the teachers and students of primary schools implementing the Merdeka Curriculum. The process of developing the computational thinking learning module in this study involves several critical stages: needs analysis, module design and development, expert validation, field testing, and module revision based on the test results.

Needs Analysis
The first stage of this research is the needs analysis, which is conducted to gain a deep understanding of the specific challenges and needs faced in teaching computational thinking in primary schools. During this stage, the researchers conduct surveys and interviews with teachers and students from several primary schools that have implemented the Merdeka Curriculum. The surveys are designed to explore students' understanding of computational thinking concepts, while the interviews aim to delve deeper into the experiences and challenges faced by teachers in teaching these materials. Through this needs analysis, the researchers also seek to identify gaps between the ideal needs in teaching computational thinking and the realities of implementation in the field. The data obtained from this stage will form the basis for designing a learning module that is relevant and aligned with the educational context in primary schools. The data collection methods involve the use of structured and semi-structured questionnaires, as well as in-depth interviews, to obtain a comprehensive picture of the needs and expectations of module users.

Module Design and Development
Once the needs are identified, the next stage is the design and development of the computational thinking learning module. This module is designed to include various interactive activities and exercises aimed at developing computational thinking skills in primary school students. The design of the module is based on the principles of active, student-centered learning, and integrates elements of information and communication technology (ICT) that are relevant to the Merdeka Curriculum. The learning module is designed to be integrated with other subjects taught in primary schools, such as mathematics and science, to facilitate students' understanding through an interdisciplinary

approach. Each activity in the module is developed with consideration of the students' cognitive levels and is aligned with the current curriculum. The development process also involves selecting and creating supporting educational media, such as student worksheets and teacher guides, designed to facilitate the application of computational thinking concepts in the classroom.

Expert Validation and Field Testing

After the learning module is fully developed, the next stage is validation by experts in the field of education, particularly those experienced in teaching computational thinking and the Merdeka Curriculum. Expert validation aims to ensure that the developed module meets the applicable educational standards and to evaluate its practicality and effectiveness in teaching computational thinking. Field testing is conducted following expert validation. This testing involves implementing the module in several primary schools that are part of the study. The teachers and students participating in the field test provide valuable feedback on their experiences using the module. Data collection during the field test includes classroom observations, interviews with teachers, and evaluation tests to measure students' understanding of the computational thinking concepts taught.

Revision and Implementation

Based on the results of the validation and field testing, the learning module will be revised to address any weaknesses or deficiencies identified. This revision is carried out by considering feedback from the experts and field experiences gained during the testing. The goal of the revision is to ensure that the final module is not only effective in enhancing students' computational thinking skills but also user-friendly for teachers in the field. Once the revision process is complete, the improved learning module will be implemented more broadly in the schools that are the subjects of the study. This implementation will also be accompanied by continuous evaluation to monitor the module's long-term effectiveness. This evaluation is crucial to ensure that the module can significantly contribute to improving the quality of education in primary schools, particularly in the development of 21st-century skills emphasized in the Merdeka Curriculum.

Results and Discussion

Results

The development of the computational thinking learning module based on the Merdeka Curriculum for primary schools followed several stages as designed in the research methodology. The resulting module comprises various components, including teaching materials, interactive activities, exercises, and evaluations. Each component is designed to support the development of computational thinking skills among primary school students.

Description of the Developed Module

The learning module consists of several chapters, each addressing fundamental concepts of computational thinking, such as problem decomposition, pattern recognition, abstraction, and algorithms. Each chapter is supplemented with real-life examples relevant to the students' everyday experiences, along with interactive activities designed to practice the concepts learned. For instance, in the chapter on problem decomposition, students are guided to break down complex problems into simpler parts. An example activity provided is breaking down the steps of making a sandwich into smaller, easy-to-follow instructions. In the chapter on pattern recognition, students are tasked with identifying patterns in a series of numbers or shapes and applying these patterns to new situations.

Expert Validation Results

The developed module was subsequently validated by several education experts experienced in teaching computational thinking and the Merdeka Curriculum. The experts provided highly positive feedback regarding the relevance and effectiveness of the module in teaching computational thinking. Several suggestions for improvement were also given, particularly concerning the simplification of certain concepts to make them easier for primary school students to understand.

Table 1. Expert Validation Results

Module Component	Rating (1-5)	Improvement Suggestions
Teaching Materials	4.5	Simplification of the decomposition concept
Interactive Activities	4.7	Addition of varied activities for pattern recognition
Exercises	4.6	Enhancement of evaluation questions to match difficulty levels
Evaluation	4.8	Addition of evaluation instruments for practical skills

The average expert ratings indicate that the developed module is of very high quality and can be effectively used in the teaching process in primary schools.

Field Testing

After validation, the learning module was field-tested in several primary schools that implement the Merdeka Curriculum. This testing involved a number of teachers and students from grades 4 and 5. During the field test, teachers implemented the module across several learning sessions, and students participated in the designed activities and exercises. Feedback from teachers indicated that the module was highly effective in systematically and engagingly teaching computational thinking concepts. Teachers appreciated the interactive activities, which made students more engaged and active in learning. Some teachers also noted that the module helped students develop analytical and problem-solving skills, as reflected in the improvement of students' evaluation results.

Table 2. Field Testing Results

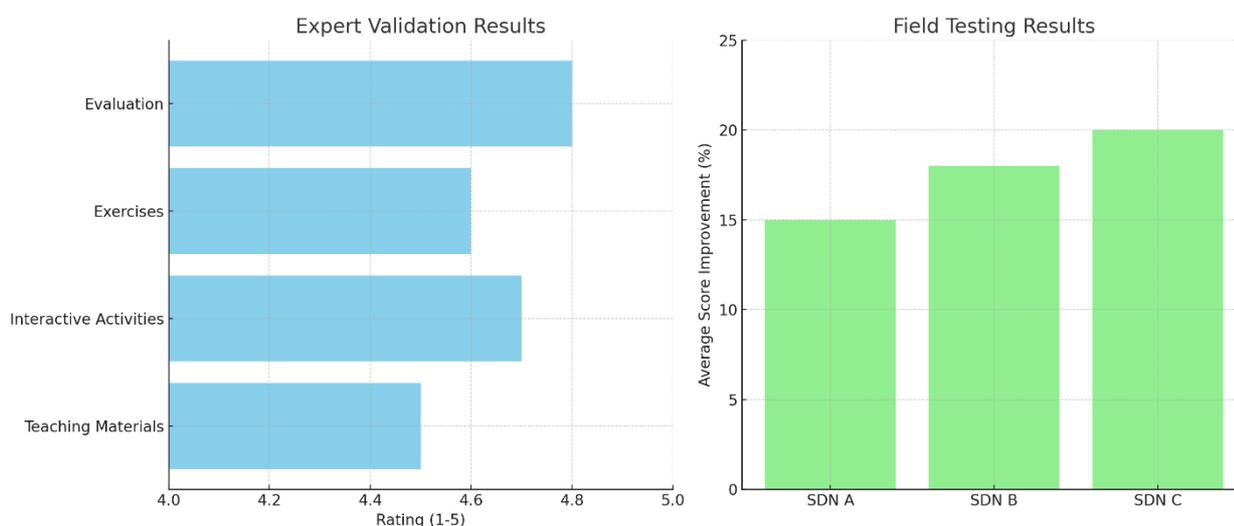| School	Number of Students	Average Score Improvement	Teacher Feedback
SDN A	30	15%	The module helps students understand concepts well
SDN B	28	18%	Interactive activities increase student engagement
SDN C	25	20%	Exercises are effective in evaluating student understanding

Figure 1. Field Testing Results

The first graph depicts the ratings given by education experts on four key components of the module: Teaching Materials, Interactive Activities, Exercises, and Evaluation. The ratings are on a scale of 1 to 5, where 5 indicates the highest level of quality. The data reveal that all components received high ratings, with scores ranging from 4.5 to 4.8. The Evaluation component received the highest rating at 4.8, suggesting that the experts found the assessment tools in the module particularly robust and effective for evaluating students' practical skills. Interactive Activities were also rated highly at 4.7, indicating that the module's approach to engaging students actively in the learning process was

well-regarded. The slight variance in ratings reflects minor suggestions for improvement, particularly in simplifying certain concepts within the teaching materials to ensure they are accessible to primary school students. The second graph illustrates the average score improvement of students across three schools (SDN A, SDN B, and SDN C) following the implementation of the module. The results show a positive impact, with all schools reporting an increase in student performance, ranging from 15% to 20%. SDN C exhibited the most significant improvement at 20%, suggesting that the module was particularly effective in enhancing students' understanding and application of computational thinking concepts in this school. The consistent improvement across all schools reinforces the module's overall effectiveness in contributing to students' academic development in computational thinking.

Discussion

The findings of this study indicate that the computational thinking learning module based on the Merdeka Curriculum developed for primary school students has proven effective in enhancing students' computational thinking abilities. The observed improvement in students' evaluation scores suggests that the module successfully deepened their understanding of computational thinking concepts, aligning with previous research that underscores the importance of integrating computational thinking into primary education to boost students' analytical and problem-solving skills (Aydeniz, 2018). The content presented in the module is crafted in simple language with examples that are directly relevant to the students' daily lives. This approach aligns with best practices in educational material design, which emphasize the importance of contextual learning to make abstract concepts more accessible (Garvin *et al.*, 2019). The module's content has been adjusted based on expert feedback to further simplify complex concepts, ensuring that the material is child-friendly and appropriate for primary school students.

The interactive activities included in the module have proven to be effective in increasing student engagement. Activities such as breaking down tasks into smaller instructions, identifying patterns, and creating simple algorithms have made students more active and interested in learning. This is consistent with findings from previous studies that highlight the value of interactive learning in making abstract concepts more concrete and understandable for young learners (Yeni *et al.*, 2023). Teachers also observed that these activities helped students grasp abstract concepts more concretely. The exercises included in the module are designed to thoroughly evaluate students' understanding. These exercises cover a range of difficulty levels, from simple to complex, allowing teachers to assess the extent of students' comprehension of the material taught. This approach aligns with effective assessment strategies that recommend varying levels of question difficulty to capture a more accurate measure of student understanding (Bocconi *et al.*, 2016).

The module's evaluation system includes both formative and summative assessments. Formative assessments are conducted throughout the learning process to monitor students' progress, while summative assessments are administered at the end of each chapter to gauge students' overall understanding. The results from these evaluations demonstrate that students showed improved comprehension after engaging with the module. This dual approach to assessment is supported by educational research, which advocates for ongoing assessments to provide a clearer picture of student learning and progress (Waterman *et al.*, 2019). Despite the module's effectiveness, several implementation challenges were identified. One of the main issues reported by teachers was the limited time available to fully implement the module. Additionally, the lack of sufficient facilities and resources in some schools posed challenges for incorporating technology-based learning into the computational thinking curriculum. These challenges are not uncommon and have been highlighted in previous research, which suggests that successful implementation of new educational modules often requires adequate time and resources (Dagienė *et al.*, 2022).

Based on the findings and challenges encountered, several recommendations for future research and practice are proposed. Intensive training programs should be organized for teachers to enhance their understanding of computational thinking and how to teach it effectively. This aligns with previous studies that highlight the importance of teacher professional development in the successful integration of new curricula (Wali *et al.*, 2023). Schools should be equipped with better facilities and resources to support the use of technology in learning computational thinking. Investing in infrastructure is essential for the successful adoption of innovative teaching methods (Elfiadi *et al.*, 2023). Future research should focus on developing advanced modules that cover more complex computational thinking

concepts for higher-grade students. This step is necessary to continue building students' skills as they progress through their education (Anggreni *et al*., 2023). Conducting longitudinal studies to measure the long-term impact of the module on students' computational thinking skills is recommended. Long-term studies provide valuable insights into how sustained exposure to computational thinking education influences student outcomes over time (Nurbaya *et al*., 2023). These recommendations aim to address the current challenges and further enhance the effectiveness of computational thinking education in primary schools.

Conclusion

This research aimed to develop a computational thinking learning module aligned with the Merdeka Curriculum for primary school students. Through a Research and Development (R&D) approach, the study successfully produced a module encompassing several key components, including teaching materials, interactive activities, exercises, and evaluations. The findings indicate that this module is effective in enhancing the computational thinking skills of primary school students. The development process involved multiple stages: needs analysis, module design and development, expert validation, and field testing. The needs analysis, conducted with the participation of teachers and students, identified critical challenges and requirements in teaching computational thinking. The results of the needs analysis highlighted an urgent need for structured and interactive learning materials to effectively teach computational thinking concepts. Based on these findings, the module was designed with real-life examples and relevant activities to facilitate students' understanding. Expert validation of the developed module indicated that it is of high quality and relevant for use in educational settings. Experts provided positive feedback on the structure and content of the module, along with suggestions for further refinement. Field testing conducted in several primary schools showed that the module was well-received by both teachers and students. Evaluation results demonstrated a significant improvement in students' understanding of computational thinking concepts after using the module. The module proved to be effective in enhancing students' computational thinking skills, with interactive activities engaging students more deeply in the learning process, while the exercises and evaluations provided clear insights into students' comprehension levels. Despite the positive outcomes, some challenges were encountered during implementation. The primary obstacles included limited time and resources available in some schools, which hindered the full deployment of the module. Therefore, future research should focus on providing intensive training for teachers to improve their understanding and ability to teach computational thinking. Additionally, enhancing school facilities and resources is essential to support the integration of technology in learning. This research successfully achieved its goal of developing an effective computational thinking learning module that aligns with the Merdeka Curriculum. The module not only improved students' understanding of computational thinking concepts but also aided teachers in designing more engaging and interactive teaching strategies. Consequently, this research makes a significant contribution to improving the quality of primary education in Indonesia and preparing a generation of young people with strong analytical and problem-solving skills.

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