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Enhancing High School Students' Problem-Solving Skills Through Digital Module Integration

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Abstract

In programming education, problem-solving skills are essential for high school students to understand and apply coding concepts effectively. Traditional teaching methods often lack interactive elements, making it difficult for students to engage with complex programming concepts. Digital modules offer an interactive and structured learning approach that can enhance students' engagement and cognitive abilities in problem-solving. This study aimed to evaluate the effectiveness of digital modules in enhancing high school students' problem-solving skills in programming education. A quasi-experimental design with pre-test and post-test assessments was used to compare the outcomes between experimental and control groups. The study involved 60 high school students, divided into two groups: 30 students in the experimental group using digital modules and 30 in the control group relying on conventional methods such as lectures and PowerPoint presentations. The digital module was designed with structured tasks and collaborative coding activities to support analytical thinking and practical problem-solving. Data analysis, including independent sample t-tests and N-Gain calculations, demonstrated a significant improvement in the experimental group's problem-solving performance. The experimental group achieved an N-Gain score of 85.2%, categorized as "high effectiveness," highlighting the module's ability to enhance critical problem-solving skills. These findings indicate that digital modules are effective tools for improving problem-solving competencies in programming education. This study suggests that integrating digital modules into teaching practices can foster student engagement and skill development, addressing the needs of modern education. Further research is recommended to explore their long-term impact and application across different subjects.

Keywords: Digital Modules; Problem-solving Skills; Programming Education; Collaborative Coding

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INTRODUCTION

The rapid advancement of technology in recent years has profoundly transformed various sectors, including education. As technology continues to evolve, its integration into educational practices has become not only a necessity but also a fundamental driver of innovation in teaching and learning. Traditional approaches are increasingly supplemented or replaced by digital tools, such as digital modules, which offer significant advantages in enhancing learning outcomes. Digital modules have been recognized as effective tools for enabling personalized learning experiences by allowing students to access educational

content anytime and anywhere. This fosters flexibility and inclusivity, as well as supports diverse learning needs, including those of students with disabilities or specific preferences (S. Y. Chen & Wang, 2019; Moon & Park, 2021). Moreover, they provide an interactive platform where students can engage with content more effectively compared to conventional methods.

In an era where 21st-century competencies such as problem-solving, critical thinking, and digital literacy are paramount, educators face increasing pressure to equip students with skills relevant to real-world challenges. Among these competencies, problem-solving skills have gained particular attention due to their relevance in addressing real-life challenges. However, current educational practices often fail to adequately develop these skills, leaving a significant gap in students' preparedness for future endeavors (Rokhani & Purnami, 2021). This underscores the pressing need for innovative teaching strategies and tools, including digital modules, which are tailored to bridge existing gaps in educational practices. Such modules not only support personalized and inclusive learning but also enhance engagement and effectiveness through features like interactivity, adaptability, and the integration of multimedia content. Additionally, the utilization of digital resources encourages critical thinking and problem-solving skills by providing students with hands-on, experiential learning opportunities (Camilleri & Camilleri, 2017; Edwards, 2015; Rajan & Pandit, 2022; Tshukudu et al., 2022).

Problem-solving is a crucial 21st-century skill that enables students to approach real-world challenges with creativity, logical reasoning, and adaptability. Research highlights that integrating Science, Technology, Engineering, and Mathematics (STEM)-based teaching materials into digital learning environments enhances students' ability to analyze and resolve complex issues (Camilleri & Camilleri, 2017; Solihah et al., 2023). At the high school level, structured approaches to problem-solving—such as identifying issues, evaluating alternatives, and implementing solutions—play a significant role in preparing students for higher education and future careers (Rajan & Pandit, 2022). Given these benefits, digital modules provide an interactive platform to reinforce these essential problem-solving skills.

ICT-based tools, particularly digital modules, create an interactive and learner-centered environment where students engage with structured, problem-based scenarios. Research highlights that problem-based learning (PBL) not only enhances cognitive and problem-solving abilities but also develops collaborative skills for addressing complex challenges (Nicholus et al., 2023; Ramdani et al., 2023). By incorporating PBL into digital modules, students can apply theoretical knowledge to real-world problem-solving contexts, making learning more practical and engaging (Edwards, 2015).

As global challenges grow more complex, the ability to solve problems creatively and effectively has become indispensable. Without a strong foundation in problem-solving, students risk being unprepared for the demands of the modern workforce and society. Based on these considerations, this study seeks to investigate the role of digital modules in fostering students' problem-solving skills in programming education. Specifically, the research is guided by the following questions: 1) Can the use of digital modules improve students' problem-solving skills? 2) To what extent can digital modules enhance students' problem-solving

skills in programming? And 3) How effective are these modules in enhancing students' ability to apply problem-solving frameworks in programming tasks?

The reality in the field highlights several challenges in the current ICT learning environment. The lack of real-world simulation in digital modules makes it difficult for students to connect theory with daily practice and the lack of effective collaborative features. Based on observations at SMA ABBS Surakarta, instructional practices in the 10th-grade ICT program still rely heavily on traditional lectures, collaborative coding sessions, and limited use of digital modules. A survey of 172 students revealed that 93% believe interactive digital modules significantly enhance their understanding of programming concepts. This finding aligns with studies showing that interactive platforms and digital collaboration tools foster higher engagement levels and better problem-solving outcomes among students (Gopinathan et al., 2022; Greener, 2022). Despite this, classroom practices in ICT education often rely heavily on PowerPoint presentations, which, while informative, lack the interactivity necessary to fully engage students and support hands-on learning. Furthermore, students reported spending 4-6 hours daily on smartphones and laptops, highlighting the potential of these devices as platforms for interactive and effective learning experiences.

Teachers also emphasized the urgent need for more advanced learning tools, citing the limitations of existing resources and the reliance on static presentations. They noted that current practices lack the interactivity and problem-solving orientation necessary for preparing students to tackle real-world challenges. This underscores the need for innovative solutions, such as digital modules, which not only simulate real-world programming tasks but also actively engage students in structured problem-solving processes. Research highlights that interactive learning tools, when designed with task-based scenarios and immediate feedback, can significantly improve students' ability to analyze, synthesize, and apply solutions to complex challenges (MacDougall, 2022). By addressing these gaps, ICT education can transition from traditional instruction to a more dynamic, student-centered approach, empowering learners to build essential 21st-century skills.

Digital modules provide students with an interactive platform to develop programming and problem-solving skills. By integrating features such as real-time feedback, structured tasks, and interactive exercises, these tools enable students to analyze and solve programming challenges more effectively (Kane & Baggaley, 2002; Rennstich, 2019). Moreover, they address the limitations of traditional teaching methods by fostering active engagement and collaboration (Camilleri & Camilleri, 2017).

Collaborative coding enhances teamwork and active learning, which are essential in mastering programming concepts. Digital modules support this by providing shared coding spaces, peer reviews, and group problem-solving tasks, fostering both technical and interpersonal skills (Kane & Baggaley, 2002; Rennstich, 2019). Additionally, these tools allow teachers to monitor group dynamics and provide targeted guidance, ensuring equitable participation and optimal learning outcomes.

Digital modules enhance problem-solving skills by integrating interactive features such as collaborative coding, real-time feedback, and task-based scenarios (Rennstich, 2019). Collaborative coding, as a key feature, fosters teamwork and

problem-solving, emphasizing active engagement and critical thinking in solving real-world challenges. hese structured activities promote active learning, critical thinking, and teamwork, helping students apply their knowledge in real-world contexts (Xu et al., 2023).

The advancements of the fourth industrial revolution, marked by the integration of digital devices and internet networks, present tremendous opportunities for enhancing education through technology. Digital modules, as an innovation of this era, offer a dynamic solution to traditional learning challenges by providing interactive and effective tools for both teachers and students. While students have access to vast information via digital platforms, educators play a pivotal role in curating high-quality and relevant materials to ensure meaningful learning experiences (Sari et al., 2020). Research highlights that digital modules can significantly enhance students' cognitive and social capacities by fostering collaboration and problem-solving through structured, task-based activities. These modules are also proven to improve learning outcomes and promote consistent knowledge retention, as demonstrated in web-based module studies (Ben Fadel & McAleer, 2020; Xu et al., 2023). Moreover, these modules are proven to enhance student motivation, engagement, and academic performance, demonstrating their effectiveness in fostering a dynamic learning environment tailored to 21st-century educational demands (G. Chen et al., 2024; Jiang, 2024). By integrating technology with pedagogy, digital modules empower educators to create impactful, student-centered learning.

Digital modules, supported by educators' digital competencies, are effective in enhancing students' cognitive, affective, and psychomotor skills. They also help develop collaboration and adaptability as complementary traits that strengthen students' problem-solving abilities, essential for navigating digital learning environments (Sarva et al., 2023). However, their effectiveness still relies on teachers' strategies in integrating technology. By tailoring digital modules to students' needs, educators can create engaging and active learning environments. These modules integrate problem-solving tasks through multimodal strategies that enhance engagement and actively involve students in analyzing and resolving challenges (Mohamad Hsbollah & Hassan, 2022; Vrzakova et al., 2020). This integration transforms classrooms into dynamic spaces, preparing students for real-world challenges.

The use of digital modules assumes that students engage with them not only for completing assignments but also to develop problem-solving skills, collaborate effectively, and experience meaningful learning. These modules encourage critical thinking and teamwork while providing structured, task-based activities tailored to students' needs (Rennstich, 2019; Xu et al., 2023). Research from various educational contexts demonstrates that digital modules can significantly improve academic performance and be adapted to multiple subjects and competencies (Sarva et al., 2023). However, their implementation is still not widespread, particularly in integrating collaborative coding as a feature. Therefore, this study aims to explore the academic benefits provided by using digital modules to foster problem-solving and collaborative skills.

Learning with digital modules enables students to extend their problem-solving activities beyond the classroom, providing flexibility to engage with content

anytime and anywhere. These modules foster self-directed learning by offering structured tasks, real-time feedback, and interactive scenarios, enabling students to develop problem-solving skills through reflective and experiential processes (Hmelo-Silver, 2004; Morris-Eyton & Pretorius, 2023). Digital modules, designed with a constructivist approach, facilitate the active participation of learners, enabling them to apply knowledge in meaningful, real-world contexts while fostering critical thinking and independent problem-solving (Bosancic & Matijevic, 2020; Gruba & S⊘ndergaard, 2001; Neo et al., 2007). With the rapid adoption of digital technologies, the integration of collaborative coding as a supplementary feature supports teamwork and enhances the problem-solving process. Survey indicates that digital modules equipped with interactive features and multimodal strategies significantly enhance students' computational thinking and problem-solving abilities by fostering self-regulated learning and engagement through structured and contextualized tasks (Nasrulloh et al., 2024; Olvet & Sadigh, 2023; Rodríguez del Rey et al., 2021).

In the context of using digital modules for educational purposes, several previous studies have demonstrated their effectiveness in enhancing problem-solving skills. Research on the use of digital modules in teaching programming has shown significant improvements in students' ability to identify, analyze, and solve coding problems compared to traditional methods (Hmelo-Silver, 2004; Nasrulloh et al., 2024). These modules provide structured environments that encourage learners to approach problems systematically, fostering both analytical and practical skills.

Other studies emphasize how digital modules, designed with structured tasks and problem-solving frameworks, foster active engagement and enhance students' creative problem-solving skills, particularly in subjects requiring critical thinking, such as mathematics and science (AYTEKİN & TOPÇU, 2024). Features like interactive exercises, real-time feedback, and contextualized problem-solving tasks enable students to bridge the gap between theory and application, making learning more impactful and relevant. Moreover, the integration of problem-solving-based e-modules has been shown to significantly enhance students' critical thinking and problem-solving abilities. These e-modules, when tailored to specific challenges and presented in interactive formats, promote active engagement and independent exploration (Pitorini et al., 2024; Sunarya et al., 2024). Such findings underscore the potential of digital modules to create meaningful learning experiences, equipping students with essential skills for both academic success and real-world challenges.

Building on these findings, further research is needed to develop digital modules specifically designed to enhance problem-solving skills in programming education. While digital modules have been shown to foster engagement and critical thinking, programming-specific applications often lack structured, interactive frameworks essential for skill development. Many current resources rely on static content, limiting their ability to simulate real-world problem-solving tasks effectively. Evaluations also tend to focus on variables like motivation and engagement, overlooking deeper cognitive and analytical impacts. This gap highlights the need for innovative digital modules that integrate contextualized problem-solving tasks tailored to programming. Addressing these challenges offers

significant opportunities to advance digital modules as effective tools for equipping students with essential problem-solving skills.

A key consideration for educators is to begin adopting and adapting technological advancements as innovative learning tools, particularly in programming education, which has traditionally relied on lecture-based methods and static materials. With students increasingly accustomed to using digital devices in their daily lives, educators have an opportunity to innovate by employing digital modules that incorporate structured problem-solving tasks. Such modules leverage students' familiarity with technology while fostering critical thinking and problem-solving skills through engaging, hands-on activities. This study aims to address the need for more effective problem-solving-focused tools in programming education by developing and evaluating digital modules. Grounded in the findings of previous research, which have shown that digital modules can enhance both engagement and cognitive development, this study seeks to determine whether these tools can significantly improve students' problem-solving abilities. Additionally, the research evaluates the effectiveness of these modules in bridging the gap between theoretical concepts and practical applications.

METHODS

The digital module product developed in this study has undergone a feasibility test by media experts, material experts, and programming teachers. The results of the feasibility evaluation place the product in the appropriate category for use as an interactive learning tool in teaching programming. In this study, a quantitative approach was adopted to assess the effectiveness of the digital module in enhancing students' problem-solving abilities (Jiang, 2024). The primary purpose of this study is to evaluate the effectiveness of the digital module in improving students' problem-solving abilities through structured tasks and interactive learning experiences. This study employed a quasi-experimental method with a nonequivalent control group design, which is commonly used in educational research to compare learning outcomes between experimental and control groups (Martínez-Borreguero et al., 2020).

The study involved 60 students selected through cluster sampling, with 30 students in the experimental group and 30 in the control group. The experimental group used digital modules designed to enhance problem-solving skills, while the control group used conventional methods like lectures and PowerPoint slides. This comparison aimed to evaluate the effectiveness of digital modules in improving students' problem-solving abilities. Consider the experimental research design as follows:

Table 1. Experimental design to improve students' problem-solving skills

Group	Pretest	Treatment	Posttest
Experimental Group	O1	X1	O2
Control Group (without treatment)	O3	X2	O4

Explanations:
O1 : Pretest for the experimental group.
O3 : Pretest for the control group.

O2 : Posttest for the experimental group.
O4 : Posttest for the control group.
X1 : Treatment using digital modules.
X2 : Conventional method (e.g., lectures, PowerPoint slides).

The test was used as the primary instrument in this study to collect data on high school students' problem-solving abilities. Prior to conducting the t-test, assumptions of normality and equal variance were tested and met to ensure the validity of the analysis. The instrument was developed and adapted from several relevant studies on problem-solving assessments in educational contexts (Hmelo-Silver, 2004; Polya & Pólya, 2014). The test consists of structured questions designed to measure students' ability to analyze problems, develop strategies, and implement solutions in a systematic manner. The following are the instrument grids and indicators used in this study. Table 2 presents an instrument grid for students' problem-solving ability tests.

Table 2. Instrument Grid for Students' Problem-Solving Ability Tests

No	Indicator	Number of Items
1	Understanding the problem	4
2	Planning a solution	4
3	Implementing the solution	3
4	Re-checking the results	3
	Total	14

The instrument to measure students' problem-solving abilities included 16 items based on four indicators: understanding the problem, planning a solution, implementing the solution, and re-checking the results. A validity test using SPSS version 25 showed 14 valid items and 2 invalid items. A reliability test with Cronbach Alpha was also conducted to ensure the instrument's consistency. The results of the reliability test are presented in Table 3.

Table 3. Instrument Reliability Test Results

Description	Details
Reliability Test Method	Cronbach's Alpha
Reliability Coefficient	0.825
Number of Valid Items	14

Table 3 presents the results of the instrument reliability and validity tests. The reliability analysis using Cronbach's Alpha produced a value of 0.825, which exceeds the acceptable threshold, indicating strong internal consistency. For validity, the r-count values of the 14 valid items were greater than the r-table value (0.361) for a sample size of 30 students (N = 30). This confirms that the instrument is both valid and reliable for measuring students' problem-solving abilities.

The independent sample t-test was used to analyze the pre-test and post-test scores from both the experimental and control groups. This method assessed the significance of differences in students' problem-solving abilities after using the digital module. The t-test results were evaluated based on the significance value (Sig. 2-tailed) to test the research hypothesis. The criteria for decision-making were as follows:

If the value of Sig. (2-tailed) < 0.05, then H0 is rejected, and Ha is accepted.
If the value of Sig. (2-tailed) > 0.05, then H0 is accepted, and Ha is rejected.

The formulated hypotheses are:

- H0: There is no significant difference in the average pre-test and post-test results between the experimental and control groups.
- Ha: There is a significant difference in the average pre-test and post-test results between the experimental and control groups.

Further data analysis was conducted to measure the effectiveness of the digital module in improving students' problem-solving abilities using the N-Gain Score test. To minimize the influence of potential confounding variables, external factors such as prior knowledge, learning environment, and student motivation were considered and controlled where possible. The N-Gain Score test was applied to compare the pre-test and post-test results of both the experimental and control groups.The effectiveness of the digital module was evaluated based on the following table 4:

Table 4. N-Gain category for the basis of Product Effectiveness assessment

N-Gain Score (%)	Category
≥ 0.7	High effectiveness
0.3 - 0.7	Moderate effectiveness.
< 0.3	Low effectiveness

(Sukarmin & Sani, 2023)

RESULTS & DISCUSSION

The digital module developed for this study was implemented in the experimental class and integrated into the teaching and learning process. This module aimed to improve students' problem-solving abilities by providing structured, interactive tasks. To evaluate its effectiveness, the experimental class utilized the digital module, while the control class relied on conventional teaching methods. The primary objective was to compare the problem-solving outcomes between the two groups. In addition to measuring problem-solving performance through test scores, the assessment criteria were expanded to include students' analytical reasoning, adaptability in approaching problems, and collaboration skills. Before proceeding to analyze the impact of the digital module, data collected during the study were subjected to normality and homogeneity tests. These tests were conducted to ensure that the data met the assumptions required for further statistical analysis. The results of the normality and homogeneity tests are presented in Table 5.

Table 5. Normality Test Results

Variable	Class	Statistic	Df	Sig.
Problem-Solving Skills	Pretest Experiment	0.945	30	0.112
	Posttest Experiment	0.905	30	0.058
	Pretest Control	0.970	30	0.240
	Posttest Control	0.920	30	0.076

The normality of the data was assessed using the Shapiro-Wilk test, which is recommended for sample sizes less than 50 (N < 50). The results of the test, as shown in Table 5, indicate that all significance values (Sig.) were greater than 0.05. This confirms that the data for both the experimental and control groups, including pre-test and post-test

scores, are normally distributed. Meeting the normality assumption ensures that further statistical analyses, such as the homogeneity test and independent sample t-test, can be conducted with valid results. Following the normality test, a homogeneity test was conducted using Levene's test to evaluate whether the variances between the experimental and control groups were homogeneous, as shown in Table 6.

Table 6. Homogeneity test results

Problem-Solving Skills	Levene Statistic	Df1	Df2	Sig.
Based on Mean	1.745	1	58	0.139
Based on Median	1.582	1	58	0.182

According to Table 6, the variation in problem-solving abilities between the experimental and control groups is homogeneous, as indicated by the significance value from the homogeneity test based on the mean being 0.139 (> 0.05). The data was analyzed using an independent t-test after meeting the prerequisite tests for normality and homogeneity. The normality test confirmed that the data were normally distributed, and the homogeneity test indicated that the variances of the experimental and control groups were homogeneous. Following these confirmations, the independent t-test was employed to evaluate the impact of the digital module on students' problem-solving abilities. Table 7 presents the results of the t-test analysis, highlighting the effectiveness of the digital module in improving students' problem-solving skills.

Table 7. Acquisition of independent t - test results

Results of students' problem-solving abilities	t	Df	Sig. (2-tailed)	Mean diff	Std. error diff	95% Confidence interval of the difference	
						Lower	Upper
Equal Variances Assumed	7.452	58	0.000	15.25	2.051	11.145	19.355
Equal Variances Not Assumed	7.452	55.345	0.000	15.25	2.063	11.130	19.370

Referring to the results presented in Table 7, the independent sample t-test analysis revealed a significant difference in problem-solving abilities between the experimental and control groups, with a Sig. (2-tailed) value of 0.000 (< 0.05). This finding forms the basis for decision-making, leading to the rejection of H0 and acceptance of Ha. Thus, it can be concluded that there is a significant difference in the average problem-solving skills between students in the experimental group, who used the digital module during the learning process, and those in the control group, who relied on conventional teaching methods. The results indicate that the developed digital module effectively enhances students' problem-solving abilities. However, this study does not compare the module with other existing e-learning platforms or similar interactive learning tools. Future research could explore how this digital module performs relative to other digital learning solutions to provide deeper insights into its effectiveness in various learning contexts. To further evaluate the level of effectiveness of the digital module, an N-Gain Score analysis was conducted. The results of the Gain Score analysis, which compare the problem-solving test results of the experimental and control groups, are presented in Table 8.

Table 8. N-Gain Score Results

Group	Mean N-Gain (%)	Max N-Gain (%)	Min N-Gain (%)
Experimental Group	85.2	100	50
Control group	55.7	98	42

According to the N-Gain test calculations presented in Table 8, the average N-Gain value for the experimental class is 85.2%, placing it in the highly effective category. In contrast, the control class achieved an average N-Gain score of 55.7%, which falls under the moderately effective category. These results demonstrate that the use of digital modules significantly enhances students' problem-solving abilities compared to conventional teaching methods. Thus, it can be concluded that the integration of digital modules into the learning process is a powerful tool for fostering students' problem-solving skills and supporting effective learning outcomes.

Recent research highlights the significant role of digital modules in enhancing students' problem-solving abilities by providing structured and interactive learning environments (Nasrulloh et al., 2024). Digital teaching resources, particularly in the form of interactive modules, offer innovative approaches to education by incorporating multimedia elements such as text, images, and animations (Hmelo-Silver, 2004). These resources have been shown to improve students' understanding of complex concepts and support their cognitive development. Similarly, findings by Pitorini et al., (2024) highlight that problem-solving-based digital modules effectively enhance students' engagement and comprehension of abstract topics. This effectiveness is attributed to the design features of digital modules, which integrate interactive and multimodal components that facilitate deeper comprehension and encourage active learning. These findings align with the results of this study, which confirm the significant impact of digital modules on improving students' problem-solving skills in programming.

The digital module developed in this study was carefully designed to address the specific needs of high school students in programming courses, emphasizing the enhancement of problem-solving abilities. This module features structured learning pathways, real-time feedback, and interactive coding tasks that foster independent learning and deeper engagement with programming concepts (Nasrulloh et al., 2024). Its visually appealing design, incorporating multimedia elements such as videos, animations, and interactive exercises, aligns with the preferences of today's digital-native learners (Hmelo-Silver, 2004). Unlike traditional printed materials, digital modules, such as problem-based e-modules, provide interactive and dynamic learning experiences that enhance students' problem-solving abilities by fostering systematic approaches and critical analysis of complex scenarios (Munzil et al., 2022). Additionally, the adaptive nature of these modules allows teachers to personalize learning, making it easier to address diverse student needs while maintaining curriculum alignment (Pitorini et al., 2024). By integrating these modules, educators can present programming concepts in ways that are accessible and practical, facilitating a connection between abstract theories and real-world applications (Marnita et al., 2024). Furthermore, while collaboration is not the primary focus of this study, the module includes optional peer-learning activities that enhance engagement and foster better problem-solving outcomes through structured and interactive designs (Fradila et al., 2021). Research supports that tools designed for the digital generation must be interactive, engaging, and capable of fostering essential 21st-century skills such as critical thinking, creativity, and decision-making (Suhartini et al., 2023). This study demonstrates that the digital module successfully meets these criteria, providing an effective tool for improving students' problem-solving skills in programming and equipping them with the competencies needed for real-world challenges in a technology-driven era.

The supporting elements and applications of digital modules, particularly collaborative features and interactive content, play a vital role in fostering problem-solving skills among high school students. These modules are grounded in Vygotsky's theory of social constructivism, which emphasizes that meaningful learning occurs through collaborative problem-solving and peer interaction (Vygotsky, 1978). The design of the digital module in this study incorporates real-world scenarios, guided inquiry tasks, and

immediate feedback mechanisms, aligning with findings that digital-based interactive modules effectively support active learning, provide flexibility for independent learning, and engage students (Afriana et al., 2023; Syahri et al., 2024). Techniques such as using contextually relevant problems, step-by-step task breakdowns, and reflective learning checkpoints ensure that students not only solve problems but also critically evaluate their approaches. However, this study has limitations, particularly in focusing only on a narrow set of indicators to measure problem-solving skills, such as analyzing and synthesizing, while neglecting other dimensions like creativity, adaptability, and collaboration. Additionally, the short-term implementation of the digital module does not provide insight into its long-term impact on students' cognitive and affective development. Further studies should expand the scope of indicators used to measure problem-solving skills comprehensively and explore how these modules influence other 21st-century skills, including critical thinking and teamwork. Moreover, since this study focuses on high school students in programming, its findings may not be directly generalizable to other subjects or educational levels. Future research could explore how the digital module performs across different disciplines, age groups, and learning styles to provide a more comprehensive understanding of its effectiveness and adaptability. Examining these factors can further enhance the scalability and sustainability of digital modules as transformative tools in modern education.

CONCLUSION

Improving students' problem-solving skills is a critical aspect of preparing them for programming education in the digital era. This study demonstrates that the use of a digital module tailored for programming lessons significantly supports the development of students' ability to analyze and solve problems systematically. The module provides structured activities that guide students through the process of identifying issues, formulating solutions, and applying their knowledge in practical contexts. Results from the study show notable improvements in students' problem-solving performance, indicating that the module is an effective tool for enhancing these essential skills. However, it is important to acknowledge that this study was conducted within a specific educational setting and focused on high school students in programming courses, which may limit the generalizability of the findings to other subjects or educational levels. Future research could explore the module's applicability in different contexts to validate its broader effectiveness.

Beyond these findings, this study provides practical implications for educators, schools, and policymakers in integrating digital learning tools into programming education. Teachers can implement similar digital modules by embedding structured problem-solving activities into lesson plans, fostering student engagement through interactive exercises, and utilizing collaborative coding features to enhance peer learning. Schools can support the adoption of digital modules by providing necessary infrastructure, training educators in effective technology integration, and aligning these tools with competency-based curricula. Additionally, policymakers should consider the role of digital learning resources in national education strategies, promoting their development and implementation to equip students with essential 21st-century skills

This study lays the groundwork for further research into how digital modules can effectively improve students' problem-solving skills, particularly within programming education. Future investigations could explore the use of these modules in diverse educational settings or assess their impact using a wider range of indicators tailored to specific subjects. Beyond the application of digital modules, examining additional factors such as the role of instructional strategies, student engagement, or the integration of

collaborative learning could provide deeper insights into optimizing problem-solving abilities. Lastly, this study highlights the crucial role of digital learning tools in fostering students' ability to achieve essential competencies and meet the demands of modern education.

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REFERENCES

Afriana, M., Jayanti Syahfitri, & Fitriani, A. (2023). Development of Digital-Based Interactive Modules in Senior High School. *Quagga: Jurnal Pendidikan Dan Biologi*, *15*(2), 179–187. https://doi.org/10.25134/quagga.v15i2.5

AYTEKİN, A., & TOPÇU, M. S. (2024). Improving 6th Grade Students' Creative Problem Solving Skills Through Plugged and Unplugged Computational Thinking Approaches. *Journal of Science Education and Technology*, *33*(6), 867–891. https://doi.org/10.1007/s10956-024-10130-y

Ben Fadel, N., & McAleer, S. (2020). Impact of a web-based module on trainees' ability to interpret neonatal cranial ultrasound. *BMC Medical Education*, *20*(1), 489. https://doi.org/10.1186/s12909-020-02400-1

Bosancic, B., & Matijevic, M. (2020). Information as a construction. *Journal of Librarianship and Information Science*, *52*(2), 620–630. https://doi.org/10.1177/0961000619841657

Camilleri, M. A., & Camilleri, A. C. (2017). Digital Learning Resources and Ubiquitous Technologies in Education. *Technology, Knowledge and Learning*, *22*(1), 65–82. https://doi.org/10.1007/s10758-016-9287-7

Chen, G., Jin, Y., & Chen, P. (2024). Development of a platform for state online education services: Design concept based on meta-universe. *Education and Information Technologies*, *29*(17), 23605–23629. https://doi.org/10.1007/s10639-024-12792-y

Chen, S. Y., & Wang, J.-H. (2019). Human Factors and Personalized Digital Learning: An Editorial. *International Journal of Human–Computer Interaction*, *35*(4–5), 297–298. https://doi.org/10.1080/10447318.2018.1542891

Edwards, R. (2015). Software and the hidden curriculum in digital education. *Pedagogy, Culture & Society*, *23*(2), 265–279. https://doi.org/10.1080/14681366.2014.977809

Fradila, E., Razak, A., Santosa, T. A., Arsih, F., & Chatri, M. (2021). Development Of E-Module-Based Problem Based Learning (PBL) Applications Using Sigil The Course Ecology And Environmental Education Students Master Of Biology. *International Journal of Progressive Sciences and Technologies (IJPSAT, 27 (2), 673–682. Http://Ijpsat. Ijsht-Journals. Org*.

Gopinathan, S., Kaur, A. H., Veeraya, S., & Raman, M. (2022). The Role of Digital Collaboration in Student Engagement towards Enhancing Student Participation during COVID-19. *Sustainability*, *14*(11), 6844. https://doi.org/10.3390/su14116844

Greener, S. (2022). The tensions of student engagement with technology. *Interactive Learning Environments*, *30*(3), 397–399. https://doi.org/10.1080/10494820.2022.2048550

Gruba, P., & S∅ndergaard, H. (2001). A Constructivist Approach to Communication

Skills Instruction in Computer Science. *Computer Science Education*, *11*(3), 203–219. https://doi.org/10.1076/csed.11.3.203.3833

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Jiang, L. (2024). Digital Technology Boosts the Construction of English Smart Classroom in Colleges and Universities. *Applied Mathematics and Nonlinear Sciences*, *9*(1). https://doi.org/10.2478/amns-2024-0658

Kane, T., & Baggaley, J. (2002). Selection of Collaborative Tools. *The International Review of Research in Open and Distributed Learning*, *2*(2). https://doi.org/10.19173/irrodl.v2i2.45

MacDougall, C. (2022). 1297. Design and Testing of an Interactive Module for Improving Understanding and Application of Institutional Antibiograms. *Open Forum Infectious Diseases*, *9*(Supplement_2). https://doi.org/10.1093/ofid/ofac492.1128

Marnita, Nurdin, D., Prihatin, E., & Marwan. (2024). Developing Digital Module Using the TPACK Framework to Enhance Students' Life Skill. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 2956–2970. https://doi.org/10.29303/jppipa.v10i6.7635

Martínez-Borreguero, G., Perera-Villalba, J. J., Mateos-Núñez, M., & Naranjo-Correa, F. L. (2020). Development of ICT-Based Didactic Interventions for Learning Sustainability Content: Cognitive and Affective Analysis. *Sustainability*, *12*(9), 3644. https://doi.org/10.3390/su12093644

Mohamad Hsbollah, H., & Hassan, H. (2022). CREATING MEANINGFUL LEARNING EXPERIENCES WITH ACTIVE, FUN, AND TECHNOLOGY ELEMENTS IN THE PROBLEM-BASED LEARNING APPROACH AND ITS IMPLICATIONS. *Malaysian Journal of Learning and Instruction*, *19*. https://doi.org/10.32890/mjli2022.19.1.6

Moon, J., & Park, Y. (2021). A Scoping Review on Open Educational Resources to Support Interactions of Learners with Disabilities. *The International Review of Research in Open and Distributed Learning*, *22*(2), 314–341. https://doi.org/10.19173/irrodl.v22i1.5110

Morris-Eyton, H., & Pretorius, E. (2023). Cultivating a Digital Promise: Promoting Reflective and Reflexive Activities to Enhance Self-Directed Learning for the 21st Century. *Student Success*, *14*(1), 88–99. https://doi.org/10.5204/ssj.2659

Munzil, M., Affriyenni, Y., Mualifah, S., Fardhani, I., Fitriyah, I. J., & Muntholib, M. (2022). Development of problem based learning based e-modules in the form of flipbooks on environmentally friendly technology materials as an independent learning material for students especially online learning. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *10*(1), 37–46.

Nasrulloh, I., Ibrahim, N., & Solihatin, E. (2024). Improving Mathematical Problem-Solving Skills through the Development of Interactive Digital Modules. *Mosharafa: Jurnal Pendidikan Matematika*, *13*(1), 17–28.

Neo, M., Neo, T.-K., & Tai, X.-L. (2007). A constructivist approach to learning an interactive multimedia course: Malaysian students' perspectives. *Australasian Journal of Educational Technology*, *23*(4). https://doi.org/10.14742/ajet.1247

Nicholus, G., Muwonge, C. M., & Joseph, N. (2023). The Role of Problem-Based Learning Approach in Teaching and Learning Physics: A Systematic Literature Review. *F1000Research*, *12*, 951. https://doi.org/10.12688/f1000research.136339.1

Olvet, D. M., & Sadigh, K. (2023). Comparing the effectiveness of asynchronous e-modules and didactic lectures to teach electrocardiogram interpretation to first year US medical students. *BMC Medical Education*, *23*(1), 360. https://doi.org/10.1186/s12909-023-04338-6

Pitorini, D. E., Suciati, & Harlita. (2024). Students' Critical Thinking Skills Using an E-Module Based on Problem-Based Learning Combined with Socratic Dialogue. *Journal of Learning for Development*, *11*(1), 52–65.

https://doi.org/10.56059/jl4d.v11i1.1014
Polya, G., & Pólya, G. (2014). *How to solve it: A new aspect of mathematical method* (Vol. 34). Princeton university press.
Rajan, K. K., & Pandit, A. S. (2022). Comparing computer-assisted learning activities for learning clinical neuroscience: a randomized control trial. *BMC Medical Education*, *22*(1), 522. https://doi.org/10.1186/s12909-022-03578-2
Ramdani, Y., Kurniati Syam, N., Karyana, Y., & Herawati, D. (2023). Problem-based learning in research method courses: development, application and evaluation. *F1000Research*, *11*, 378. https://doi.org/10.12688/f1000research.75985.2
Rennstich, J. K. (2019). Creative online collaboration: A special challenge for co-creation. *Education and Information Technologies*, *24*(2), 1835–1836. https://doi.org/10.1007/s10639-019-09875-6
Rodríguez del Rey, Y. A., Cawanga Cambinda, I. N., Deco, C., Bender, C., Avello-Martínez, R., & Villalba-Condori, K. O. (2021). Developing computational thinking with a module of solved problems. *Computer Applications in Engineering Education*, *29*(3), 506–516. https://doi.org/10.1002/cae.22214
Rokhani, R. A., & Purnami, A. S. (2021). Manajemen Mutu Pelayanan Pendidikan di Sekolah Kejuruan. *Media Manajemen Pendidikan*, *4*(1), 69–80. https://doi.org/10.30738/mmp.v4i1.8563
Sari, D. I., Rejekiningsih, T., & Muchtarom, M. (2020). Students' Digital Ethics Profile in the Era of Disruption: An Overview from the Internet Use at Risk in Surakarta City, Indonesia. *International Journal of Interactive Mobile Technologies (IJIM)*, *14*(03), 82. https://doi.org/10.3991/ijim.v14i03.12207
Sarva, E., Lāma, G., Oļesika, A., Daniela, L., & Rubene, Z. (2023). Development of Education Field Student Digital Competences—Student and Stakeholders' Perspective. *Sustainability*, *15*(13), 9895. https://doi.org/10.3390/su15139895
Solihah, P. A., Kaniawati, I., Samsudin, A., & Riandi, R. (2023). Prototype of Greenhouse Effect for Improving Problem-Solving Skills in Science, Technology, Engineering, and Mathematics (STEM)-Education for Sustainable Development (ESD): Literature Review, Bibliometric, and Experiment. *Indonesian Journal of Science and Technology*, *9*(1), 163–190. https://doi.org/10.17509/ijost.v9i1.66773
Suhartini, K., Prasetyorini, P., & Rachman, I. (2023). E-Module of Science Development Based on Higher Order Thinking Skills on the Material of the Human Circulatory System for VIII Grade Students. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9278–9289. https://doi.org/10.29303/jppipa.v9i11.5229
Sukarmin, S., & Sani, D. M. (2023). Analysis Student Critical Thinking Skill on Physic Learning with E-Modules type Information Search during The Covid 19 Pandemic. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4130–4134. https://doi.org/10.29303/jppipa.v9i6.2652
Sunarya, R. R., Hijriansyah, R., & Aisyah, R. (2024). Implementation of Problem Solving-Based Electron Configuration E-Modules to Improve Student Learning Outcomes. *Jurnal Pendidikan Kimia Indonesia*, *8*(1), 11–20. https://doi.org/10.23887/jpki.v8i1.70029
Syahri, A. A., Akib, I., & Sukmawati, S. (2024). The Need for Development of Meaningful E-Module Teaching Materials to Optimize Mathematics Learning with a Focus on Critical Thinking Skills. *PPSDP International Journal of Education*, *3*(2), 102–110. https://doi.org/10.59175/pijed.v3i2.286
Tshukudu, E., Olaosebikan, S., Omeke, K., Pancheva, A., McQuistin, S., Jilantikiri, L. J., & Al-Anqoudi, M. (2022). Broadening Participation in Computing. *Proceedings of the 27th ACM Conference on on Innovation and Technology in Computer Science Education Vol. 1*, 393–399. https://doi.org/10.1145/3502718.3524773
Vrzakova, H., Amon, M. J., Stewart, A., Duran, N. D., & D'Mello, S. K. (2020). Focused or stuck together. *Proceedings of the Tenth International Conference on Learning Analytics & Knowledge*, 295–304. https://doi.org/10.1145/3375462.3375467

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (Vol. 86). Harvard university press.

Xu, E., Wang, W., & Wang, Q. (2023). The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature. *Humanities and Social Sciences Communications*, *10*(1), 16. https://doi.org/10.1057/s41599-023-01508-1