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Need analysis of AI narrative game for computational thinking

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ABSTRACT

Computational Thinking (CT) is a fundamental 21st-century competency that supports logical reasoning and problem-solving. However, its implementation in schools still faces challenges due to the concept's abstract nature and the lack of a contextually grounded learning approach, resulting in suboptimal student engagement. This study aims to analyze the needs of CT learning in the school environment as a basis for developing a more interactive, adaptive, and contextual AI-based narrative game learning model. This study was conducted because of a gap, namely, the integration of innovative approaches such as game-based learning, AI, and learning analytics has not been comprehensively implemented to support CT mastery. The method used is a sequential exploratory mixed-method design involving semi-structured interviews with Informatics teachers and the distribution of questionnaires to MTs students. The research findings indicate that CT learning is still hampered by abstract concepts, analog learning media, and low student engagement. The analysis results emphasize the urgent need for interactive, adaptive digital learning media with automatic feedback to improve students' understanding and motivation in mastering CT.

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ABSTRAK

Computational Thinking (CT) adalah kompetensi fundamental abad ke-21 yang mendukung penalaran logis dan pemecahan masalah. Namun, implementasinya di sekolah masih menghadapi tantangan akibat sifat konsep yang abstrak dan kurangnya pendekatan pembelajaran yang kontekstual, sehingga keterlibatan murid belum optimal. Penelitian ini bertujuan untuk menganalisis kebutuhan pembelajaran CT di lingkungan sekolah sebagai dasar pengembangan model pembelajaran berbasis AI narrative game yang lebih interaktif, adaptif, dan kontekstual. Penelitian ini dilakukan karena adanya kesenjangan, yaitu integrasi pendekatan inovatif seperti game-based learning, AI, dan learning analytics belum diterapkan secara menyeluruh untuk mendukung penguasaan CT. Metode yang digunakan adalah desain sequential exploratory mixed-method yang melibatkan wawancara semi-terstruktur dengan guru Informatika dan penyebaran kuesioner kepada murid MTs. Temuan penelitian menunjukkan bahwa pembelajaran CT masih terkendala oleh konsep yang abstrak, media pembelajaran yang masih bersifat analog, serta rendahnya keterlibatan murid. Hasil analisis menegaskan kebutuhan mendesak akan media pembelajaran digital yang interaktif dan adaptif dengan fitur umpan balik otomatis guna meningkatkan pemahaman dan motivasi murid dalam menguasai CT.

Kata Kunci: *berpikir komputasional; kecerdasan buatan; pembelajaran berbasis game; pembelajaran naratif*

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INTRODUCTION

Computational Thinking (CT) is a fundamental competency of the 21st century that supports logical, systematic reasoning and cross-disciplinary problem-solving (Tariq et al., 2025). However, its implementation in schools still faces challenges due to the abstract nature of the concept and the lack of a contextually and interactively oriented approach, resulting in suboptimal student involvement (Santaengracia et al., 2026). This condition is associated with low mastery of important aspects of CT, such as abstraction and algorithmic thinking (Tang et al., 2020). Therefore, a deeper understanding of CT learning conditions is needed to identify relevant learning needs. Exploring innovative methodologies, such as game-based learning, can increase student motivation and engagement through interactive learning experiences (Weng et al., 2024).

Game elements such as rewards and competition encourage active participation, while game-based learning in evaluation improves learning outcomes and creates an adaptive environment (Haryanti et al., 2023; Zafar et al., 2022). However, its implementation in schools is still limited (Troussas et al., 2024). Therefore, a needs analysis is needed to optimize the implementation of game-based learning in CT development. The integration of Artificial Intelligence (AI) in education opens up opportunities for adaptive and personalized learning through instant feedback (Chen et al., 2020; Guan et al., 2020). Game-based learning on digital platforms, such as mobile learning, also increases engagement and learning consistency, although it remains limited in developing advanced skills (Fitriani, 2024).

The application of learning analytics allows for in-depth analysis of student interaction patterns, thereby helping educators understand cognitive strategies and problem-solving processes more precisely (Ifenthaler & Yau, 2020; Viberg et al., 2023). However, its use in schools remains limited and is not optimal for supporting learning decision-making, especially in CT (Celik et al., 2022; Wasson et al., 2024). A needs analysis is necessary to optimize the use of learning data to support adaptive, data-driven learning. CT learning in schools is still suboptimal and tends to be isolated (Holmes & Tuomi, 2022).

The integration of game-based learning, AI, and narrative-based learning has not been widely implemented, despite its potential to increase students' understanding of abstract concepts and engagement (Brunetti et al., 2024; Radianti et al., 2020). Therefore, a needs analysis is needed to integrate these various approaches into CT learning. This statement indicates that the implementation of various CT learning approaches in schools is still not optimally integrated and is often carried out separately. Approaches such as game-based learning, AI, learning analytics, and narrative-based learning have not been combined within a comprehensive framework, thus failing to produce adaptive, contextual, and data-driven learning.

Despite its potential to increase engagement, personalization, and conceptual understanding, its implementation still does not foster holistic thinking skills. It has not been optimally utilized to support meaningful learning. This situation indicates a research gap: no study has specifically analyzed the need to integrate these approaches in CT learning within real-world school settings. Most previous research has focused on each approach in isolation and has

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not examined the need for integration between approaches as a basis for developing innovative learning.

Therefore, the novelty of this research lies in the analysis of CT learning needs that integrates perspectives on game-based learning, AI, learning analytics, and narrative-based learning, serving as a foundation for developing AI-based narrative game learning that is more adaptive, contextual, and student-centered. This research proposes a conceptual framework that integrates game-based learning, AI, learning analytics, and narrative-based learning within a complementary CT learning ecosystem.

This conceptual framework serves as a basis for analyzing CT learning needs in schools, leading to recommendations for developing a more effective, appropriate AI-narrative, game-based learning model that aligns with student characteristics. Given this urgency, this study aims to analyze CT learning needs in schools as a basis for developing a more interactive, adaptive, and contextually relevant AI-narrative, game-based learning model.

LITERATURE REVIEW

Computational Thinking (CT) in Education

CT is an essential competency in 21st-century education, encompassing the ability to think logically, solve problems, and reason algorithmically through decomposition, pattern recognition, abstraction, and algorithm design (Dagienė et al., 2022; Tang et al., 2020). CT is evolving as a cross-disciplinary thinking framework that supports problem-based learning and innovation (Weng et al., 2024). However, students still experience difficulties in understanding the concept of CT, especially in abstraction and algorithmic thinking, due to its abstract nature and the lack of a contextualized learning approach (Tang et al., 2020).

Game-based Learning in CT Learning

Game-based learning is an approach that can increase student motivation, engagement, and learning experience through interaction in an interactive learning environment, with elements such as challenges, rewards, and instant feedback (Sailer & Homner, 2020). The use of game-based learning also encourages active student participation through more engaging and competitive learning experiences (Zafar et al., 2022). In the context of CT, game-based learning has the potential to support the development of problem-solving, algorithmic thinking, and decision-making skills, including through the use of serious games and adaptive games that enhance conceptual understanding, as well as create a more responsive and collaborative learning environment (Haryanti et al., 2023; Makransky et al., 2022). However, its implementation in schools still tends to focus on the motivational aspect and has not fully integrated cognitive processes and adaptive support optimally (Kasurinen & Knutas, 2018).

Artificial Intelligence (AI) in Adaptive Learning

AI is an important component of digital education that supports adaptive and personalized learning through analysis of learning behavior and real-time feedback (Chen et al., 2020).

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The integration of AI with game-based learning on digital platforms has the potential to increase student engagement and consistency in learning, as well as help students understand CT concepts through adaptive scaffolding and personalized learning recommendations (Fitriani, 2024). In addition, the development of generative AI also encourages creativity and high-level thinking skills (Crompton & Burke, 2023; Rudolph et al., 2023). However, the implementation of AI in CT learning still faces challenges, especially in its integration with contextual and student-centered pedagogical approaches and in its lack of synergy with effective learning strategies (Bond et al., 2023).

Learning Analytics in CT Evaluation

Learning analytics is a data-driven approach to analyzing student interactions in digital learning, including play patterns, completion times, and strategies that reflect students' thinking processes (Ifenthaler & Yau, 2020). This approach allows evaluation of CT not only from final results but also from cognitive processes, and it supports adaptive learning through adjustments in difficulty levels and learning strategies (Matcha et al., 2023). However, its use in schools remains limited, focusing more on reporting than on in-depth analysis to support pedagogical decision-making (Kaliisa et al., 2022). In addition, limited educator competencies and the lack of integration between analytical systems and learning design are major challenges (Liu et al., 2024; Sajja et al., 2025).

Narrative-based Learning in CT Learning

Narrative-based learning is a contextual approach that helps students understand abstract CT concepts through problem representations that are close to real life (Yang et al., 2022). In digital and game-based learning, this approach also increases student engagement, motivation, and understanding (Alaiksander et al., 2026; Roy, 2024). However, its implementation in schools is still limited and has not been integrated with technologies such as AI and learning analytics.

METHODS

This study used a sequential, exploratory, mixed-methods (QUAL → QUAN) design to analyze needs in CT learning. This approach was chosen because it can integrate qualitative and quantitative data to gain a more comprehensive understanding. This design begins with a qualitative exploration to identify problems, then proceeds to a quantitative stage to test and strengthen the findings. The study was conducted at MTs Al-Haq Margahayu, Bandung, involving one Informatics teacher and 25 students selected through purposive sampling based on the relevance of their experiences to CT learning.

The qualitative phase involved semi-structured interviews with teachers to identify learning conditions, student difficulties, and CT needs, which were subsequently analyzed using thematic analysis. The quantitative phase used a 5-point Likert-scale questionnaire (28 items) covering indicators of understanding, difficulties, interests, and needs, and the data were analyzed using descriptive statistics (mean and categories).

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Data integration was performed through triangulation to increase validity and generate a comprehensive understanding. The analysis results served as the basis for developing more interactive, adaptive, and context-aware AI-based narrative game-based CT learning. The analysis results from both stages served as the basis for formulating the needs for developing more interactive, adaptive, and context-aware AI-based narrative game-based CT learning.

RESULTS AND DISCUSSION

Understanding Computational Thinking (CT)

Teachers have a fairly good understanding of CT as a systematic thinking skill that can be applied in everyday life. CT learning is not delivered directly in the form of formal computational concepts, but rather through a contextual approach to make it easier for students to understand. In interviews, teachers stated the following,

> *"Konsep computational thinking dalam pembelajaran informatika lebih mengarah pada cara berpikir komputer yang diterapkan dalam kehidupan sehari-hari. Misalnya murid diajarkan bagaimana menyelesaikan masalah dengan membaginya menjadi bagian-bagian kecil,"*

This shows that the teacher has made an effort to link the CT concept with real activities as an initial step before students understand more complex concepts.

Implementation of CT Learning

In implementing learning, teachers use various approaches to help students understand CT concepts, including simple game-based activities. In interviews, teachers explain,

> *"Saya menggunakan game menggambar, di mana murid menyusun langkah-langkah membuat gambar, lalu murid lain mengikuti langkah tersebut,"*

This approach demonstrates that CT learning has been directed toward interactive activities that directly involve students. However, learning is still dominated by analog approaches and has not made extensive use of digital technology.

Problems in CT Learning

The teacher revealed that the main difficulty for students lies in their ability to understand abstract concepts, particularly in abstraction. In the interview, the teacher stated,

> *"Kesulitan utama murid itu pada cara berpikirnya, mereka sulit membayangkan sesuatu yang abstrak dan perlu contoh yang nyata,"*

Furthermore, students tend to understand practical material more easily than conceptual CT concepts. This indicates a gap between the characteristics of CT material and students' learning needs.

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Student Engagement and Interest

Student engagement in CT learning varies. Some students show good interest, while others show less, especially when the learning is less interactive. The teacher conveys,

> *"Ada murid yang bisa mengikuti, tapi ada juga yang kurang tertarik karena materinya sulit. Guru harus menyajikan pembelajaran yang menarik agar murid tertarik,"*

These findings show that learning methods and media play an important role in increasing students' interest in learning.

Use of Media and Technology

In CT learning, teachers have used a game-based approach, but it is still analog. The use of digital media is still limited. Teachers stated,

> *"Untuk game saya sudah pakai, tapi masih analog. Media digital belum digunakan karena belum menemukan yang sesuai dan ada keterbatasan fasilitas,"*

Another obstacle faced is limited devices and access to technology in schools, such as a limited number of laptops and network constraints.

The Need for Adaptive Learning and Technology

Teachers stated that adaptive learning is essential to adapt to students' diverse abilities. In interviews, teachers explained,

> *"Pembelajaran adaptif dibutuhkan, seperti adanya feedback otomatis, bantuan langkah-langkah, dan sistem level yang bisa menantang murid."*

This shows that integrating technologies such as AI can support more effective CT learning.

The Need for Evaluation and Learning Analytics

In the evaluation aspect, teachers need data on students' learning progress, though it does not need to be detailed. The teacher stated,

> *"Perkembangan murid perlu dilihat, misalnya dari nilai latihan, tidak harus tiap hari."*

Currently, evaluation is still carried out and has not yet been optimally utilized by the learning analytics system.

The Need for Narrative-Based Learning

The use of narratives in learning is considered to help students understand the concept of CT. The teacher conveys,

> *"Cerita berbasis kehidupan sehari-hari bisa membantu, tapi harus dibuat menarik dan tidak terlalu serius,"*

This suggests that a narrative approach can increase students' understanding and engagement.

https://doi.org/10.17509/curricula.v5i2.602

The Need for Learning Media Development

Teachers expressed a need for more interactive, innovative learning media. In interviews, teachers stated,

> *"Media yang ideal itu interaktif, variatif, dan bisa menyesuaikan dengan minat murid. game dengan visual menarik dan sistem level akan lebih efektif,"*

Interview results indicate that CT learning still requires innovation, particularly in the development of interactive, adaptive, and contextual media.

Overall, the interviews revealed students' difficulties in understanding abstract CT concepts and the need for more interactive, context-based learning. These findings served as the basis for developing a questionnaire to elicit students' perspectives.

The quantitative phase involved questionnaires to identify students' understanding, difficulties, and needs, and to validate the interview results more comprehensively. The results of the student questionnaire analysis are presented in **Table 1** below.

Table 1. Results of Student Needs Analysis in CT Learning

No	Indicators	Sub-Indicators	Mean	Categories
1	CT Understanding	Thinking step by step	2.80	Medium
		Solving problems in an organized manner	2.80	Medium
		Making simple steps	2.88	Medium
		Getting confused when the material is difficult	4.16	High
2	Learning Difficulties	Lessons are difficult to understand	3.88	High
		The material is confusing	3.80	High
		Difficulty working on problems	3.76	High
		Need help while studying	3.92	High
3	Game Interest	Prefer learning through games	4.32	Very High
		Games create enthusiasm for learning	4.44	Very High
		I understand better through games	4.24	Very High
		I want game-based learning	4.48	Very High
4	Adaptive Learning	Want to be at your own pace	4.36	Very High
		Need immediate feedback	4.48	Very High
		Need guidance when things get tough	4.52	Very High
		Like a level system	4.44	Very High
5	Learning Analytics	Want to know the progress	4.44	Very High
		Want to know the mistakes	4.48	Very High
		Want to see the learning outcomes	4.52	Very High
6	Narrative Learning	Interested in learning through stories	4.24	Very High
		Stories help with understanding learning	4.28	Very High
		Life context helps	4.36	Very High
		Want story-based games	4.40	Very High

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No	Indicators	Sub-Indicators	Mean	Categories
7	Instructional Media	Want engaging media	4.52	Very High
		Bored with traditional methods	4.32	Very High
		Want exciting learning	4.60	Very High
		Agree with AI-based games	4.36	Very High

Source: Research 2026

Based on the questionnaire analysis results in **Table 1**, students' level of understanding of CT was in the moderate range (2.80–3.36), indicating a basic understanding, but not yet optimal. Conversely, the level of learning difficulty was in the high category (3.76–3.92), indicating challenges in understanding the abstract concept of CT. On the other hand, students showed a very high interest in game-based learning (4.24–4.48) and a high need for adaptive learning (4.36–4.52), including direct feedback and a level system. The need for learning analytics was also high, especially for understanding progress and errors in the learning process. Furthermore, students showed a strong preference for narrative-based and technology-enabled interactive learning media. Overall, the results indicate a strong need for developing more interactive, adaptive, and contextual CT learning through the integration of games, narratives, and digital technology.

Discussion

The results of the study indicate that CT learning at MTs Al-Haq Margahayu still faces challenges, particularly in conceptual understanding and student learning difficulties. Student understanding falls within the moderate category, while difficulties fall within the high category, reinforced by qualitative findings that students struggle to grasp abstract CT concepts, particularly those related to abstraction. This indicates that students have not been able to internalize the concepts in depth, in line with research stating that CT requires gradual, structured, and contextual learning (Denning & Tedre, 2021). The gap between moderate understanding and great difficulty indicates a mismatch between the characteristics of CT material and the learning approach. The abstract nature of CT demands strategies that can concretize concepts, yet learning still falls short in meeting this need.

Students understand material more easily when it is practical and contextual, so CT learning needs to be designed based on real-world experiences and contexts. This finding aligns with research emphasizing the importance of a contextual approach in improving CT understanding (Baidoo-Anu & Ansah, 2023). The results of the study indicate that game-based learning has the potential to increase student motivation and engagement in CT learning, as evidenced by students' high interest and preference for interactive learning compared to conventional methods. This finding aligns with previous research showing that GBL increases engagement through active, challenge-based learning experiences (Sailer & Homner, 2020). However, its implementation is still limited to analog formats, necessitating the development of technology-based GBL to enhance the effectiveness of CT learning.

The need for adaptive learning is a key finding, demonstrated by students' strong preference for learning that adapts to individual abilities, complemented by immediate feedback, step-by-step assistance, and a level system. This reflects the diversity of student learning

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characteristics that require a flexible approach. AI integration has the potential to support personalization through real-time feedback and difficulty adjustments (Khosravi et al., 2023). However, its use needs to be balanced with pedagogical strategies to encourage critical thinking and serve as a tool rather than a substitute for the learning process. The need for learning analytics is a significant finding, as demonstrated by students' desire better to understand their progress, mistakes, and learning outcomes. This suggests that CT learning requires a continuous, data-driven evaluation system.

Previous research confirms that learning analytics supports understanding learning patterns and instructional decision-making (Cukurova et al., 2020; Liu & Moon, 2023). However, its use in schools is still limited and has not been systematically integrated into learning. Student interest in narrative-based learning is also high, as evidenced by a preference for story-based learning and everyday-life contexts. This approach helps understand abstract CT concepts through more concrete representations while increasing emotional engagement and conceptual understanding.

In CT learning, narratives can present problems contextually, supporting a more systematic problem-solving process. Overall, CT learning requires a more innovative, integrated approach tailored to students' characteristics. Findings indicate that students do not lack motivation, but rather require more relevant strategies. The integration of game-based learning, AI, learning analytics, and narrative-based learning is a potential solution because these elements complement one another to increase engagement and support adaptive, contextual, and data-driven learning. Therefore, the development of AI-based narrative game learning is an innovative solution to bridge the abstract concepts of CT with students' learning needs.

CONCLUSION

CT learning requires an approach that bridges abstract concepts into concrete, interactive, and easily understood ones. Students also need adaptive, contextual learning supported by engaging media to enhance engagement and understanding. These findings emphasize the need to integrate learning strategies and technology tailored to student characteristics, making the development of AI-based narrative game learning a relevant solution. Furthermore, it is recommended that educators integrate game-based approaches, adaptive technology, and narrative into CT learning. Future research can focus on developing and testing these models more broadly to obtain more comprehensive results.

AUTHOR'S NOTE

The author confirms that this article is independent and without any conflict of interest, and guarantees the originality of all data and content in it to ensure that the manuscript is completely free from all forms of plagiarism.

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