

Adapting the *Bebras Challenge* into an Educational Game for Learning Computational Thinking and Assessing Its Usability

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Abstract: Computational Thinking (CT) is now a key part of the school curriculum, but many CT tasks are still presented as static text, which can be boring for students. This study aimed to develop and test the usability of "*Magic Potion*", an interactive educational game adapted from the *Bebras Challenge* for 8th-grade students. The game uses a "*learning by doing*" approach where students mix potions and observe the results to solve problems. Using a Design and Development Research (DDR) framework, the game was tested with 55 junior high school students using the System Usability Scale (SUS) and feedback questions. The results showed a mean SUS score of 75.3, meaning the game is easy and fun to use. Students especially liked the visuals and the way the game challenged their thinking. While this study focused on usability and did not measure actual learning outcomes, the findings show that turning textbook tasks into games is a better way to teach CT. Future research will focus on measuring how much students' skills improve after playing this game in a classroom setting.

Article History

Received: 24-04-2025

Revised: 29-01-2026

Published: 31-01-2026

Key Words :

Bebras Challenge,
computational thinking,
educational game, usability,
game-based learning

How to Cite: Sukirman, S., Yuliana, I., & Ramadhan, F. A. W. (2026). Adapting the *Bebras Challenge* into an Educational Game for Learning Computational Thinking and Assessing Its Usability. *Jurnal Teknologi Pendidikan : Jurnal Penelitian Dan Pengembangan Pembelajaran*, 11(1), 124–135. <https://doi.org/10.33394/jtp.v11i1.15373>

 <https://doi.org/10.33394/jtp.v11i1.15373>

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Introduction

Computational Thinking (CT) has emerged as a fundamental skill in the digital era, equipping individuals with the ability to solve problems systematically and algorithmically across various disciplines (Scherer et al., 2020; Wing, 2006). Recognized as a critical component of 21st-century education, CT fosters problem-solving, abstraction, decomposition, and pattern recognition, enabling students to tackle complex challenges in an increasingly technology-driven world (Cachero et al., 2020; Masduki et al., 2024). In response to its growing importance, educational systems worldwide have integrated CT into curricula, particularly in subjects like Informatics or "*Informatika*" in Indonesia, to prepare students for future technological advancements (Kemdikbud, 2019; SUKIRMAN et al., 2022; Thota & Berglund, 2016). However, engaging young learners in CT remains a challenge due to its abstract nature, necessitating innovative pedagogical approaches such as gamification to enhance motivation and learning outcomes (Grover & Pea, 2013).

One established platform for enhancing CT is the *Bebras Challenge*, an international initiative designed to promote CT, offers engaging, age-appropriate tasks that align with educational standards and have been adopted in various national curricula (Dagiene et al., 2016; Dagiene et al., 2023). These tasks encourage students to develop CT skills through problem-solving in a non-programming context, making them accessible to novices. However, the

format of *Bebras* tasks, often presented as static problems, may limit interactivity and sustained engagement (Kalelioğlu, 2015). Despite the integration of *Bebras* tasks into the national informatics curriculum, research on transforming these static problems into interactive educational games remains scarce. This lack of interactive adaptation represents a significant research gap, as static materials may not fully address the instructional challenges of teaching abstract CT concepts. Therefore, it is urgent to develop interactive game-based learning (GBL) tools that can bridge this gap and provide more engaging, effective learning experiences for students (Yulianto et al., 2024). Transforming these tasks into interactive educational games presents an opportunity to leverage the motivational affordances of gamification while maintaining the pedagogical rigor of the original tasks (Chen et al., 2024; Sari et al., 2025).

Educational games have been widely recognized for their ability to create immersive learning environments that enhance motivation and facilitate active learning (Giannakoulas & Xinogalos, 2018; Prensky, 2003). By embedding CT concepts within game mechanics, such as puzzles or simulations, students can practice problem-solving in a context that feels playful yet intellectually stimulating. Research has shown that well-designed educational games can improve learning outcomes in CT by providing immediate feedback and scaffolding complex concepts (Lamb et al., 2018; Vita-Barrull et al., 2024). Nevertheless, the success of such games hinges on their usability, as poorly designed interfaces or overly complex mechanics can frustrate users and undermine educational goals (Bauer et al., 2019; Nielsen, 1992).

Usability evaluation is critical to ensuring that educational games are effective and user-friendly, particularly for young learners who may have limited technological proficiency (Brooke, 1996). The System Usability Scale (SUS) offers a standardized, reliable method for assessing usability, providing insights into user satisfaction and system effectiveness (Lewis, 2018). Recent studies emphasize the importance of combining quantitative usability metrics, like SUS, with qualitative feedback to gain a comprehensive understanding of user experiences (Barz et al., 2025). This approach is particularly valuable in educational contexts, where student perceptions can inform iterative design improvements and enhance the game's alignment with learning objectives.

This study introduces an educational game adapted from a *Bebras Challenge* task, developed to support CT learning among junior high school (SMP) students in Indonesia. The usability of the developed game was evaluated through SUS questionnaires and open-ended feedback, capturing both quantitative and qualitative insights from student participants. By investigating the adaptation process, usability outcomes, and student perceptions, this research advances the understanding of GBL in CT education. This study underscores the potential of gamified *Bebras* tasks to enhance CT learning while addressing usability challenges, offering practical implications for educators and game designers.

Research Method

Research Design

This study employed a Design and Development Research (DDR) approach, a systematic process to develop educational products while simultaneously generating design principles through iterative analysis, development, and evaluation (Richey & Klein, 2007). DDR was deemed appropriate for this study due to its dual focus: (1) producing a usable and pedagogically grounded educational game, and (2) deriving insights that contribute to both theory and practice in the field of technology-enhanced learning. The nature of the research, which involves the transformation of existing a *Bebras Challenge* task into an interactive game

format aligned with the informatics curriculum of SMP, necessitates a methodology that supports design iteration, theory-informed development, and empirical validation.

Moreover, DDR enables researchers to closely align the development process with authentic educational needs, integrating continuous feedback from users to refine the product (McKenney & Reeves, 2014). Given that the intended users are middle school students, whose engagement levels and cognitive development stages must be carefully considered, DDR provides the flexibility to iteratively evaluate usability and pedagogical effectiveness. This makes it particularly suitable for the development of digital learning tools that must balance educational content, game mechanics, and user experience within a real-world classroom context. Furthermore, the iterative nature of DDR supports the integration of both formative evaluation during the design and development stages and summative evaluation post-implementation, ensuring both product quality and theoretical contribution.

The design process in this study was structured into three iterative phases: *Needs Analysis*, *Design & Development*, and *Evaluation*, as illustrated in Figure 1. These phases reflect the core structure of the DDR, enabling the integration of theoretical foundations, user-centered design, and empirical assessment throughout the project lifecycle (McKenney & Reeves, 2014; Richey & Klein, 2008). The adoption of this structure was instrumental in ensuring that the developed game addressed curriculum-specific CT competencies while remaining usable and engaging for its target users, junior high school students.

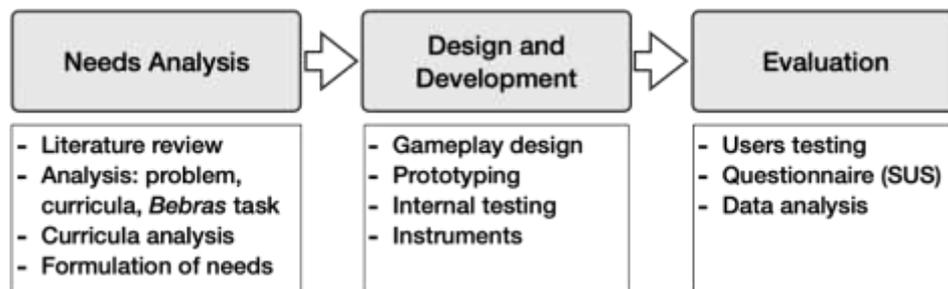


Figure 1. Research design of this study

In the *Needs Analysis* phase, a review of the Indonesian informatics curriculum was conducted to identify core CT components, including decomposition, pattern recognition, abstraction, and algorithm design. In parallel, relevant *Bebras Challenge* tasks were analyzed and mapped to these curriculum outcomes to serve as the pedagogical foundation for the game. This stage also considered documented instructional challenges associated with CT education at the junior secondary level.

The *Design and Development* phase focused on translating selected *Bebras* problems into interactive game mechanics using an iterative prototyping approach. Key design elements included narrative structure, feedback systems, and the integration of CT elements into game-based tasks. Multiple internal tests were conducted to ensure consistency between the game's functionality and its intended educational goals.

The final *Evaluation* phase involved user testing with students to assess usability and gather learner feedback. A mixed-methods approach was employed: the SUS questionnaire provided quantitative data on perceived usability (Brooke, 1996), while open-ended questions yielded qualitative insights regarding students' experiences, challenges, and suggestions. Together, these evaluation activities ensured the game's alignment with both pedagogical intent and user expectations.

Participants

Participants involved in this study were 55 students of SMP. As shown in Table 1, the majority of participants were aged 13–14 years ($n = 48, 87.3\%$), while a smaller proportion were aged 15–16 years ($n = 7, 12.7\%$). This age distribution aligns with the target demographic for which the game was designed, ensuring that the usability evaluation was relevant to the intended user group.

Table 1. Demographic profile and prior experience

Info	n	%
Age	13-14	48 87.3
	15-16	7 12.7
	Total	55 100
Have you ever used a similar game?	Yes	30 54.5
	No	25 45.5
	Total	55 100

In addition, participants were asked whether they had previously used a similar game. Slightly more than half of the students ($n = 30, 54.5\%$) indicated that they had prior experience with similar games, while the remaining 45.5% ($n = 25$) reported no such experience. This mix of experienced and inexperienced users provided a balanced perspective on the game’s usability, allowing the evaluation to capture both novice and informed user experiences.

Instruments & Data Analysis

To evaluate the usability of the developed educational game, the study employed the *System Usability Scale* (SUS) (Brooke, 1996). The SUS was chosen over other methods because it is a highly reliable, standardized, and cost-effective instrument that provides a robust measure of perceived usability even with smaller sample sizes. Its widespread validation in GBL research allows for meaningful benchmarking against similar educational tools. However, it should be noted that this study focuses on assessing usability and user experience. Evaluating the actual learning effectiveness of the *'Magic Potion'* game in improving CT skills was not within the scope of this phase and is identified as a primary goal for future research.

The SUS questionnaire consists of ten statements rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), alternating between positively and negatively worded items. The items were adapted slightly to directly reference the name of the developed game, ensuring contextual clarity for participants. In this study, the statements were adapted to refer directly to the name of the game, *“Magic Potion”*, an educational game designed for learning CT. In the game, players engage in a problem-solving activity where they mix digital potions to find the correct composition as instructed, thereby practicing CT elements such as decomposition, pattern recognition, and algorithmic reasoning. To ensure clarity and cultural appropriateness for junior high school students in Indonesia, the instrument was translated and linguistically adapted into *Bahasa Indonesia*.

As presented in Table 2, the ten SUS items used in this study include statements such as *“I think that I would like to use this 'Magic Potion' game frequently”* and *“I found this 'Magic Potion' game unnecessarily complex”*. These items are structured to capture both ease of use and potential usability challenges. The odd-numbered items reflect positive user experiences, while the even-numbered items are negatively worded to probe potential issues or confusion

during gameplay. The inclusion of the game's name within each item helped students better contextualize their responses based on their firsthand interaction with the *Magic Potion* game.

Table 2. SUS items used to assess student perceptions

Code	Statements
Q1	I think that I would like to use this " <i>Magic Potion</i> " game frequently
Q2	I found this " <i>Magic Potion</i> " game unnecessarily complex
Q3	I thought this " <i>Magic Potion</i> " game was easy to use. I think that I would need the support of a technical person to be able to use this
Q4	" <i>Magic Potion</i> " game
Q5	I found the various functions in this " <i>Magic Potion</i> " game were well integrated.
Q6	I thought there was too much inconsistency in this " <i>Magic Potion</i> " game I would imagine that most people would learn to use this " <i>Magic Potion</i> " game
Q7	very quickly.
Q8	I found this " <i>Magic Potion</i> " game very cumbersome to use
Q9	I felt very confident using this " <i>Magic Potion</i> " game I needed to learn a lot of things before I could get going with this " <i>Magic</i>
Q10	<i>Potion</i> " game

To analyze the responses, the SUS scoring procedure established by (Brooke, 1996) was followed. For positively worded items (odd-numbered), one point was subtracted from each response. For negatively worded items (even-numbered), the response was subtracted from five. This adjustment resulted in a score ranging from 0 to 4 per item. The scores were then summed and multiplied by 2.5 to generate a final usability score on a scale from 0 to 100. Descriptive statistics including mean and standard deviation were used to summarize overall user perceptions. The final SUS scores were interpreted using the benchmark categories proposed by (Bangor et al., 2009), which classify scores below 50 as unacceptable, scores between 68–80 as acceptable or good, and scores above 80.3 as excellent. This allowed for a standardized, quantitative interpretation of the *Magic Potion* game's usability as perceived by junior high school students.

Result and Discussion

Developed Game: "*Magic Potion*"

The developed game, *Magic Potion*, is an interactive digital game designed to enhance students' CT skills through problem-based experimentation. The game invites players to solve a logic-based challenge by analyzing patterns and deducing rules from experimental outcomes. Visually engaging and linguistically accessible for junior high school students, *Magic Potion* integrates narrative elements, interactive feedback, and progressively complex tasks to promote active learning.

The game's conceptual foundation was derived from a problem found in the Grade 8 Informatics textbook, which in turn references a Bebras Challenge problem, an internationally recognized source of CT-based tasks. The original problem involves a flower farmer who accidentally mixed up five types of magical fertilizers and one cup of water across six labeled cups (A–F). Each fertilizer has a distinct effect on a flower's physical attributes, such as changing petal color or growing leaves, while the water has no effect. Students are challenged to identify which cup contains water through logical deduction based on the effects of multiple experimental combinations. This problem was selected for its alignment with core CT competencies and its proven use in formal education contexts.

Figure 2 shows screenshots of the game, players are introduced to a narrative scenario in which Pak Taro (Figure 2 (a)), the flower farmer, has forgotten which cup contains which fertilizer. A brief explanation outlines the potential effects of the five fertilizers, such as duplicating flower petals, growing leaves, altering stem shape, changing petal color, and darkening the flower's center. The player is then directed to begin an experiment by selecting three cups from the six available options and applying them to a digital flower. The effect of the mixture is then visually displayed.



Figure 2. Gameplay interface of the game, shows the problem context and experimental setup

As seen in Figure 2 (b), game screen presents four flowers on pots, one of which is labeled "*Bunga tanpa ramuan*" to serve as a baseline comparison. Below the flowers are cups labeled A through F. Students are expected to pour mixtures of three cups into the flowers and observe visual changes, which may include petal duplication, leaf emergence, or changes in color and shape. These features are directly aligned with the problem-solving activity in the original *Bebras* task and allow learners to perform controlled experiments to isolate variables, a core principle of CT.

By engaging with this feature, students practice *decomposition* (breaking down complex changes into individual effects), *pattern recognition* (identifying consistent outcomes based on input combinations), and *abstraction* (eliminating possibilities to find the correct answer). These interactions are not only visually appealing but also cognitively meaningful, embedding CT principles within the gameplay experience.

Usability Score & Open-ended Feedback

To evaluate the usability of developed game, "*Magic Potion*", SUS questionnaire was administered to students after they had completed the gameplay session. As detailed in Table 3, the SUS consists of ten standardized items that assess different dimensions of usability, such as ease of use, system integration, and user confidence. Each item was rated on a 1–5 *Likert* scale, converted into an adjusted score between 0 and 4, and then scaled to a 0–100 score following the SUS calculation procedure (Brooke, 1996). The resulting scores provide a holistic measure of how the game was perceived in terms of usability and interaction quality.

Table 3. SUS score obtained from the participants

Items	Raw	SUS Score	
		0-4	0-100
Q1	3,96	2,96	74
Q2	1,91	3,09	77,25
Q3	4,22	3,22	80,5
Q4	2,31	2,69	67,25
Q5	4,45	3,45	86,25
Q6	1,75	3,25	81,25
Q7	4,22	3,22	80,5
Q8	2,13	2,87	71,75
Q9	4,35	3,35	83,75
Q10	2,98	2,02	50,5
Average		3,012	75,3

The final mean SUS score was 75.3, placing the usability of *Magic Potion* in the "Good" category according to benchmark classifications by (Bangor et al., 2009). This indicates that the game, as implemented, was well-received by students, offering a generally smooth and satisfying user experience. Positively worded items such as "I thought this game was easy to use" (Q3) and "I felt very confident using this game" (Q9) scored particularly high, with SUS values exceeding 80. This suggests that the core mechanics, selecting potion combinations, observing flower transformations, and making logical inferences, were intuitive and engaging.

Negatively worded items such as Q2 and Q6, which address perceived complexity and inconsistency, also received strong scores after reverse coding, further reinforcing the game's overall ease of use. However, Q10 ("I needed to learn a lot of things before I could get going with this game") had the lowest SUS score (50.5), indicating that some users may have needed more instructional support at the beginning. This aligns with the earlier observation that *Magic Potion* requires players to engage in structured reasoning and experimentation, which may benefit from more guided onboarding in future iterations.

In addition to the SUS questionnaire, students were asked to respond to two open-ended questions to gain deeper insights into their experiences with the *Magic Potion* game. These questions explored (1) *the most interesting aspect of the game* and (2) *suggestions for improvement or additional features*. Thematic analysis of the responses revealed three dominant themes: visual and gameplay appeal, cognitive engagement, and requests for more content and support features. A majority of students highlighted the visual and interactive design as a key attraction, specifically mentioning the animation, colorful flower transformations, and the overall aesthetic of the game interface. Many students described the gameplay as fun, unique, and interesting, noting the enjoyable experience of mixing potions and observing the flower's changes. These findings suggest that the game's presentation and interaction model were successful in capturing attention and sustaining engagement.

The second theme related to cognitive stimulation and challenge. Several students pointed out that the game stimulated thinking and required them to focus on patterns and logical deduction. This aligns well with the pedagogical goal of promoting computational thinking, as the game encouraged players to make strategic decisions, identify patterns across trials, and isolate variables through structured reasoning. The third prominent theme was suggestions for development, most of which centered on adding more levels and increasing difficulty. Students expressed enthusiasm for continued play and suggested that more levels would enhance

enjoyment and learning. A smaller but notable number of students also recommended the inclusion of features such as hints, leaderboards, rewards, and explanations or feedback on correct answers. These requests indicate that while the current version of the game offers a solid usability experience, learners are motivated to go further, both in terms of challenge and clarity.

Overall, the open-ended responses complement the quantitative SUS results, reinforcing that *Magic Potion* is not only usable but also engaging and educational. These findings suggest strong potential for future iterations of the game to expand in both content and adaptive support, further enhancing its role as a tool for teaching computational thinking in fun and meaningful ways.

Discussion

The findings of this study offer promising evidence that *Magic Potion*, the developed educational game adapted from a *Bebras Challenge* problem, effectively supports the development of CT skills while maintaining a high level of usability and learner engagement. The game's mean SUS score of 75.3, classified as “*Good*” usability, indicates that the design was well-aligned with students' expectations. This score is consistent with or higher than results reported in similar studies evaluating educational games or interactive CT tools (Gris & Bengtson, 2021), suggesting that the combination of clear visual feedback, engaging challenges, and a narrative-driven structure may be critical factors in shaping students' positive perceptions. While the score reflects a high level of acceptance, it did not reach the “*Excellent*” threshold (scores above 80.3) established by Bangor et al. (2009). This gap can be primarily attributed to the low score in Q10 (50.5), which revealed that students felt they needed to learn too much before starting the game. This suggests that while the core mechanics are intuitive, the initial onboarding process was not sufficiently seamless, potentially affecting initial student engagement as they struggled to understand the instructions without prior guidance. and capabilities, offering an intuitive and satisfying interaction experience.

Qualitative responses further reinforce this conclusion, highlighting that students were not only entertained by the visual and interactive aspects of the game but were also intellectually stimulated by the gameplay mechanics. Many participants noted that the game encouraged them to “*think*”, “*analyze*”, and “*solve patterns*”, which aligns with core components of CT such as pattern recognition, decomposition, and logical reasoning (Brennan & Resnick, 2012; Wing, 2006; Yuliana et al., 2021). Compared to the findings of Gris and Bengtson (2021), who noted a prevalence of learning assessments over usability in GBL research, our study provides a necessary foundation by ensuring the tool is usable before testing its effectiveness. However, the “*Good*” but not “*Excellent*” rating serves as a critical reminder that for complex CT tasks, visual appeal must be matched with robust instructional scaffolding to prevent cognitive overload during the first few minutes of play. These skills are especially crucial in middle school informatics education, where abstract CT concepts often pose instructional challenges.

The game's structure, centered around controlled experiments to identify causal relationships, mirrors scientific inquiry and promotes the iterative testing of hypotheses, a key feature in CT-based problem solving. This aligns with constructivist learning theories, where students actively build knowledge through exploration and interaction (Fatihatussa'adah et al., 2024; Papert, 1980; Piaget, 2013). By embedding CT challenges in a game-based environment, *Magic Potion* demonstrates how game mechanics can serve as meaningful representations of curriculum content and contribute to deeper learning processes.

Nevertheless, the open-ended feedback also revealed opportunities for improvement. While students appreciated the simplicity and clarity of the game, several requested more levels, increased difficulty, and additional support features such as hints and answer explanations. These responses suggest that although the game is usable and engaging, adaptive scaffolding and content scaling may be necessary to sustain long-term learning and engagement. These findings are aligned with prior work by (Xiang et al., 2025) and (C.-H. Chen & Chang, 2024), who emphasized the need for balance between cognitive load, motivation, and instructional design in game-based learning environments.

In sum, Magic Potion represents a viable approach to integrating CT instruction into formal curricula using a game-based format. The study underscores the potential of adapting CT challenges, such as those found in *Bebras* tasks, into interactive digital media that are both pedagogically grounded and practically usable. Future development should focus on refining onboarding processes, expanding content complexity, and integrating formative feedback mechanisms to enhance learning outcomes further.

Conclusion

This study assessed the usability of an educational game adapted from a task of the *Bebras Challenge*, named "*Magic Potion*". The game was designed to engage students in CT learning through interactive experimentation, visual feedback, and problem-solving tasks that simulate logical deduction. Usability was evaluated using the SUS questionnaire and qualitative student feedback. The resulting SUS score of 75.3, along with consistently positive open-ended responses, indicates that the developed game offers a user-friendly and engaging experience for junior high school students. The findings suggest that transforming curriculum-relevant CT problems into digital game formats is a feasible strategy for designing learning tools that are both pedagogically meaningful and practically accessible. Through its combination of intuitive mechanics, thematic coherence, and challenge-based structure, the game presents a strong foundation for usability in educational contexts where CT is introduced.

Recommendation

Although the study confirms positive usability, the primary limitation remains the lack of empirical evidence regarding learning outcomes. Therefore, future research should employ quasi-experimental designs, using pre-test and post-test measures with a control group to evaluate the game's actual effectiveness in improving specific CT skills like abstraction and algorithmic thinking. To address the identified usability gaps, the next development phase must focus on implementing adaptive scaffolding. This includes adding a dynamic 'Hint' system that triggers when a student is stuck, providing immediate formative feedback on potion combinations, and developing a multi-level progression system that gradually increases task complexity to maintain student motivation. Finally, future studies should involve a larger, more diverse sample of schools to validate these findings across different educational contexts.

Acknowledgment

We would like to express our sincere gratitude to the *Majelis Pendidikan Tinggi Penelitian dan Pengembangan (Diktilitbang)*, *Pimpinan Pusat Muhammadiyah*, for funding this research through the *Hibah Riset Nasional Muhammadiyah Batch VIII 2024*, under the scheme of *Penelitian Fundamental Reguler 1 (Contract No: 0258.157/I.3/D/2025)*. We also extend our appreciation to the *Lembaga Riset dan Inovasi (LRI) Universitas Muhammadiyah Surakarta*

(UMS) for providing administrative and logistical support throughout the research process. Special thanks are also due to all individuals and institutions who contributed to this study in various capacities, and whose assistance, though not mentioned individually, is deeply appreciated.

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