Prima: Jurnal Pendidikan Matematika
Vol. 6, No. 2, May 2026, pp. 426 - 436
P-ISSN: 2579-9827, E-ISSN: 2580-2216
Web: http://jurnal.umt.ac.id/index.php/prima

TRANSFORMATECH: INTERACTIVE LEARNING WEBSITE BASED ON CHALLENGE-BASED DIFFERENTIATED LEARNING INTEGRATED WITH SCRATCH FEATURING BATIK NUSANTARA TO OPTIMIZE STUDENTS' COMPUTATIONAL THINKING SKILLS

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Abstract

Computational thinking (CT) has become a vital competence in mathematics education, yet students in Indonesia often demonstrate low proficiency in this area, particularly in abstraction and algorithmic thinking. This study aimed to develop a technological innovation named TransformaTech, an interactive learning website integrating the Challenge-Based Differentiated Learning model and Scratch programming featuring Batik Nusantara to optimize students' CT skills. Applying the 4D development model, this research involved a population of 9th-grade students at SMP Negeri 13 Semarang for the 2025/2026 academic year. From this population, 29 students were selected through simple random sampling to serve as the experimental class. Data were collected using validation sheets, teacher practitioners' questionnaires, student response forms, and CT tests. The results indicated that TransformaTech was highly feasible, with an expert validation score of 85.72%, and highly practical, with a practitioner assessment of 90.63%. The media proved effective in improving students' CT skills, as evidenced by an N-Gain score of 0.6068, falling into the moderate category. Furthermore, students provided a highly positive response with an average score of 78.43%, highlighting the platform's ability to create an engaging learning environment.

Keywords: batik nusantara, challenge-based learning, computational thinking, differentiated learning, scratch

Abstrak

Berpikir komputasional (CT) telah menjadi kompetensi vital dalam pendidikan matematika, namun siswa di Indonesia seringkali menunjukkan kemahiran yang rendah dalam bidang ini, khususnya pada aspek abstraksi dan berpikir algoritma. Penelitian ini bertujuan untuk mengembangkan sebuah inovasi teknologi bernama TransformaTech, yaitu situs web pembelajaran interaktif yang mengintegrasikan model *Challenge-Based Differentiated Learning* dan pemrograman *Scratch* dengan fitur Batik Nusantara untuk mengoptimalkan kemampuan CT siswa. Menggunakan model pengembangan 4D, penelitian ini melibatkan populasi siswa kelas IX di SMP Negeri 13 Semarang tahun ajaran 2025/2026. Dari populasi tersebut, 29 siswa dipilih melalui *simple random sampling* untuk bertindak sebagai kelas eksperimen. Data dikumpulkan menggunakan lembar validasi, kuesioner praktisi guru, angket respon siswa, serta tes kemampuan CT. Hasil penelitian menunjukkan bahwa TransformaTech dikategorikan sangat layak dengan skor validasi ahli sebesar 85,72%, dan sangat praktis dengan penilaian praktisi sebesar 90,63%. Media ini terbukti efektif dalam meningkatkan kemampuan CT siswa, yang dibuktikan dengan skor *N-Gain* sebesar 0,6068 yang termasuk dalam kategori sedang. Selain itu, siswa memberikan respon yang sangat positif dengan skor rata-rata 78,43%, yang menunjukkan kemampuan platform dalam menciptakan lingkungan belajar yang menarik.

Kata kunci: batik nusantara, berpikir komputasional, challenge-based learning, pembelajaran berdiferensiasi, scratch

INTRODUCTION

Ccomputational thinking (CT) has become a vital competence supporting the advancement of education (Park & Green, 2019). CT fosters the development of critical,

Received: March 5, 2026; Revised: April 16, 2026; Accepted: May 27, 2026

creative, and analytical thinking skills in addressing various complex problems, both in computational contexts and everyday life (Putri et al., 2024). The significance of computational thinking in mathematics education is reflected in the 2021 PISA framework, which incorporates this ability as a key assessment aspect (Augie, 2021). Within this framework, CT is understood as a competence that enables students to represent dynamic concepts and mathematical interrelationships effectively (Zahid, 2020).

However, empirical evidence indicates that students' computational thinking skills in Indonesia remain low. According to the 2022 PISA results, the average mathematics score for Indonesian students was only 366, ranking 63rd out of 81 participating countries (OECD, 2023). This low achievement reflects the significant challenges students face in mastering computational thinking as a core assessed component (Haniifah & Nugraheni, 2024). Furthermore, research by Supiarmo et al. (2021) revealed that students' computational thinking skills in solving PISA-style problems are often limited to pattern recognition, while the abstraction and algorithmic thinking stages have yet to be achieved. These findings underscore the urgent need for alternative pedagogical approaches in mathematics to enhance students' computational thinking skill.

Integrating technology into instruction is considered a viable solution to improve learning quality. Technological learning media that can be utilized include interactive learning websites and Scratch. A website is a collection of pages containing diverse digital information, such as text, images, video, audio, and animation, accessible via the internet (Rohi, 2015). Research by Sausan et al. (2024) suggests that web-based platforms are a potential strategy for training students' computational thinking skills. Meanwhile, Scratch is a game-based application that employs a simple visual block-based programming language (Aulia, 2021). This application has been proven to have a significant impact on improving students' computational thinking skills (Maulana & Waluya, 2024).

Furthermore, differentiated learning and challenge-based learning (CBL) are considered effective in enhancing students' computational abilities. Differentiated learning is an approach focused on adjusting classroom processes to accommodate individual student learning needs (Pitaloka & Arsanti, 2022). A study by Ndraha et al. (2024) showed that differentiated learning is effective in improving students' computational thinking. Simultaneously, challenge-based learning provides students with experiences to develop

knowledge through solving real-world problems (Nufus & Duskri, 2018). Research by Putri (2024) further confirms that challenge-based learning is effective in enhancing these skills.

Moreover, research by Herzani et al. (2024) indicates that combining mathematics education with culture can enhance students' computational abilities. One cultural element that can be integrated into mathematics learning is *Batik Nusantara*, which has been proven effective in helping students explore and understand geometric transformation concepts (Sari, 2023). Based on the aforementioned context, this study aims to develop a technological innovation in mathematics learning—an interactive website named TransformaTech. This platform integrates a challenge-based differentiated learning approach with Scratch programming, while incorporating the cultural nuances of Batik Nusantara to optimize students' computational thinking skills.

METHODS

This study employs a Research and Development (R&D) approach. The development model used is the 4D model, which consists of four primary stages: Define, Design, Develop, and Disseminate (Thiagarajan et al., 1974). The research was conducted at SMP Negeri 13 Semarang involving 9th-grade students for the 2025/2026 academic year. Using a simple random sampling technique, a group of 29 students was selected to serve as the experimental class. The development workflow of TransformaTech is illustrated in Figure 1 below.

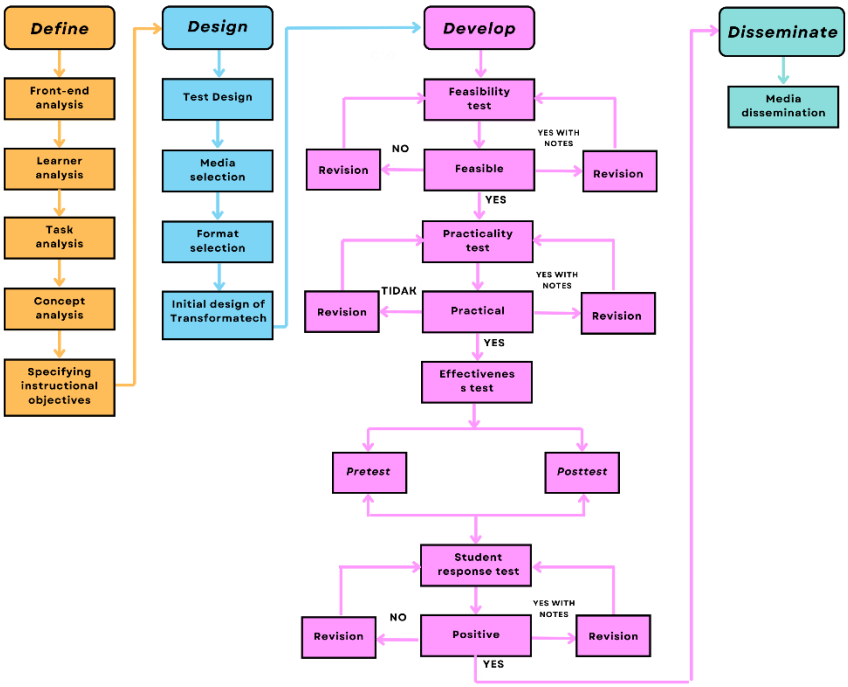

Figure 1. Product Development Workflow

Data collection was carried out through interviews, questionnaires, and tests. Initial interviews were conducted with teacher to analyze learning characteristics and relevant materials for the development phase. Furthermore, questionnaires were utilized to assess the product's feasibility, which was evaluated by two experts (lecturers) in mathematics education, and its practicality, which was assessed by four practitioners (mathematics teachers). Questionnaires were also used to capture student responses toward the TransformaTech media. To measure students' computational thinking skills, pre-tests and post-tests were administered. The collected data were analyzed using both qualitative and quantitative descriptive techniques. Qualitative data were derived from initial interview, while quantitative analysis was applied to data concerning feasibility, practicality, effectiveness, and student responses.

Student responses were measured using a Guttman scale. The feasibility and practicality of the media were evaluated using a 4-point Likert scale. Each respondent was asked to rate the items using four categories: Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1). The scoring criteria for the Likert scale are presented in Table 1 (Erinsyah et al., 2024).

Table 1. The scoring criteria for the likert scale

Category	Score (Positive)	Score (Negative)
Strongly Agree (SA)	4	1
Agree (A)	3	2
Disagree (D)	2	3
Strongly Disagree (SD	1	4

The percentage score P is calculated by dividing the total score by the maximum possible score and multiplying by 100%. The product is categorized as highly feasible, practical, or positively received if the percentage score exceeds 75%, 50%, and 50%, respectively; otherwise, it requires revision and re-validation. The interpretation of the scores follows the criteria presented in Table 2 (Erinsyah et al., 2024).

Table 2. The interpretation of scores

Percentage (P)	Feasibility	Practicalty	Student Response
$75\% < P \leq 100\%$	Highly Feasible	Highly Practical	Highly Positive
$50\% < P \leq 75\%$	Feasible	Practical	Positive
$25\% < P \leq 50\%$	Weak	Poor	Negative
$0\% < P \leq 25\%$	Very Weak	Very Poor	Highly Negative

The improvement in students' computational thinking skills was measured using the N-Gain test. The N-Gain score (g) is calculated using the following formula:

$$g = \frac{Post\ test\ score - Pre\ test\ score}{Ideal\ Score - Pre\ test\ score} \quad (1)$$

The results of the N-Gain calculation are then categorized to determine the level of improvement based on the criteria presented in Table 3 (Negara, 2017, as cited in Ismiati, 2023).

Table 3. N-Gain Score Classification

Score	Category
$g > 0.7$	High
$0.3 < g \leq 0.7$	Moderate
$g \leq 0.3$	Low

Furthermore, to determine the effectiveness of the developed product, the N-Gain score is converted into a percentage and interpreted according to the effectiveness criteria shown in Table 4 (Arini, 2016, as cited in Ismiati, 2023).

Table 4. Effectiveness Interpretation of N-Gain Score

Percentage (%)	Interpretation
$> 76\%$	Effective
$56\% - 75\%$	Moderately Effective
$40\% - 55\%$	Less effective
$< 40\%$	Ineffective

The final conclusion of the research is drawn based on the descriptive analysis of whether the product meets the criteria for being highly feasible, practical, effective, and positively received by students.

RESULTS AND DISCUSSION

Define Stage

The define stage aimed to establish the fundamental requirements for the media. Based on interviews with a mathematics teacher at SMP Negeri 13 Semarang, it was identified that the learning process for translation topics remained conventional and did not optimize students' computational thinking (CT) skills. Consequently, the teacher emphasized an urgent need for technological innovation to create a more adaptive and engaging learning environment. The output of this stage was the formulation of learning objectives and CT indicators—decomposition, pattern recognition, abstraction, and algorithmic thinking—

integrated into the website's features thorugh culturally-themed activities on Scratch, specifically featuring Batik Nusantara.

Design Stage

In this stage, the website was realized using Canva platform. The website's structure was meticulously planned to incorporate several key pages: the Home Page, Instruction Manual, Road Map, Learning Style Test, Concept Map, and Learning Material (Translation). The learning material within TransformaTech were structured according to the Challenge-Based Learning (CBL) syntax, which includes Essential Questions, The Challenge, Guiding Questions, Guiding Activities, Guiding Resources, and Solution Action. Specifically, the Challenge section requires students to design Batik motifs on Scratch by applying the mathematical principles of translation. To accommodate differentiation, the materials are presented in various formats—Visual, Auditory, and Kinesthetic—alongside comprehensive summaries. Throughout the challenge, students are assisted by an E-LKM (Electronic Student Worksheet) to guide their progress. Furthermore, the website includes Practice Questions (Quizzes) and a Student Digital Gallery to showcase their work. Some of these components are illustrated in Figure 1, providing a cohesive and interactive learning environment.

Figure 1. Some Features of TransformaTech Website

Develop Stage

The develop stage involved transforming the initial designs into a functional learning media and rigorously testing its quality through expert validation, practitioner assessment, and field trials. The evaluation began with a feasibility study conducted by two experts

(lecturers) to assess the instructional design, visual elements, and mathematical content. The results of the feasibility validation are presented in Table 5.

Table 5. Feasibility Validation Results from Experts

Evaluator	Score (%)
Expert 1	84.30%
Expert 2	87.14%

Based on the data in Table 5, the average feasibility score reached 85.72%, placing TransformaTech in the "Highly Feasible" category. This indicates that the integration of Batik-themed Scratch activities and the Challenge-Based Differentiated Learning model is theoretically sound and suitable for educational use.

Following the feasibility test, the media's practicality was evaluated by four practitioners (mathematics teachers) to determine its usability in a real classroom setting. The detailed practicality scores are shown in Table 6.

Table 6. Practicality Validation Results from Practitioners

Evaluator	Score (%)
Practitioner 1	85.00%
Practitioner 2	95.00%
Practitioner 3	85.00%
Practitioner 4	97.50%

The practitioners gave an average practicality score of 90.63%, which falls into the "Highly Practical" category. This high score is attributed to the website's intuitive navigation and the clarity of the Learning Style Test and The Challenge features, which assist teachers in managing differentiated instruction effectively.

After being declared feasible and practical, the media's effectiveness was tested through a trial with 29 students who utilized TransformaTech as their primary learning platform. The results showed an N-Gain score of 0.6068, indicating a "Moderate" improvement. This effectiveness percentage of 60.68% proves that TransformaTech successfully serves as a catalyst for enhancing students' computational thinking.

Furthermore, students provided a very positive response with an average score of 78.43%, indicating that TransformaTech successfully cultivated high levels of student engagement and enthusiasm by translating complex mathematical theories into an interactive learning experience.

Disseminate Stage

The final stage of the 4D model is dissemination, which focuses on sharing the validated TransformaTech website with the relevant educational community. At this stage, the dissemination was carried out on a limited basis by sharing the media directly with the mathematics teachers at SMP Negeri 13 Semarang for implementation in their classrooms. Furthermore, the media was also published through the FMIPA UNNES Instagram account and articles on Kompasiana to reach a broader audience.

CONCLUSION

This research successfully developed TransformaTech, an innovative website-based learning media that integrates the Challenge-Based Differentiated Learning model and Scratch programming to optimize students' computational thinking skills. The media achieved a high level of feasibility with an average score of 85.72% from experts and demonstrated excellent practicality with a score of 90.63% from practitioners. Furthermore, the implementation in the experimental class proved effective, yielding an N-Gain score of 0.6068 (moderate category), which confirms a good improvement in computational thinking skill. Students also provided a highly positive response with an average score of 78.43%, indicating that the interactive Batik-themed coding challenges successfully fostered a more engaging mathematical learning experience.

ACKNOWLEDGMENTS

First and foremost, the researchers express the deepest gratitude to Allah SWT for His blessings throughout the entire research process. Sincere appreciation is extended to the Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Negeri Semarang (UNNES) for providing the research funding that made this study possible. The researchers also wish to thank the Advisor for the mentorship, the mathematics teacher at SMP Negeri 13 Semarang for the exceptional cooperation, and all research colleagues who contributed to the successful completion of this research.

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