



Development of Interactive Multimedia Based on Culturally Responsive Teaching for Force to Enhance Problem-Solving Skills of Fifth-Grade Elementary Students

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ABSTRACT

This research was motivated by the need to improve students' problem-solving skills in IPAS learning, particularly on force, through learning connected to their daily lives and environment. This research aimed to develop interactive multimedia based on the Culturally Responsive Teaching (CRT) approach on force and determine its validity, practicality, and effectiveness. The research employed the Research and Development (R&D) method using the ADDIE model consisting of five stages: analysis, design, development, implementation, and evaluation.. The developed product, "Gatani Explore," integrates force with students' agrarian context and Polya-based problem-solving activities. The subjects were 26 fifth-grade students at SDN Karangtengah 1 Ngawi. Data were collected through expert validation, teacher and student response questionnaires, and pretest-posttest results. The multimedia achieved validity scores of 95.2% from material experts and 95.1% from media experts, categorized as highly valid. Practicality reached 91.5% from students and 92% from teachers, categorized as highly practical. Its effectiveness was indicated by an N-Gain score of 0.70 (high) and 100% posttest mastery. The Wilcoxon test showed an Asymp. Sig. (2-tailed) value of < 0.001. Thus, "Gatani Explore" was valid, practical, and effective in improving students' problem-solving skills.

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INTRODUCTION

Science education in elementary school aims not only to help students master scientific facts and concepts but also to enable them to apply that knowledge in their daily lives. Science instruction should provide meaningful experiences that encourage students to think critically, solve problems, and connect scientific concepts to real-world situations (Amelia et al., 2025). Problem-solving skills are a key competency because students need to understand problems, determine appropriate solution strategies, implement those strategies, and systematically evaluate the results (Hidayatulloh et al., 2020). Therefore, science education must provide learning experiences that encourage students to apply scientific knowledge to solve problems they encounter in their daily lives.

However, students still need to become accustomed to dealing with contextual problems that require systematic thinking. Teaching that remains conventional and teacher-centered can result in students being less actively engaged and less accustomed to solving problems that require higher-order thinking skills (Muna & Attalina, 2026). Students may also become more accustomed to solving routine problems rather than those related to real-life situations (Habibatuzzahro & Istianah, 2025). These conditions highlight the need for instruction that actively engages students and provides opportunities to develop problem-solving skills through meaningful and contextual situations.

This issue was identified in the teaching of force concepts to fifth-grade elementary school students. The concept of force is closely related to students' daily activities, such as pushing, pulling, lifting, and using various tools. However, instruction on force concepts is still primarily delivered through definitions and classifications, thereby limiting the connection between scientific concepts and students' daily experiences (Gumilar, 2023). The pretest results in this study showed that 58% of students achieved mastery, while 42% did not achieve mastery in solving problems related to problem-solving skills. These findings indicate that students' problem-solving skills regarding the topic of force still need to be improved.

One approach to addressing this issue is the use of instructional media that can present concepts in a more concrete, visual, and interactive manner. Learning media can help students understand concepts while creating a more engaging learning experience (Putri et al., 2025). Interactive multimedia allows students to interact directly with learning materials through various features such as navigation, questions, and feedback. Such interactions provide students with opportunities to participate more actively in the learning process (Surjono, 2017).

Research also highlights the potential of digital media in supporting science learning in elementary schools. Dwiqi et al. (2020) found that interactive multimedia can support the presentation of scientific concepts through engaging learning experiences. Additionally, Oktarizka & Abidin (2024) identified a need for digital learning media to support higher-order thinking skills among fifth-grade elementary school students. Meanwhile, Sofia et al. (2024) reported that educational media can support students' understanding of scientific concepts and their problem-solving abilities. These findings indicate that the development of interactive and digital media can support science learning while providing students with opportunities to engage more actively in the learning process.

In addition to the use of interactive media, science learning needs to be connected to students' experiences and sociocultural environments so that scientific concepts become more meaningful. Learning that is closely related to students' lives can help them understand concepts contextually (Ummah et al., 2025). This is particularly relevant for students in Ngawi, who live in an agrarian environment closely tied to community life. Activities such as hoeing, plowing rice fields, pushing carts loaded with crops, and using farming tools involve various forms of force that can be observed in the students' immediate surroundings (Fadlillah et al., 2023). Therefore, the local environment can be utilized as a learning resource for understanding the concept of force.

Local culture and community activities also have the potential to serve as contextual resources in science education. Kasi et al. (2024) demonstrate that local cultural contexts can be utilized in science education to make learning more closely aligned with students' experiences. This provides an opportunity to develop instruction that does not separate scientific concepts from the environment in which students live.

Integrating students' cultural backgrounds and experiences into learning can be achieved through the Culturally Responsive Teaching (CRT) approach. CRT emphasizes the use of students' cultural backgrounds, experiences, and environments as meaningful components of the learning process (Gay, 2010). Utilizing students' social and cultural contexts can also support the creation of learning experiences that are more relevant to them (Fitriani et al., 2024). In this study, the agrarian context of the Ngawi community was integrated into interactive multimedia so that the concept of force could be presented through situations familiar to the students.

The development of problem-solving skills in the multimedia is further supported by Polya's problem-solving stages: understanding the problem, formulating a plan, executing the plan, and reviewing the solution (Polya, 1973). These stages provide a systematic framework for students to identify relevant information, determine a solution strategy, implement the strategy, and evaluate their solution. Safitri & Hadi (2024) demonstrate that the use of systematic problem-solving stages can support students in developing problem-solving abilities. Therefore, integrating Polya's stages into interactive multimedia can provide students with structured opportunities to apply problem-solving concepts when addressing contextual problems.

Previous research has examined the use of various media to develop students' problem-solving skills. Yani (2025), for example, developed SSCS-based worksheets to support problem-solving activities. Sofiah (2024) used comic-based learning media to develop students' problem-solving skills. These studies indicate that learning media can be designed to facilitate students' problem-solving processes. However, the media used in those studies differ from the interactive multimedia developed in this study.

Research on CRT-based media also highlights the importance of linking learning content to students' cultural contexts. Arini et al. (2025) developed learning media that integrates cultural contexts into the learning process. However, the integration of CRT with agrarian contexts, interactive multimedia, and systematic problem-solving activities in style-related content has not been specifically addressed in the previous studies outlined above.

Previous studies have also highlighted the importance of developing instructional media that support science learning and connect scientific concepts with students' contextual experiences. Lisnawati & Kristin (2024) developed the Kirandalam learning media to support learning outcomes in fourth-grade elementary school students. Their study illustrates how instructional media can be designed to support the delivery of learning materials and provide students with more engaging learning experiences. In addition, Mulia et al. (2026) examined the need for an Ethno-STEM-based learning kit using the traditional slingshot game to teach force and energy in elementary schools. This study emphasizes the potential of integrating cultural activities into science learning to help students relate scientific concepts to familiar experiences. These findings are relevant to the present study because they highlight the importance of developing learning media that connect scientific concepts with students' sociocultural environments. However, the previous studies have not specifically addressed the integration of interactive multimedia, the Culturally Responsive Teaching (CRT) approach, and systematic problem-solving activities within a single learning resource for teaching force in elementary schools. This gap provides an opportunity to develop learning media that combine contextual science learning with structured problem-solving activities.

The novelty of this study lies in the development of “Gatani Explore,” an interactive multimedia program that integrates the agrarian context of Ngawi with Polya’s problem-solving stages through the CRT approach. By presenting force-related problems drawn from students’ familiar surroundings, the multimedia is designed to help students connect scientific concepts with their everyday experiences while practicing systematic problem-solving. This integration distinguishes the present study from previous research on instructional media, cultural contexts, and science learning.

Based on the identified problems and research gap, this study aims to develop interactive multimedia oriented toward the Culturally Responsive Teaching (CRT) approach for teaching force to fifth-grade elementary school students and to evaluate its validity, practicality, and effectiveness in improving students’ problem-solving skills.

METHODS

Type and Design

This study is a research and development (R&D) project that employs a mixed-methods approach. The mixed-methods approach integrates quantitative and qualitative data to gain a more comprehensive understanding of the research process and outcomes (Creswell, 2014). Product development utilized the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Rayanto & Sugianti, 2020). The procedures for multimedia development at each stage followed the application of the ADDIE model, adapted from Muryandari & Sujatmiko (2025).

The study was conducted at SDN Karangtengah 1 Ngawi with 26 fifth-grade students as research subjects during the 2026–2027 school year. The product pilot test used a One-Group Pretest-Posttest Design, which included administering a pretest before the intervention, using interactive multimedia based on Culturally Responsive Teaching (CRT) as the intervention, and administering a posttest after the intervention. The pilot test was conducted during lessons on forces using contextual problems related to daily life and agricultural activities. This design was used to determine changes in students’ problem-solving skills before and after the use of multimedia.

Data and Data Sources

The research data sources consisted of validators, teachers, and students. Validation data were obtained from two validators—a subject matter expert and a media expert—through validation sheets provided before the product was tested. This data consisted of assessment scores as well as comments, critiques, and suggestions used to evaluate the product’s suitability and serve as the basis for product improvements.

Practicality data were obtained from the responses of teachers and 26 students after using the multimedia in learning activities. Meanwhile, effectiveness data were obtained from the pretest and posttest results of 26 students during the field trial.

Data collection technique

The research instruments included validation sheets for subject matter experts and media experts, response questionnaires for teachers and students, and a problem-solving skills test. The validation sheets were used to assess content and media aspects. The response questionnaires were used to determine the level of practicality of the multimedia based on users’ experiences after using the product. The test was used to measure students’ problem-solving skills before and after using the multimedia.

Quantitative data from the validation forms and response questionnaires were analyzed using a four-point Likert scale. The scale was modified to four points to avoid neutral response options, thereby making response trends more clearly visible (Erinsyah et al., 2024). On the validation sheet, a score of 4 indicates "very good," a score of 3 indicates "good," a score of 2 indicates "not very good," and a score of 1 indicates "very poor" (Rahayu & Anwar, 2024). On the response questionnaire, a score of 4 indicates "strongly agree," a score of 3 indicates "agree," a score of 2 indicates "disagree," and a score of 1 indicates "strongly disagree" (Prasetyo & Purwihartuti, 2025).

Data analysis

Qualitative data in the form of comments, criticisms, and suggestions from validators were analyzed descriptively by identifying feedback related to the product's strengths, weaknesses, and aspects that need improvement. The results of this analysis were used as the basis for revising the multimedia before testing. Quantitative data analysis was conducted on data regarding validity, practicality, and effectiveness.

Validity data were analyzed by calculating the percentage of the obtained score relative to the maximum score using the formula:

$$V_{ah} = \frac{TS_e}{TS_h} \times 100\%$$

Notes:

V_{ah} = validity percentage;

TS_e = total score obtained;

TS_h = total maximum score.

After being calculated using that formula, the percentage results were then interpreted based on the validity criteria shown in Table 1 below.

Table 1. Percentages and validity criteria

Percentages	Validity categories
81% - 100%	Very Valid
61% - 80%	Valid
41% - 60%	Fairly Valid
21% - 40%	Less Valid
0% - 20%	Invalid

(Andriani et al., 2025)

Practicality data were analyzed based on the responses of teachers and students after using interactive multimedia. The practicality percentage was determined by comparing the scores obtained to the maximum possible score. The calculation was performed using the following formula:

$$P = \frac{\Sigma \text{ scores obtained}}{\Sigma \text{ maximum scores}} \times 100\%$$

Notes:

P = Percentage of practicality

Σ scores obtained = Total scores from respondents
 Σ maximum scores = Maximum scores for all questionnaire items

The resulting practicality percentage was then interpreted based on practicality criteria to determine the level of practicality of the interactive multimedia. The practicality percentage criteria and categories are presented in Table 2 below.

Table 2. Percentages and practicality criteria

Percentages	Practicality categories
$80\% < P \leq 100\%$	Very Practical
$60\% < P \leq 80\%$	Practical
$40\% < P \leq 60\%$	Fairly Practical
$21\% < P \leq 40\%$	Less Practical
$0\% < P \leq 20\%$	Impractical

(Azizah & Zuhdi, 2025)

The effectiveness of multimedia was analyzed based on students mastery and improvement in problem-solving skills. Students were considered to have achieved mastery if they obtained a score of ≥ 75 . The mastery rate was calculated by comparing the number of students who achieved a score of ≥ 75 with the total number of students, then multiplying by 100% (Hermawan et al., 2024). Improvements in problem-solving skills were analyzed using N-gain with the following formula:

$$\text{N-Gain} = \frac{\text{posttest} - \text{pretest}}{\text{score ideal} - \text{pretest}}$$

The N-gain value is then interpreted based on Hake's categories as outlined by Sukarelawan, (2024), namely $0,70 \leq g \leq 100$ for the high category, $0,30 \leq g < 0,70$ for the moderate category, and $0,00 < g < 0,30$ for the low category. Multimedia is considered effective if it achieves an N-gain of ≥ 0.30 —or at least falls within the moderate category—and the percentage of students meeting the proficiency standard is greater than 61%.

Furthermore, to determine the difference in problem-solving skills before and after the use of multimedia, a Shapiro-Wilk normality test was conducted at a significance level of 0.05. Since the data were not normally distributed, the analysis of differences between the pretest and posttest was performed using the Wilcoxon Signed-Rank Test. Decision-making was based on the Sig. (2-tailed) value. A significance value < 0.05 indicates a significant difference between the pretest and posttest results.

FINDINGS AND DISCUSSION

Findings

This study produced an interactive multimedia resource based on the Culturally Responsive Teaching (CRT) approach for teaching the topic of wind styles to fifth-grade elementary school students. The product, named Gatani Explore, was developed using the ADDIE model, which consists of the Analysis, Design, Development, Implementation, and Evaluation phases. The multimedia resource was designed to integrate the topic of wind styles

with the students' real-life contexts, particularly agricultural activities common in the Ngawi community.

The multimedia was developed using Canva and features interactive navigation, content presentation, "Explore" activities, and Wordwall-assisted assessment. The material presented covers friction, muscle force, and magnetic force. The application of the CRT is evident through the use of agricultural contexts in the presentation of material and problem-solving scenarios, such as using a cart to move sacks, hoeing and plowing rice fields, and the problem of scattered bolts when a farmer repairs a tractor tire.



Figure 3. Force Materials Menu



Figure 4. Friction Force Materials Menu



Figure 5. Muscular Force Materials Menu



Figure 6. Magnetic Force Materials Menu



Figure 7. Problem-Solving Exploration



Figure 8. Incorrect Answer Display



Figure 9. Correct Answer Display



Figure 10. Wordwall Quiz

The “Explore” activity is designed using Polya’s four-step problem-solving process: understanding the problem, formulating a plan, carrying out the plan, and reviewing. Students are presented with contextual problems related to friction, muscle force, and magnetic force and are guided through each stage of the problem-solving process.

Validity Of Interactive Multimedia

The validity of the multimedia was established through validation by subject matter experts and media experts before the product was used in a learning pilot study. The validation assessed the appropriateness of the content, instructional presentation, and visual and technical quality of the interactive multimedia. The results of the validation by subject matter and media experts are presented in Table 3.

Table 3. Results of the validation by media experts and subject matter experts

Subject Matter Expert Validation				Media Expert Validation		
Aspect		Scores obtained	Maximum score	Aspect	Scores obtained	Maximum score
Content Suitability	Aspects	39	40	Visual Aspects	39	40
Aspects of Material Presentation		37	40	Audio and Animation Aspects	31	32
Aspects of the Culturally Responsive Teaching Approach		30	32	Interactivity Aspects	31	32
Problem-Solving Skills Aspect		32	32	Aspects of Alignment with Student Characteristics	23	24
				Technical Aspects	29	32
Language Aspect		22	24	Aspects of Integrating the CRT Approach into the Media	24	24
Percentage of Score		95,2%		Percentage of Score		95,1%
Percentage Criteria		Very Valid		Percentage Criteria		Very Valid

The interactive multimedia achieved a validity percentage of 95.2% from subject matter experts and 95.1% from media experts. Both results were categorized as “very valid.” The validation results indicate that the multimedia met the eligibility criteria in terms of content and media presentation. Although the product received a “very valid” rating, the validators provided recommendations for revision. Content revisions included making the language more communicative and interactive, adapting examples to daily life and agricultural contexts, and aligning the learning objectives with the presented material. Media revisions included refining the user guide, improving navigation design, limiting animations, adding details to directional visualizations, and adjusting the font.

Practicality of Interactive Multimedia

The practicality assessment was conducted after the product was used in learning activities to determine its ease of use, attractiveness, clarity of material presentation, interactivity, and usefulness

in supporting learning. Student responses were obtained from 26 fifth-grade students, while teacher responses were obtained after the teacher used and observed the multimedia during classroom activities. The results are presented in Table 4.

Table 4. Results of the students and teachers feedback survey

Student Feedback Survey			Teacher Feedback Survey		
Aspect	Scores obtained	Maximum score	Aspect	Scores obtained	Maximum score
Ease of Use	371	416	Multimedia Appearance	14	16
Attractiveness	387	416	Material	10	12
Material Clarity	290	312	Culturally Responsive Teaching Approach	15	16
Interactivity	286	312	Learning	15	16
CRT Approach	279	312	Problem-Solving Skills	15	16
Problem-Solving Skills	291	312	Usefulness	23	24
Percentage of Score	91,5%		Percentage of Score	92%	
Percentage Criteria	Very Practical		Percentage Criteria	Very Practical	

The student questionnaire produced a response percentage of 91.5%, categorized as “very practical,” while the teacher questionnaire produced a response percentage of 92%, also categorized as “very practical.”

Effectiveness of Interactive Multimedia

The effectiveness of the multimedia was assessed based on mastery, score improvement, and differences between pretest and posttest problem-solving scores. The pilot study involved 26 fifth-grade students at SDN Karangtengah 1 Ngawi. Before using the multimedia, 5 students achieved scores of ≥ 75 , while 21 students had not yet achieved mastery. The pretest mastery rate was therefore 19.23%. After using the multimedia, all 26 students achieved scores of ≥ 75 , resulting in a posttest mastery rate of 100%. The improvement in individual scores was distributed as follows: 5 students improved by 10 points, 7 students by 20 points, 10 students by 30 points, 2 students by 40 points, and 2 students by 50 points. The 30-point improvement was the most common, occurring among 10 students (38.46%).

Table 5. Multimedia Effectiveness Results

Indicator	Result	Description
Pretest Mastery	19,23%	5 of 26 students
Posttest Mastery	100%	26 of 26 students
N-Gain	0,70	High
High N-Gain Category	13 students	50%
Medium N-Gain Category	13 students	50%

Low N-Gain Category	0 students	0%
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The average N-Gain score was 0.70, which was categorized as high. A total of 13 students were in the high category and 13 students were in the medium category, while no students were in the low category. A Shapiro-Wilk normality test was conducted to determine the distribution of the pretest and posttest data. The results indicated that the data were not normally distributed; therefore, the analysis continued using the Wilcoxon Signed-Rank Test. The Wilcoxon test produced an Asymp. Sig. (2-tailed) value of <0.001, indicating a significant difference between students' pretest and posttest problem-solving scores

Discussion

The development of Gatani Explore followed the ADDIE model and integrated the Culturally Responsive Teaching (CRT) approach by presenting learning activities within agricultural contexts familiar to students. The use of local contexts allows students to connect scientific concepts with their everyday experiences, making learning more meaningful and relevant. This approach is consistent with Berliana et al. (2026), who emphasize that culturally relevant learning can connect classroom instruction with students' backgrounds and experiences.

The integration of CRT in Gatani Explore is also reflected in the selection of examples related to agricultural activities, such as plowing fields, using farming tools, and transporting crops. These contexts were selected because they are closely related to the students' surrounding environment. Sari & Istianah (2021) explain that connecting learning with students' local environment can help create contextual and meaningful learning experiences.

The material validation result of 95.2% indicates that the content presented in Gatani Explore was highly valid. Several revisions were made based on validator suggestions, particularly regarding the communicativeness of the language, the relevance of everyday examples, and the alignment of learning objectives. These revisions ensured that the material was more appropriate for fifth-grade students. Dewi et al. (2024) state that learning materials need to use language and examples that are appropriate to students' developmental characteristics.

The media validation result of 95.1% also indicates that Gatani Explore had a high level of validity in terms of its visual and interactive aspects. Improvements included navigation, animation, font selection, and the presentation of force directions. These improvements were intended to make the multimedia easier to operate and visually support students' understanding. According to Winatha and Artha (2023), interactive media can improve the quality of learning when its visual and navigation elements are designed according to learners' needs.

The practicality results showed that Gatani Explore received positive responses from both students and teachers, with percentages of 91.5% and 92%, respectively. The interactive navigation, contextual examples, and learning activities made the multimedia easy to use during classroom instruction. Nurussyifa et al. (2021)(Nurussyifa et al., 2021) found that interactive learning media can facilitate students in participating actively and independently during learning activities.

The effectiveness of Gatani Explore was demonstrated by the improvement in students' problem-solving skills. The N-Gain score of 0.70 was categorized as high, while the Wilcoxon test produced a significance value of <0.001. These results indicate a significant improvement in students' problem-solving skills after using the developed multimedia. Damanik & Fajari (2025) explain that contextual and interactive learning can support students in developing their ability to solve problems through meaningful learning experiences.

The improvement in problem-solving skills was supported by the integration of Polya's problem-solving stages into the learning activities. Students were guided to understand the problem, develop a solution plan, carry out the plan, and recheck the results. This structure provided students with systematic guidance when solving problems related to force materials. Polya (1973) emphasizes that these four stages help learners approach problems systematically and evaluate the solutions they obtain.

The CRT approach further strengthened the problem-solving process by presenting problems related to students' daily agricultural environment. Through these contexts, students were encouraged to identify force concepts in situations they were already familiar with. Utari et al. (2025) indicate that contextual learning can help students connect abstract concepts with real situations, thereby supporting deeper understanding.

The effectiveness of the multimedia is also supported by the use of interactive activities and evaluation through Wordwall. These features provided students with opportunities to practice concepts and receive feedback during learning. Ahmad & Sari (2025) found that interactive digital learning activities can increase student engagement and provide opportunities for students to practice their understanding.

Compared with previous studies, Gatani Explore combines interactive multimedia, CRT, agricultural cultural contexts, and Polya-based problem-solving activities within one learning medium. Sari & Jupriyanto (2023) developed interactive learning media to support science learning, while Syakbany et al. (2025) emphasized the use of CRT in connecting learning with students' cultural backgrounds. Gatani Explore extends these approaches by integrating both cultural context and structured problem-solving activities into interactive multimedia.

Overall, the findings indicate that Gatani Explore is not only feasible as an interactive learning medium but also provides a learning experience that connects force concepts with students' local environment. The combination of CRT, interactive multimedia, and Polya's problem-solving stages contributes to making the learning process more contextual and systematic, while supporting the improvement of students' problem-solving skills.

CONCLUSION

This study resulted in an interactive multimedia based on the Culturally Responsive Teaching (CRT) approach for teaching force concepts to fifth-grade elementary school students. The multimedia was developed using the ADDIE model and integrated agricultural contexts that were familiar to students with problem-solving activities based on Polya's stages. The validation results showed that the multimedia was highly valid, with scores of 95.2% for material validity and 95.1% for media

validity. The multimedia was also highly practical, as indicated by student and teacher responses of 91.5% and 92%, respectively. The effectiveness results showed an increase in students' problem-solving skills after using the multimedia. The percentage of students achieving mastery increased from 19.23% in the pretest to 100% in the posttest, with an average N-Gain score of 0.70, categorized as high. The Wilcoxon Signed-Rank Test also indicated a significant difference between the pretest and posttest scores (Asymp. Sig. <0.001). Therefore, the developed interactive multimedia fulfilled the criteria of validity, practicality, and effectiveness and can be used as a learning medium for force concepts while supporting the development of elementary school students' problem-solving skills.

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