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Effectiveness of AR-STEM Integrated Cognitive Conflict-Based Physics Websites to Improve Critical Thinking and Remediation of Students' Misconceptions on Static Fluid

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ABSTRACT

Critical thinking skills and conceptual understanding form a crucial foundation in physics education, enabling students to grasp abstract concepts, analyze various phenomena, and solve problems scientifically. However, low critical thinking skills and prevalent misconceptions regarding static fluids remain significant issues, necessitating instructional innovations that address both aspects. This study aimed to evaluate the effectiveness of an AR- and STEM-integrated, cognitive-conflict-based physics website in enhancing students' critical thinking skills and remediating misconceptions. A quantitative approach was employed quasi-experimental method with pre-test and post-test control group design. The study sample consisted of 68 Grade XI (Phase F) students from SMAN 2 Padang Panjang. Data were collected using a four-tier diagnostic test and analyzed through both descriptive and inferential statistics (specifically the Mann-Whitney test). The results indicated that students in the experimental class demonstrated superior critical thinking skills compared to those in the control class, while also exhibiting lower levels of misconceptions following instruction. The Asymp. Sig. (2-tailed) value of 0.000 (p<0.05) demonstrates that the AR-STEM-integrated, cognitive-conflict-based physics website is effective in enhancing critical thinking skills and remediating misconceptions regarding static fluids. This website holds potential as an alternative digital open resource to support physics learning.

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INTRODUCTION

Critical thinking skills are one of the main skills needed in 21st-century education because students are faced with increasingly complex developments in information, technology, and problems. This ability is not only related to the ability to think rationally and logically, but also the ability to analyze information, evaluate evidence, and make decisions that can be intellectually accounted for (Wardani & Fiorintina, 2023). In physics learning, critical thinking skills are very important because students are required to understand abstract concepts, analyze relationships between concepts, and explain various natural phenomena based on scientific principles (Mahombar et al., 2026). During the learning process, it is necessary to provide opportunities for students to ask questions, reflect, and solve problems so that critical thinking skills can develop optimally (Arsyad, 2024). Therefore, the development of critical thinking skills is one of the main goals that must be achieved in the 21st-century learning process.

Critical thinking skills are closely related to concept comprehension. Understanding concepts is not only demonstrated through the ability to remember facts or formulas, but also the ability to explain concepts with relevant phenomena, applying them in a variety of contexts (Atmam & Mufit, 2023;Admas et al., 2025). A good understanding of concepts will support students in conducting logical analysis, evaluation, and decision-making so that critical thinking skills can develop (Rasyid et al., 2024). Low critical thinking skills can cause students to receive information without evaluating the truth of the concepts learned. Critical thinking skills affect the level of misconception experienced by students, where students with low critical thinking skills tend to have a high level of misconception (Maison et al., 2022). Students often enter learning with various preconceptions that are not in accordance with scientific concepts so that they have the potential to develop into misconceptions if they are not identified and corrected through proper learning (Ozkan & Topsakal, 2020).However, the reality on the ground shows that students' critical thinking skills are still low and many misconceptions are still found. This can be seen from the results of the initial test conducted on grade XII Phase F students at SMAN 2 Padang Panjang. The test results showed that the level of completion obtained was still low, thus indicating that students' critical thinking skills have not developed optimally. In addition, the level of misconceptions in the static fluid material is still relatively high, which indicates that students still experience errors in understanding several concepts. The results of the initial test regarding students' critical thinking skills can be seen in Table 1.

Table 1. Results of the Initial Test of Critical Thinking Ability

No	Aspects of Students' Critical Thinking	Student Completion Percentage (%)	Explanation
1	Basic Explanation	58.93	Critical
2	Decision Making Policy	48.81	Quite Critical
3	Conclusion	47.62	Quite Critical
4	Further Explanation	44.44	Quite Critical
5	Suspicion or Integration	41.67	Quite Critical

Based on the results of the initial test, students' critical thinking skills still need to be improved, especially in the aspect of conjecture or integration which obtained the lowest percentage of completeness (41.67%). The low achievement in this aspect shows that students still have difficulty in connecting various concepts and information to form logical predictions, conjectures, or solutions. This condition is allegedly caused by learning that still focuses on understanding concepts separately and the lack of optimal students' ability to integrate their knowledge to solve more complex problems.

In addition to measuring students' critical thinking skills, the four-tier test instrument is also capable of identifying misconceptions students have regarding the concepts being studied. The initial test results showed that the majority of students still had misconceptions regarding the static fluid material. This condition indicates that students' initial understanding is not fully in accordance with correct scientific concepts. The high level of misconceptions indicates the need for learning that can facilitate conceptual change in students. The percentage of the results of the identification of students' conceptual understanding and misconceptions can be seen in Table 2.

Table 2. Results of the Initial Test of Student Comprehension

No	Concept Understanding Aspects	Student Completion Percentage (%)	Explanation
1	Understand the Concept	21.23	Correct concept
2	Don't Understand the Concept	9.38	No concept mastery
3	Misconceptions	69.38	Incorrect concept

Based on the results of the initial concept understanding test, the percentage of misconceptions that reached 69.38% showed that most students had an understanding that was not in accordance with the actual scientific concept. The high percentage of misconceptions shows that most students still have an understanding that does not correspond to the actual scientific concept. These results are also supported by research Mellu & Langtang (2023) showed a misconception of 57.71% in static fluid matter. Therefore, misconceptions in static fluid concepts remain a significant issue that requires serious attention.

Based on the results of interviews with physics teachers at SMAN 2 Padang Panjang, it is known that learning has utilized learning resources such as student worksheet books, power point, and learning videos. However, the learning process is still dominated by the delivery of material and practice questions so that the opportunity for students to investigate, evaluate concepts, and build knowledge independently is still limited. Learning that is still teacher-centered and does not facilitate students' exploratory activities contributes to low conceptual understanding and critical thinking skills (Mufit et al., 2023). Therefore, a learning innovation is needed that is able to facilitate students to develop critical thinking skills as well as remediation of misconceptions.

One of the solutions that can be used to overcome the low critical thinking skills and high misconceptions of students is the application of a cognitive conflict-based learning model. This model is designed to expose students to situations that are contrary to their initial concepts, causing imbalances and encouraging conceptual changes towards more scientific concepts (Mufit & Fauzan, 2019). Through this process, students are not only required to compare initial understanding with new information, but also evaluate the evidence obtained and reconstruct their concepts. This condition makes cognitive conflict effective in developing critical thinking skills because students are encouraged to analyze, evaluate, and formulate arguments logically (Wilujeng & Hidayatullah, 2021). Various studies show that the application of cognitive conflict has a positive impact on physics learning. Puspitasari et al (2022) stated that cognitive conflict-based media is practically used in physics learning, while Mufit et al. (2023) stated that cognitive conflict-based learning (CCBL) is effective in remedying students' misconceptions. In addition, interactive multimedia based on cognitive conflict can improve students' conceptual understanding of physics material (Atmam & Mufit 2023). These results indicate that the cognitive conflict model improves critical thinking, conceptual understanding, and misconception remediation.

The application of cognitive conflict can be optimized through the use of digital technology, one of which is Augmented Reality (AR). AR technology is able to visualize objects and phenomena in the form of three dimensions so that abstract concepts become more concrete and easy to understand by students (Mufit et al., 2023). The visualization helps students understand the relationships between concepts and observe phenomena that are difficult to observe directly (Mufit et al., 2023). In addition to increasing understanding of concepts, the use of AR can also increase students' activeness through direct interaction with virtual objects. AR-based media has a positive influence on improving students' critical thinking skills (Hasan et al., 2025). Research Mufit & Dhanil (2024) stated that the integration of AR with cognitive conflict models is able to improve students' understanding of physics through a more contextual and interactive learning experience.

In addition to AR, the Science, Technology, Engineering, and Mathematics (STEM) approach also has the potential to improve students' critical thinking skills. This approach integrates various disciplines to help students analyze and solve problems critically through student-centered learning activities (Nurazmi & Bancong, 2021;Ashidiq et al., 2024). Through this approach, students not only learn theoretical concepts, but also engage in activities of observing, struggling, and evaluating solutions to a problem. The integration of STEM in physics learning allows students to connect the concepts they learn with real problems so that the learning process becomes more contextual, meaningful, and able to support the development of critical thinking skills (Wahyuni et al., 2023;Hafitria & Efwinda, 2024).

Various studies have developed learning media based on cognitive conflict, interactive multimedia, and Augmented Reality technology in physics learning. Atmam and Mufit (2023) developed interactive multimedia based on cognitive conflicts that were declared valid to improve understanding of concepts. Mufit et al (2023) show that Cognitive Conflict-based multimedia is effective in improving students' 21st century skills. Another study by Mufit and Dhanil (2024) proves that the integration of Augmented Reality with cognitive conflict models is effective in increasing science literacy in static fluid materials Furthermore, previous studies have demonstrated that an AR-STEM integrated cognitive conflict-based physics website is valid and practical (Mufit et al., 2026; Mufit et al., 2025). The website contains a syntax of cognitive conflict combined with AR visualization and STEM activities in one integrated digital learning environment to support a more interactive and meaningful learning process.

Based on this description, further research will be carried out, namely the effectiveness of a cognitive conflict-based physics website that integrates AR technology and STEM approaches to improve critical thinking skills and remediation of students' misconceptions about static fluid materials. Therefore, this study aims to analyze the effectiveness of AR-STEM integrated cognitive conflict-based physics websites and improve students' critical thinking skills and remediation of misconceptions in static fluid materials. The results of the research are expected to contribute as an innovative alternative to technology-based physics learning media for teachers and become a reference in the development of digital-based physics learning to improve the quality of physics learning.

METHODS

This study used a quantitative approach with a quasi-experimental method using a pretest-posttest control group design. The study was conducted in the odd semester of the 2025/2026 academic year at SMAN 2 Padang Panjang. The research subjects consisted of two classes: an experimental class that received learning using a Cognitive Conflict-based physics website integrated with Augmented Reality (AR) and STEM, and a control class that used teaching materials commonly applied in schools. Both classes were given pretests and posttests to determine differences in critical thinking skills and levels of misconceptions after the learning process.

The study population consisted of all students of Grade XI Phase F, which consisted of two classes with a total of 68 students. The sampling technique used was total sampling, where all members of the population were selected as research samples (Sugiyono, 2013). This technique was chosen because the population was limited and consisted of only two classes. Before the treatment, both classes were tested for equality using pretest data through normality, homogeneity, and independent sample t-tests. The results of the equality test showed a significance value of 0.573 (p > 0.05), which indicated that both classes had equivalent initial abilities and were suitable to be used as experimental and control classes. Based on the lottery results, Class XI F1 was designated as the experimental class, while Class XI F2 was designated as the control class.

The research instrument is in the form of a four-tier diagnostic test for critical thinking skills and identifying misconceptions in static fluid materials. The instrument is compiled based on critical thinking indicators put forward by (Ennis, 2011), namely basic explanations, decision-making basis, conclusion drawn, further explanation, and conjecture or integration. The four-tier diagnostic instrument used in this study consists of four levels. This four-tier diagnostic instrument consists of multiple-choice questions, confidence ratings for the selected answers, reasons for those answers, and confidence ratings for the selected reasons. (Juliani et al., 2021). The combination of responses at the four levels was used to identify the student's level of conceptual understanding and classify them into the category of understand, don't understand, or Misconception.

Table 3. Diagnostic Four-Tier Classification Criteria

Criteria	Answer	Confidence Answer	Reason	Confidence Reason
Understand	True	High	True	High
Don't Understand	True	High	True	Low
	True	High	False	Low
	True	Low	True	High
	True	Low	True	Low
	True	Low	False	Low
	False	Low	True	Low
	False	Low	True	High
	False	Low	False	Low
Misconception	True	High	False	High
	True	Low	False	High
	False	High	True	High
	False	High	True	Low
	False	High	False	High
	False	High	False	Low
	False	Low	False	High

(Zulrahayu & Mufit, 2024)

Before being used in the research, the instrument was first pilot-tested on 11th-grade students of SMAN 13 Padang to determine its quality and suitability as a data collection tool. The instrument pilot-testing involved several analytical steps, including validity, reliability, difficulty index, and item discrimination. The analysis showed that of the 30 items tested, the items were considered valid if they had a calculated $r_{count} > r_{table}$ (0.361). Based on the test results, 19 items met the validity criteria and were subsequently used as the research instrument. Furthermore, the test results showed that the instrument had a validity value of 0.467, which is considered moderately valid. The reliability value of 0.712 indicates that the instrument has a high level of consistency, thus deeming it suitable and suitable for collecting research data accurately and reliably.

The research data was analyzed using descriptive statistics and inferential statistics with the help of SPSS version 25. Descriptive statistics are used to describe the highest scores, lowest scores, averages, and standard deviations and variances. Before the hypothesis test was carried out, the data were first tested for prerequisites using the Shapiro-Wilk normality test and the

Levene Test homogeneity test at a significance of 0.05. The data is declared to be normally distributed if the significance value (Sig.) is > 0.05 and is declared homogeneous if the significance value of the Levene Test is > 0.05 (Ghozali, 2018). The results of the normality and homogeneity tests are used as a basis for determining the type of hypothesis test used. If the data meets the assumptions of normality and homogeneity, then hypothesis testing is carried out using an independent sample t-test to determine the difference in learning outcomes between the experimental class and the control class. On the other hand, if one or both of these assumptions are not met, then hypothesis testing is carried out using the Mann-Whitney nonparametric test as an alternative analysis.

RESULTS AND DISCUSSION

Results

Analysis Results of Critical Thinking Skills

Students' critical thinking skills were measured through a posttest administered after the entire learning process in the experimental and control classes was completed. The posttest results were used to describe the level of achievement of students' critical thinking skills in each class after receiving different learning treatments. Furthermore, the posttest data were analyzed using descriptive statistics to determine the characteristics of the scores in both classes. Descriptive statistics of the posttest results of students' critical thinking skills are presented in Table 4.

Table 4. Student Posttest Results

Classes	N	Value		X	S	S^2
		Highest	Lowest			
Experiments	35	89	58	77	8.35	71.78
Controls	33	74	32	53	12.67	165.55

Based on Table 4, the critical thinking skills of students in the experimental class showed better results compared to the control class after participating in the learning. These results indicate that the AR-STEM-integrated Cognitive Conflict-based physics website is able to facilitate the development of critical thinking skills through activities that encourage students to identify problems, analyze information, and draw conclusions based on the evidence obtained. The presentation of cognitive conflicts supported by augmented reality visualizations and STEM-based activities provides a more meaningful learning experience so that students are encouraged to redistribute their initial understanding. This process makes students more active in providing reasons, generating alternative solutions, and formulating decisions logistically. Thus, AR and STEM integrated cognitive conflict provides a learning experience that supports the development of students' critical thinking skills.

To obtain a more detailed picture of students' critical thinking skills, an analysis was conducted on each indicator of critical thinking skills after the learning implementation. The indicators analyzed included Basic Explanation (BE), Basis for Decision Making (DM), Drawing Conclusions (DC), Further Explanation (FE), and Conjecture or Integration (CI). This analysis aimed to determine which aspects of critical thinking skills had improved after using the AR-STEM-integrated Cognitive Conflict-based physics website. The results of the analysis showed differences in achievement for each indicator of critical thinking skills between the experimental and control classes. A comparison of the achievement of each indicator of students' critical thinking skills is presented in Figure 1.

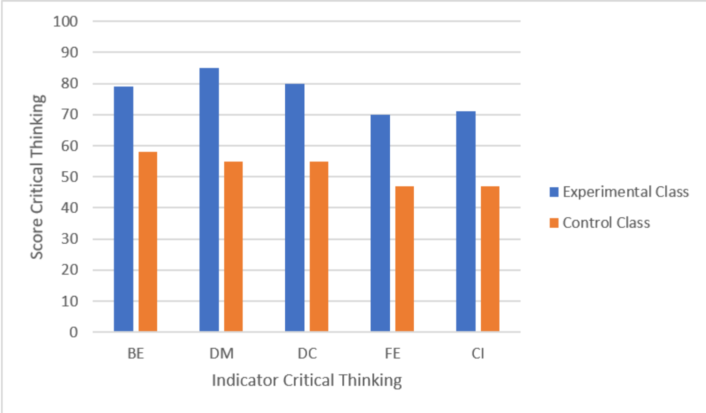

Figure 1. Students' Posttest Critical Thinking Skills by Indicator

Based on Figure 1, all critical thinking ability indicators in the experimental class, namely BE, DM, DC, FE, and CI, obtained higher scores than the control class. The largest score difference was seen in the DM indicator, while the FE and CI indicators obtained the lowest scores in both classes. These results indicate that the use of a physics website based on Cognitive Conflict integrated with AR-STEM can facilitate students in analyzing information, evaluating evidence, and drawing conclusions better than learning commonly used in schools. Thus, the developed website makes a positive contribution to improving students' critical thinking abilities in static fluid material.

After conducting the prerequisite test, the critical thinking ability data did not meet the assumptions for parametric analysis, so the hypothesis testing was conducted using the Mann–Whitney test. This test aims to determine whether there is a significant difference in critical thinking ability between students in the experimental class and the control class after the learning implementation. The results of the hypothesis testing were used to determine the effectiveness of the AR-STEM integrated cognitive conflict-based physics website in improving students' critical thinking abilities. The results of the critical thinking ability hypothesis test are presented in Table 5.

Table 5. Results of Critical Thinking Posttest Hypothesis Test Data

No	Non-Parametric Test	Critical Thinking Posttest Results
1	Mann-Whitney U	51.000
2	Wilcoxon W	612.000
3	Z	-6.474
4	Asymp. Sig. (2-tailed)	0.000

The results of the hypothesis test showed that the critical thinking skills of students in the experimental class were significantly different compared to the control class after the learning. This difference indicates that the use of a physics website based on Cognitive Conflict integrated with AR-STEM provides a more effective learning experience in training students' critical thinking skills. Through the cognitive conflict learning stages, students are encouraged to identify problems, analyze evidence, evaluate initial concepts, and draw conclusions based on correct scientific concepts. The integration of Augmented Reality technology also helps students visualize abstract static fluid phenomena so that the analysis and reasoning process is more optimal. In addition, the STEM approach encourages students to link physics concepts to real situations through logical and systematic problem solving.

Analysis Results of Remediation Misconception

The remediation of student misconceptions was analyzed based on the results of the posttest of conceptual understanding after the implementation of the learning in the experimental and control classes. This analysis aims to determine the level of students' conceptual understanding and identify the percentage of students who still experience misconceptions after participating in the learning. The results of this analysis are used to evaluate the effectiveness of the AR-STEM integrated cognitive conflict-based physics website in remediating misconceptions on static fluid material. The percentage of students' conceptual understanding categories in both classes is presented in Table 6.

Table 6. Results of Posttest Data Analysis Misconception

Indicator	Experimental Classes	Control Class
Understand the Concept	63.76	31.85
Don't Understand the Concept	0	0.48
Misconceptions	36.24	67.68

Based on Table 6, the results of the analysis show that learning using an AR-STEM integrated Cognitive Conflict-based physics website is more effective in remedying misconceptions than learning applied to the control class. The application of the website provides an opportunity for students to identify, evaluate, and reconstruct their concepts through the process of cognitive conflict so that the original misunderstanding can be corrected to be in accordance with scientific concepts. These findings indicate that the integration of cognitive conflict, Augmented Reality (AR) visualization, and STEM activities is able to facilitate conceptual changes in students. Thus, AR-STEM-integrated Cognitive Conflict-based physics websites are effectively used as a medium to remediate misconceptions in static fluid materials.

After the prerequisite test, the posttest data on conceptual understanding did not meet the assumptions for parametric analysis, so the hypothesis testing was conducted using the Mann–Whitney test. This test aims to determine whether there is a significant difference in misconception remediation between students in the experimental class and the control class after the learning implementation. The results of the hypothesis testing were used to evaluate the effectiveness of the AR-STEM integrated cognitive conflict-based physics website in remediating misconceptions on static fluid material. The results of the hypothesis testing on the misconception remediation data are presented in Table 7.

Table 7. Results of Hypothesis Test Data Analysis of Misconception Posttest

No.	Non-Parametric Test	Misconception Posttest Results
1	Mann-Whitney U	50.500
2	Wilcoxon W	680.500
3	Z	-6.491
4	Asymp. Sig. (2-tailed)	0.000

The results of the hypothesis test showed that there was a significant difference in the level of misconceptions between the experimental class and the control class after the learning. This finding indicates that the use of a physics website based on Cognitive Conflict integrated with AR-STEM provides a more effective influence in remediating misconceptions compared to the learning applied to the control class. This effectiveness occurs because the website is able to facilitate students to identify initial misconceptions, face cognitive conflicts through Augmented Reality visualization, and reconstruct erroneous concepts into correct scientific concepts. In addition, the integration of the STEM approach encourages students to connect physics concepts with real phenomena so that the understanding gained becomes more meaningful. This systematic learning process helps students build conceptual changes gradually so that the level of misconceptions experiences a greater decrease.

Discussion

The main advantage of the AR-STEM integrated Cognitive Conflict-based physics website developed lies in the presentation of material, Augmented Reality (AR) visualization, virtual experiments, and learning reflections in one flexible medium. This website allows students to learn independently, review material, and explore concepts without being limited by time and place. All learning activities are structured based on the syntax of cognitive conflict-based learning (CCBL), so that students not only receive information but also actively test and reconstruct their understanding. The integration of AR and STEM in every stage of learning provides a more interactive, contextual, and student-centered learning experience through observation, investigation, and problem-solving activities. This condition makes the learning process more meaningful because students build knowledge based on the results of observations, experiments, and reflections, thereby supporting the improvement of critical thinking skills while remediating misconceptions.

In the preconception and misconception activation stage, students observe three phenomena through Augmented Reality (AR) visualizations that present different conditions in static fluid material, then determine the correct (T), incorrect (F), or don't know (T) answer to each statement based on the observation results. This stage aims to identify the initial concepts and misconceptions held by students as the basis for conceptual change towards the correct scientific concept. Identification of initial conceptions is a crucial stage in Cognitive Conflict Based Learning (CCBL) because conceptual change can only occur if the students' initial conceptions are first known (Mufit et al., 2023).This activity encourages students to not only choose an answer, but also to consider the suitability between the observed phenomenon and their prior knowledge before choosing B, S, or T. This process shows that students begin to use the results of observations as a basis for making decisions, so that the ability of Basis for Decision Making (DM) develops during learning. In addition, AR visualization helps present the abstract concept of static fluids more concretely so that students more easily recognize the suitability or inconsistency between the initial conception and the observed phenomenon.

In the cognitive conflict presentation stage, students re-observe the phenomenon through the same Augmented Reality (AR) visualization as in the preconception and misconception activation stage, then answer questions in essay form based on the observed phenomenon. The questions require students to explain the phenomenon using concepts so that they compare their initial answers with scientific evidence obtained from the observation results. The discrepancy between the initial conception and the observed phenomenon creates a cognitive conflict that encourages students to reevaluate their understanding and reconstruct the erroneous concept into a correct scientific concept. This process plays a role in remediating misconceptions while practicing Basic Explanation (BE) skills because students are required to provide scientific explanations based on observed evidence, as well as Basis for Decision Making (DM) through the process of determining answers supported by logical reasons. This finding is in line with Mufit et al (2023) who stated that the presentation of cognitive conflict encourages students to evaluate their initial conceptions through empirical evidence, thereby facilitating conceptual change towards a correct scientific concept.

At the concept and equation discovery stage, students were able to discover relationships between variables in static fluid material through virtual experiments available on the website. This activity was supported by the integration of Augmented Reality (AR), which helped students visualize abstract concepts into more concrete three-dimensional representations. This visualization made it easier for students to observe physical phenomena, understand relationships between variables, and connect theoretical concepts to real-life situations. In addition, experimental activities that integrated the STEM approach encouraged students to independently conduct observations, analyze data, and test relationships between variables. Through this process, students were able to compare their initial concepts with the results of their observations, resulting in conceptual reconstruction towards a correct scientific understanding. Thus, the integration of AR at the concept and equation discovery stage contributed to supporting the process of remediating misconceptions in static fluid material.

In addition to contributing to improved conceptual understanding, this stage also demonstrated an increase in students' critical thinking skills. This was evident in students' ability to interpret data, draw conclusions based on empirical evidence, and provide explanations for observed phenomena. The investigative activities carried out were able to train the Drawing Conclusions (DC), Further Explanation (FE), and Conjecture or Integration (CI) aspects because students were required to connect various pieces of information obtained during the experiment. The results of this study are in line with the findings of Rasyid et al. (2024) who stated that investigative activities in physics learning can improve students' critical thinking skills. These findings are also supported by Kaçar and Balim (2021), who showed that investigative activities and scientific argumentation play a role in improving conceptual understanding and thereby minimizing misconceptions.

During the reflection stage, students are able to review observations, concepts, and equations obtained during the learning process and then compare them with their initial understanding. This process allows students to identify discrepancies between initial concepts and scientific concepts, resulting in a more accurate reconstruction of understanding. This condition indicates that the reflection stage contributes to strengthening conceptual change and reducing the possibility of recurrence of misconceptions in static fluid material. In addition, reflection activities also encourage students to evaluate their own thinking processes, assess the accuracy of their concepts, and draw conclusions based on evidence and observations obtained during the learning process. These abilities indicate an increase in critical thinking aspects, particularly in the ability to provide further explanations and make decisions based on scientific evidence. Thus, the reflection stage not only plays a role in remediating misconceptions but also supports the development of students' critical thinking skills. The results of this study are in line with the findings of Mufit et al. (2023) who stated that the reflection stage plays a crucial role in strengthening conceptual change through self-evaluation of students' understanding.

The effectiveness of the website is also supported by the integration of AR and STEM that complement each other in each learning syntax. AR visualization helps students understand abstract static fluid concepts through three-dimensional representations so that physical phenomena are easier to observe and compare to initial conceptions. These findings are supported by Devana et al. (2025), which shows that cognitive conflict-based physics teaching materials integrated with Augmented Reality provide a more interactive learning experience and make it easier for students to visualize physics concepts so that learning becomes more meaningful. Meanwhile, the STEM approach encourages students to connect physics concepts with contextual problem solving through systematic investigation, data analysis, and problem-solving activities. This condition not only develops critical thinking skills, but also strengthens the conceptual structure of students so that the misconception remediation process takes place more effectively. These findings are in line with Ridlo et al.

(2024) and Mufit et al. (2026) who stated that the integration of digital technology and STEM approaches in physics learning is able to support the development of 21st century skills, especially students' critical thinking skills. These results were also strengthened Atmam & Mufit (2023) stated that cognitive conflict-based interactive multimedia is able to improve conceptual understanding through conceptual changes that occur during the learning process.

Based on the results of the study, the AR-STEM integrated cognitive conflict-based physics website has proven to be effective in improving critical thinking skills while remedying students' misconceptions about static fluid materials**.** This effectiveness is supported by the application of cognitive conflict-based learning (CCBL) syntax which systematically facilitates learners to identify initial conceptions, experience cognitive conflicts, discover concepts through virtual experiments, and strengthen understanding through reflection. This series of activities not only helps students reconstruct erroneous concepts into scientific concepts through the process of conceptual change, but also trains critical thinking skills through observing phenomena, analyzing information, evaluating evidence, and drawing conclusions based on investigation results. These findings are in line with Mufit et al. (2023) who stated that the syntax of Cognitive Conflict Based Learning is able to facilitate conceptual changes so that it is effective in remedying misconceptions, while encouraging students to think more analytically and reflexively during the learning process. The integration of Augmented Reality technology and STEM approaches further strengthens the process by presenting more concrete physical phenomena, providing a contextual learning experience, and encouraging students to connect concepts with systematic problem solving. Therefore, a Cognitive Conflict-based physics website integrated with AR-STEM has the potential to be an effective alternative to digital teaching materials to support physics learning that focuses on improving critical thinking skills and correcting students' misconceptions.

CONCLUSION

Augmented Reality and STEM integrated cognitive conflict-based physics websites have proven to be effective in improving critical thinking skills and remediation of students' misconceptions about static fluid materials. The cognitive conflict model integrated with AR-STEM in a website provides a learning experience that encourages students to analyze phenomena, evaluate concepts, and build understanding more actively so that concepts are found in accordance with scientific concepts. The results of this study show that the use of AR-STEM integrated cognitive conflict-based websites has the potential to be a digital learning innovation that can support improving the quality of physics learning, especially in improving students' critical thinking skills and remediation of misconceptions. Further research is recommended to implement websites on other physics materials and involve a wider number of samples to obtain a more comprehensive picture of effectiveness.

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