

The Effectiveness of Using Animated Videos as A Learning Medium to Reduce Student Misconceptions About Reaction Rate Material

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ABSTRACT

Keywords:

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This study aimed to investigate the effectiveness of animated video media in reducing students' misconceptions about the factors influencing the rate of chemical reactions. The research employed a quasi-experimental design using a One Group Pretest–Posttest approach involving 20 eleventh-grade senior high school students who were identified as having misconceptions through a three-tier diagnostic test. The intervention consisted of remedial instruction utilizing animated video media, followed by a posttest to assess changes in conceptual understanding. The results revealed that the average misconception rate decreased from 65% in the pretest to 21.25% in the posttest, indicating a reduction of 43.75% in the moderate category. Furthermore, the students' conceptual understanding improved significantly, with an average N-gain score of 0.67, categorized as medium–high. These findings demonstrate that the use of animated videos is effective in facilitating conceptual change and enhancing students' comprehension of abstract chemical concepts. Therefore, animation-based instructional media can serve as an innovative alternative strategy to address misconceptions and improve the overall quality of chemistry learning.

INTRODUCTION

Chemistry education poses significant challenges for students, as many of its concepts are inherently abstract, cannot be directly observed, and involve phenomena at the microscopic level. One of the topics that often presents particular difficulty is reaction rate, especially in relation to understanding the factors that influence it, such as concentration, temperature, catalysts, and surface area. Empirical studies indicate that misconceptions in this domain are widespread among students and may impede both the learning process and the development of higher-order problem-solving skills (Rahayu, 2024). Misconceptions are not merely a consequence of limited knowledge, but rather represent alternative conceptions that contradict established scientific principles and are often resistant to remediation through conventional instructional approaches (Kulgemeyer & Peters, 2022).

Previous studies have demonstrated that the use of visual-based media, such as animations, can effectively facilitate the explanation of abstract concepts in science, including chemistry. Animated videos are particularly valuable in illustrating particle collisions and energy changes, thereby bridging the gap between macroscopic, microscopic, and symbolic representations (Putri, 2024). Several studies have further emphasized that well-designed animations can enhance students' attention and motivation, while also reducing misconceptions when integrated with appropriate instructional strategies (Marlina, 2022). Diagnostic instruments such as the three-tier test have become increasingly recognized as effective tools for identifying students' misconceptions in science learning.

This type of instrument combines multiple-choice responses, conceptual reasoning, and students' confidence levels, making it possible not only to detect incorrect answers but also to reveal the underlying reasoning errors and the degree of certainty with which students hold their conceptions. For instance, Fikri et al. (2022) successfully applied an online three-tier test to uncover misconceptions about viruses and COVID-19, showing that confidence ratings add valuable diagnostic information. Similarly, Khairunnisa and Prodjosantoso (2021) demonstrated the usefulness of three-tier tests in chemical equilibrium, where the combination of answer, reasoning, and certainty provided a more detailed profile of misconceptions compared to traditional two-tier tests. In chemistry education, the approach has also been adapted to topics such as atomic structure (Tustari et al., 2024) and reaction rates (Arifah et al., 2022), further supporting its versatility across different subject matters.

Recent developments even highlight the validity of three-tier tests in advanced topics such as organic chemistry (Febaliza et al., 2024). Strengthening the evidence that integrating conceptual reasoning with confidence levels yields a robust method for misconception diagnosis. Although numerous studies have confirmed the effectiveness of animated videos in enhancing students' understanding of scientific concepts, research that specifically examines their use in addressing misconceptions in reaction rate remains limited. Prior investigations have predominantly focused on improving learning outcomes in general, rather than on remediating misconceptions that have been previously identified.

Therefore, the present study holds particular significance as it seeks to fill this research gap by empirically examining how animated videos can be strategically employed to overcome students' misconceptions on the topic of reaction rate. The primary objective of this study is to analyze the effectiveness of animated videos as instructional media in reducing students' misconceptions about the topic of reaction rate. The research questions addressed are: (1) To what extent do students' misconceptions change before and after learning with animated videos? and (2) Is there a significant difference in the level of misconceptions following the implementation of animation-based instruction?

This study is expected to provide a theoretical contribution by strengthening empirical evidence regarding the effectiveness of animated videos in correcting misconceptions, rather than merely improving learning outcomes. Practically, the findings may serve as recommendations for chemistry teachers and educational media developers to design visualization strategies that are more effective, engaging, and responsive to students' needs. Thus, this research not only enriches the literature in chemistry education but also offers direct benefits for classroom practice.

RESEARCH METHOD

Data collection in this study was conducted in three stages. First, students from three classes were given a pretest using a three-tier diagnostic test, which has been proven effective in identifying misconceptions by combining multiple-choice items,

reasoning, and confidence levels (Khairunnisa & Prodjosantoso, 2021; Fikri, Suwono, & Susilo, 2022). This method has been applied successfully in various chemistry domains, including equilibrium (Khairunnisa & Prodjosantoso, 2021), atomic structure (Tustari et al., 2024), and organic chemistry (Febaliza et al., 2024). In this study, the test was adapted specifically for reaction rate topics and validated to ensure accuracy (Arifah et al., 2022). Students identified with misconceptions were then selected as the sample and received remedial instruction through validated animated videos.

The same instrument was administered in the posttest to measure changes in misconceptions, providing evidence of the effectiveness of animated videos in reducing misconceptions and improving conceptual understanding. The main instruments were the three-tier diagnostic test, validated by two chemistry education experts and one senior high school teacher, and animated videos validated by media and subject matter experts. The videos presented dynamic visualizations of particle collisions and the effects of temperature, concentration, surface area, and catalysts, supported with narration to connect macroscopic changes with microscopic processes (Putri, 2024). Prior research also confirms the effectiveness of visual media by Marlina (2022) showed that visualization makes invisible processes concrete, Eljinsa and Zamhari (2024) demonstrated the potential of structured animations created with Powtoon, and Ayudia and Kamaludin (2024) highlighted their motivational benefits in classroom practice.

These design principles were integrated to maximize the impact of the videos in addressing misconceptions. Data analysis was conducted quantitatively by comparing pretest and posttest results. Misconceptions were identified when students chose incorrect answers with inappropriate reasoning and high confidence. Effectiveness was measured through the reduction of misconception percentages, while conceptual understanding was assessed using N-gain (Hake, 1999).

To obtain deeper insights into conceptual change, the Certainty of Response Index (CRI) was applied, categorizing responses based on both accuracy and confidence (Arifin et al., 2020). The CRI model has been shown effective in mapping misconceptions in buffer solutions, acid-base equilibrium, and thermodynamics (Arifin et al., 2020; Erman et al., 2021; Handayani & Rahayu, 2022), and more recently in electrolyte solutions (Syahbana & Maryani, 2023). In this study, applying CRI to pretest and posttest results provided nuanced insights into how animated videos supported both improved test performance and the reduction of deeply held misconceptions. The research procedure flow is illustrated in (Figure 1).

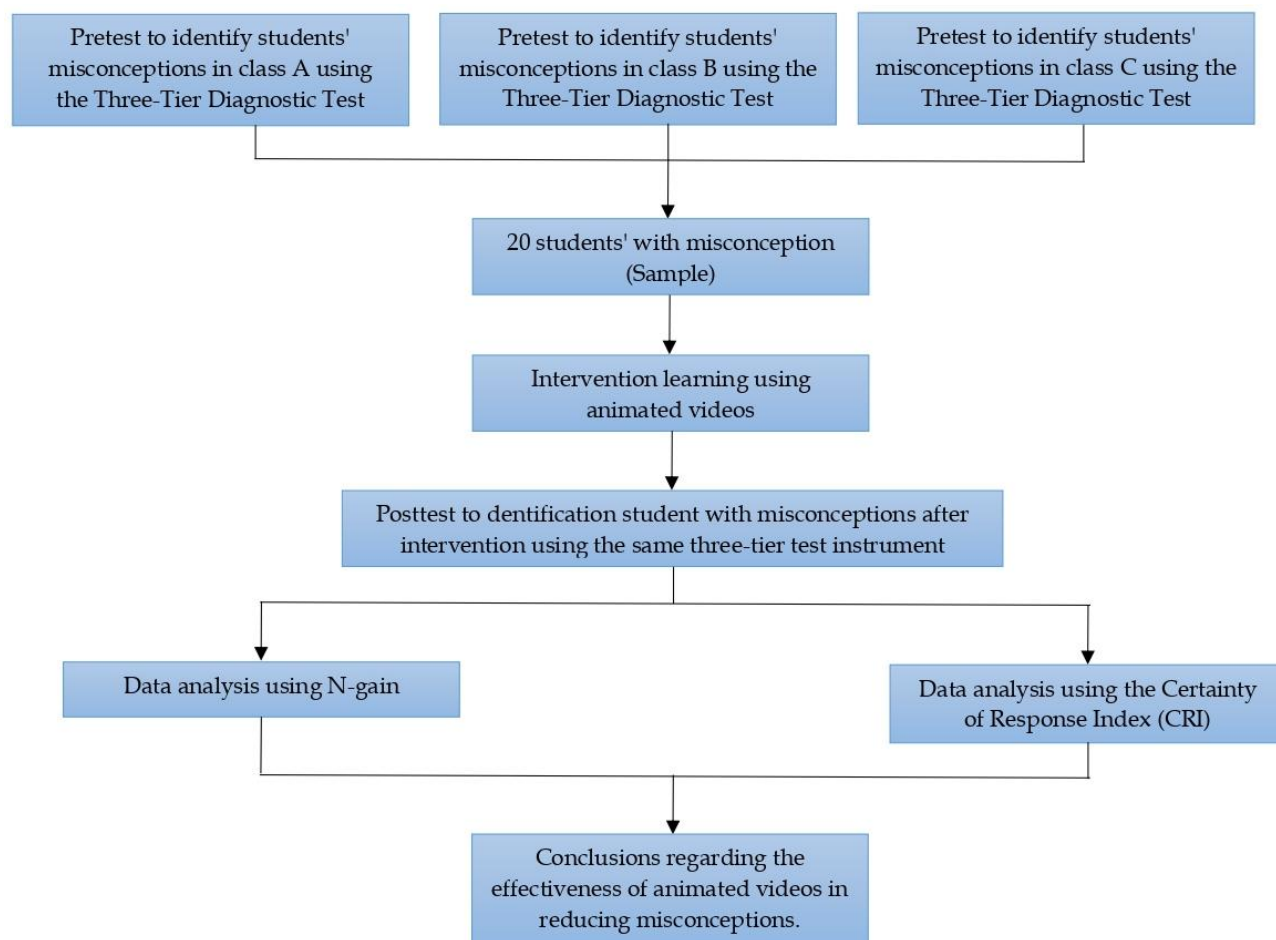


Figure 1. Research Procedure Flowchart

Analysis of student learning outcomes using the N-gain test aims to determine the increase in understanding after using the media.

N-gain formula:

$$N - gain = \frac{(\text{Score } posttest - \text{Score } pretest)}{(\text{Score maksimal} - \text{Score } pretest)} \quad (1)$$

Interpretation of N-gain values by Hake (1998):

Table 1. Interpretation of N-gain Values

Category	N-gain Score	Criteria
N-gain score distribution	N-gain > 0.7	High
	$0.3 < \text{N-gain} \leq 0.7$	Medium
	N-gain ≤ 0.3	Low
N-gain percentage effectiveness interpretation	0% - 40%	Ineffective
	41% - 55%	Less effective
	56% - 75%	Moderately effective
	76% - 100%	Effective

The analysis of learning outcomes was carried out by comparing students' pretest and posttest scores. The N-gain value was calculated using the formula proposed by Hake (1999), with results categorized as low ($g < 0.3$), medium ($0.3 \leq g < 0.7$), or high (g

≥ 0.7). The percentage of N-gain was also interpreted into four levels of effectiveness: ineffective (0%–40%), less effective (41%–55%), moderately effective (56%–75%), and effective (76%–100%).

This approach allowed for a more comprehensive assessment of improvements in conceptual understanding after learning with animated videos. To ensure the validity of statistical analyses, the normality of the dataset was first tested using the Shapiro–Wilk test, which is recommended for small samples due to its higher sensitivity compared to Kolmogorov–Smirnov (Field, 2013; Pallant, 2016; Demir, 2022). Since the sample size in this study was fewer than 50, this test was deemed most appropriate. If the data followed a normal distribution, a paired sample t-test was conducted; otherwise, the Wilcoxon Signed Rank Test was applied as the non-parametric alternative (Pallant, 2016). The results of these tests indicated a significant difference between pretest and posttest scores, demonstrating that the use of animated videos was effective in improving students' conceptual understanding while simultaneously reducing misconceptions about reaction rate. Detailed outcomes of the normality test, paired sample t-test, and Wilcoxon Signed Rank Test are presented in (Table 3).

Table 2. Statistical Analysis Criteria

Analysis Statistic	Formulas / Tests Used	Criteria	
Normality Test	Shapiro-Wilk Test	$p > 0.05$	(normal)
		$p \leq 0.05$	(not normal)
Paired Sample t-Test	$t = (\text{Mean Difference}) \text{ or } (\text{Std. Error Difference})$	$p > 0.05$	(no significant)
Wilcoxon Signed Rank Test	Based on the pretest and posttest score difference ranking	$p \leq 0.05$	(significant)

In this study, the Certainty of Response Index (CRI) was used to measure the extent to which students' misconceptions decreased after instruction with animated videos. Unlike assessments that only classify answers as correct or incorrect, CRI incorporates students' confidence, thereby distinguishing between genuine misconceptions and mere lack of knowledge. Previous studies have confirmed its diagnostic value. For example, an e-diagnostic tool based on CRI in simple harmonic motion provided richer insights into the link between correctness and confidence (Pribadi et al., 2023). Similarly, two-tier multiple-choice tests integrated with CRI effectively diagnosed misconceptions in acid–base concepts, where students often answered incorrectly with high confidence (Cahyani et al., 2022). CRI has also proven effective in physics topics such as temperature, heat, and waves, in which it successfully differentiated misconceptions from low-confidence errors (Hajar et al., 2023). In the present study, CRI provided deeper insights into how animated videos fostered conceptual change by not only reducing the occurrence of misconceptions but also lowering students' confidence in incorrect ideas. As previous research has shown, CRI classifies responses into three categories: understanding (correct answer with high confidence), lack of knowledge (incorrect answer with low confidence), and

misconception (incorrect answer with high confidence) (Mujib, 2022; Cahyani et al., 2022; Hajar et al., 2023). These categories allowed for a more nuanced analysis, highlighting whether errors reflected temporary uncertainty or deeply rooted misconceptions.

The misconceptions reduction calculation was performed by comparing the percentage of misconceptions in the pretest and posttest, using the formula:

$$\text{Reduction Misconception (CRI)} = \frac{(\% \text{Misconception}_{pre}) - (\% \text{Misconception}_{post})}{(\% \text{Misconception}_{pre})} \quad (2)$$

Table 3. Interrpretation Criteria of Reduction Misconception

Percentage of Misconception Reduction (CRI)	Criteria
0%-30%	Low
31%-60%	Medium
61%-100%	High

RESULTS AND DISCUSSION

Results

Research results After data collection and analysis, the results of this study are presented both numerically and visually to provide a comprehensive overview of the impact of animated video media on students' misconceptions. The graph demonstrates a decrease in the average percentage of misconceptions from the pretest to the posttest, while the tables present detailed statistical results, including N-gain values, category distributions, hypothesis testing outcomes, and CRI percentage.

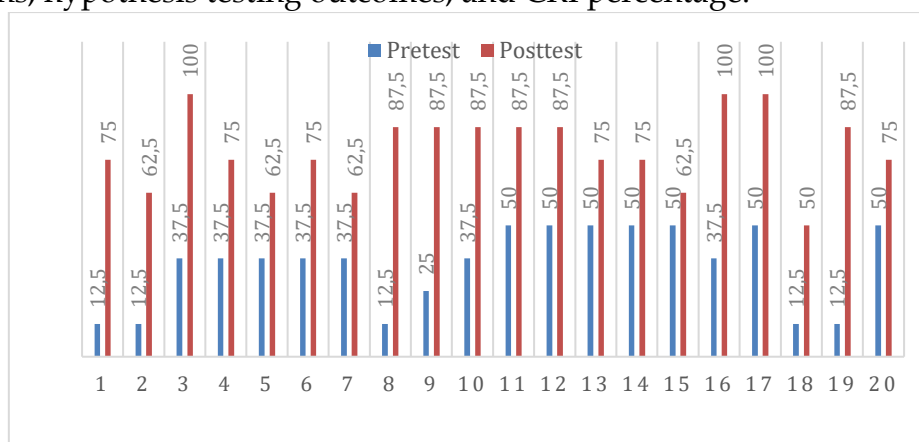


Figure 2. Average of Pretest-Posttest Score

The graphical representation in (Figure 2) illustrates the comparison between pretest and posttest scores. The results show that the average pretest score was 35, while the average posttest score increased to 78.75. This substantial difference indicates that learning with animated videos contributed to an overall improvement in students' performance.

Table 4. Analysis N-gain Result

	N	Minimum	Maximum	Mean	Std. Deviation
N-gain_Score	20	.001	1.00	.6656	.22259
N-gain_Percentage	20	.080	100.00	66.5595	22.25924

Valid N (listwise) 20

The analysis in Table 5 shows that the average pretest score was 35 and the posttest score increased to 78.75. The N-gain ranged from 0.25 to 1.00 with an average of 0.67, categorized as medium. In terms of effectiveness, the average N-gain reached 67.30%, also classified as moderately effective. These findings suggest that animated videos meaningfully improved students' conceptual understanding of reaction rate, with most students achieving medium to high gains and only one student remaining in the low category.

Table 5. Analysis Normality Test

Shapiro-Wilk			
	Statistic	df	Sig.
Pretest	.796	20	.001
Posttest	.924	20	.117

The results of the normality test, presented in (Table 6), show that the pretest data did not follow a normal distribution ($p = 0.001$), while the posttest data did ($p = 0.117$). Due to this finding, the Wilcoxon Signed Rank Test was selected as the appropriate statistical test to examine differences between the pretest and posttest scores.

Table 6. Wilcoxon Signed Rank Test

		N	Mean Rank	Sum of Ranks
Pretest_Posttest	Negative Ranks	0 ^a	.00	.00
	Positive Ranks	20 ^b	10.50	210.00
	Ties	0 ^c		
	Total	20		

Table 7. Wilcoxon Signed Ranks Test Statistics

Posttest - Pretest	
Z	-3,939 ^b
Asymp. Sig. (2-tailed)	,000

The results of the Wilcoxon Signed Rank Test are summarized in (Table 7) and (Table 8). The test yielded a Z value of -3.939 with a significance level of 0.000 ($p < 0.05$), indicating a statistically significant difference between pretest and posttest scores. This confirms that the intervention using animated videos had a measurable and significant effect in reducing misconceptions and improving students' understanding.

The graphical representation in (Figure 3) provides a more detailed view of the distribution of misconception reduction across students, highlighting that most participants experienced a substantial decline in misconceptions after the intervention. the results of the CRI analysis, which are also presented in the tables, provide additional depth to the findings. The analysis shows that misconceptions decreased from an average of 65.00% in the pretest to 21.25% in the posttest, yielding an average reduction of 67.31%,

which falls into the high category. This confirms that animated videos were effective not only in improving scores but also in remediating students' prior misconceptions.

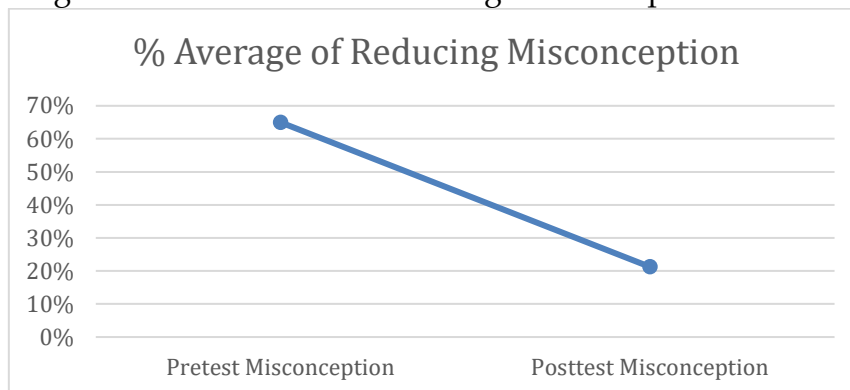


Figure 3. Percentage Average of Reducing Misconception

Discussion



Figure 4. Misconception Diagnosis with Three-Tier Test

The learning activity depicted in the (Figure 4) is the implementation of a misconception diagnosis stage through the administration of a pretest on the topic of factors affecting chemical reaction rate. This stage is essential within the constructivist learning framework, as it enables educators to identify students' prior conceptions before providing instruction through innovative learning media. In line with the view of Posner et al. (1982) in the conceptual change theory, meaningful conceptual transformation can only occur when misconceptions are first identified, allowing teachers to design learning experiences that provoke cognitive conflict. In this context, the pretest serves as a tool to map students' levels of understanding and misconceptions regarding reaction rate concepts, including the effects of concentration, temperature, and pressure on the direction of reaction rate. Based on the diagnostic results, students identified as having misconceptions received follow-up instruction using interactive animation-based video learning at (Figure 5). This medium was chosen because it helps students visualize the microscopic processes of reaction rate that cannot be directly observed. Previous studies (Azizah et al., 2021; Hutabarat & Wiyarsi, 2020) have suggested that the use of animation in chemistry learning significantly enhances conceptual understanding and reduces the prevalence of misconceptions.



Figure 5. Learning with Video Animation Medium

The study found an N-gain score of 0.67 in the medium-high category and a CRI-based misconception reduction of 43.75% in the moderate category. These results indicate that animated videos significantly improved students' conceptual understanding while reducing their confidence in prior misconceptions. According to the theory of conceptual change, such improvements occur when learners replace unsatisfactory ideas with intelligible, plausible, and fruitful conceptions. The dynamic visualizations in the instructional video, which depicted particle collisions and the effects of temperature, concentration, surface area, and catalysts, facilitated this process by making abstract microscopic phenomena more comprehensible. These elements are often difficult for students to grasp when explained only through symbolic representations, as they require connecting macroscopic phenomena with microscopic processes (Putri, 2024). By integrating narration with animations, the video supported students in linking observable changes to the underlying molecular interactions, thereby enhancing comprehension (Marlina, 2022). Previous studies confirm that visual-based media like animations are effective in improving students' understanding of abstract chemistry concepts. Visualization has been shown to significantly reduce misconceptions by making invisible processes more concrete (Marlina, 2022). The development of animation-based learning media using platforms such as Powtoon has also been proven to illustrate abstract ideas, such as particle motion in solutions, in ways that traditional methods cannot (Eljinsa & Zamhari, 2024). Furthermore, animated videos have been found to increase student motivation and engagement, particularly when narration is integrated with multimedia explanations (Ayudia & Kamaludin, 2024). In this study, these design principles were embedded to maximize the effectiveness of the video in remediating misconceptions about reaction rates (Putri, 2024).

These findings are consistent with previous studies that emphasize the effectiveness of animation-based media in science learning. Clarisa et al. (2022), Putri (2024), and Marlina (2022) reported that animations play an important role in reducing students' misconceptions of abstract chemical concepts. Similarly, the integration of video animation in blended learning models has been shown to not only increase students' motivation but also significantly improve their science learning outcomes (Utami & Amaliyah, 2022). Recent research also confirmed that students taught using animated video media achieved higher interest and better learning outcomes compared

to those using conventional methods (Caella & Yulianto, 2024). Animations have been shown to help students understand abstract chemical phenomena while simultaneously reducing misconceptions (Astuti et al., 2021). The development of contextually based animated videos on acid-base solutions using Powtoon has also been proven to improve conceptual understanding and reduce students' misunderstandings in chemistry learning (Mutiarasani & Kamaludin, 2021). Taken together, these findings reinforce the evidence that animations are effective instructional media for addressing misconceptions across various science topics, including reaction rate (Astuti et al., 2021; Mutiarasani & Kamaludin, 2021).

However, the results of this study were also influenced by several factors. Learning motivation is one of the key factors, as students who are more motivated tend to pay closer attention to the explanations presented in the animations and consequently achieve better understanding (Putri et al., 2024). Students' prior knowledge also played a role, since those with lower initial understanding generally exhibited greater improvement compared to students who already had relatively good conceptual comprehension from the outset. In particular, in studies using animations or 3D models, learners with less prior knowledge tend to benefit more dramatically from visualization tools, as these tools help them build mental models that they initially lacked (Teplá et al., 2022). However, the results of this study were also influenced by several limitations of the media, such as lower display quality of animation frames or limited duration of media exposure, which may reduce its effectiveness (Caella & Yulianto, 2024). Another study found that when animations were used under time constraints or with low resolution media, student improvements in outcomes were less pronounced (Imelda et al., 2024). Specifically, testing with brain-based learning models also revealed that despite using animation, inadequate length of exposure or rushed pacing diminished the gains in student understanding (Wulansari & Suarni, 2022). If the animation is shown only once or in low quality, the potential for fostering conceptual change becomes limited, since repeated exposure and higher quality visuals tend to support deeper engagement and comprehension (Mutiarasani & Kamaludin, 2021). Studies have shown that animations developed with high Fidelity and used multiple times significantly improve students' understanding of complex chemistry topics, such as acid-base solutions and atomic structure (Astuti et al., 2021). In contrast, when animations are deployed in discovery learning without sufficient repetition or technical quality, students' abilities to represent submicroscopic or symbolic aspects of Chemical equilibrium are less improved (Azzajjad et al., 2020).

This study, like many educational interventions, has several limitations. The relatively small sample size and the absence of a control group reduce the generalizability of the findings, as also noted in prior research on animation-based modules, where limited samples and no comparison groups often weaken external validity (Fatmah et al., 2023). Another limitation concerns the timing of measurement, which was conducted only immediately after the intervention. While such short-term assessments reveal immediate gains, they do not capture whether conceptual changes are sustained over time. Longitudinal studies show that retention can decline without reinforcement,

underscoring the importance of delayed posttests for evaluating long-term effectiveness (Haycocks et al., 2024). In addition, this study did not systematically examine affective factors such as motivation, interest, and attitudes, even though these dimensions significantly influence how learners engage with animated content and whether short-term gains translate into long-term knowledge (Haycocks et al., 2024). Furthermore, the quality of the animations was not specifically assessed, making it difficult to evaluate the contribution of media quality to learning effectiveness.

Future research should therefore include larger and more diverse samples, employ control groups, extend assessments with delayed posttests, and incorporate affective variables. It would also be valuable to integrate animated videos with strategies such as group discussions, simple experiments, or cooperative learning, and to test their application across other abstract chemistry topics. Despite these limitations, the findings confirm that animated videos were effective in improving students' conceptual understanding and reducing misconceptions. With an N-gain of 0.67 and a CRI reduction of 43.75%, the study concludes that animation is a powerful medium for fostering conceptual change, although additional strategies are needed to fully address more resistant misconceptions.

CONCLUSION

The study concludes that animated videos are effective in reducing students' misconceptions and improving conceptual understanding of reaction rate factors. Misconceptions decreased from 65% to 21.25% (a 43.75% reduction, moderate category), while the average score increased from 35 to 78.75 with an N-gain of 0.67 (medium-high category). These results highlight the potential of animation-based media as an effective strategy for fostering conceptual change in abstract chemistry topics.

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