

COMPARATIVE ANALYSIS OF STUDENTS' MOTIVATION AND LEARNING ACHIEVEMENT THROUGH PROJECT-BASED LEARNING AND PROBLEM-BASED LEARNING ASSISTED BY INSTRUCTIONAL VIDEOS IN REACTION RATE LEARNING

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Abstract: Students' low learning motivation and learning achievement in chemistry, particularly on reaction rate topics, remain a challenge due to the abstract nature of the concepts and the limited use of innovative learning models and instructional media. This study aimed to analyze the differences in learning achievement and learning motivation between students taught using Project-Based Learning (PjBL) and Problem-Based Learning (PBL), both assisted by instructional videos, and to examine the relationship between learning motivation and learning achievement. This study employed a quantitative approach with a quasi-experimental design involving two experimental classes selected through random sampling. One class was taught using the PjBL model assisted by instructional videos, while the other received the PBL model with the same instructional media. Data were collected through pretest-posttest achievement tests and a learning motivation questionnaire and analyzed using SPSS 26.0. The results revealed a significant difference in students' learning achievement between the two learning models ($\text{Sig.} = 0.026 < 0.05$). A significant difference was also found in students' learning motivation ($\text{Sig.} = 0.043 < 0.05$). Furthermore, learning motivation showed a significant positive relationship with students' learning achievement. These findings indicate that integrating instructional videos with student-centered learning models effectively enhances students' motivation and academic achievement in learning reaction rates. Therefore, both PjBL and PBL assisted by instructional videos can be recommended as effective instructional approaches to improve chemistry learning outcomes.

Keywords: Learning Motivation; Project-Based Learning; Problem-Based Learning; Instructional Video; Reaction Rate Learning.

1. INTRODUCTION

Education plays a strategic role in developing human resources who are capable of adapting to the rapid advancement of science and technology. In chemistry education, learning is expected not only to improve students' cognitive achievement but also to foster learning motivation, critical thinking, and problem-solving skills. However, chemistry is frequently perceived as a difficult subject because many of its concepts are abstract and require students to connect macroscopic phenomena with microscopic and symbolic representations (Marfu'ah, 2021). One of the topics that students often find challenging is

reaction rates, which involve concepts such as collision theory, activation energy, reaction order, and factors affecting reaction rates.

Based on preliminary observations at SMA Negeri 1 Parongil, the learning process on reaction rate topics was still dominated by conventional teaching methods, with teachers relying mainly on lectures and textbooks. Consequently, students' learning motivation and academic achievement remained relatively low. Previous studies have shown that the integration of instructional media can increase students' interest and participation during learning activities, leading to better learning outcomes (Afnita et al., 2022). In addition, instructional videos enable abstract chemistry concepts to be presented through audiovisual visualization, making them easier for students to understand (Wildaiman et al., 2022).

To address these challenges, student-centered learning models have been widely recommended. Project-Based Learning (PjBL) emphasizes collaborative project activities that encourage students to construct knowledge through authentic experiences, thereby improving creativity, critical thinking, and learning achievement (Pratama et al., 2023; Waruwu et al., 2023). Similarly, Problem-Based Learning (PBL) promotes meaningful learning by engaging students in solving real-world problems through investigation, discussion, and reflection, which enhances analytical and problem-solving skills (Rahmadani, 2019; Meilasari et al., 2020). Previous studies have consistently reported that both PjBL and PBL contribute positively to students' academic performance and classroom engagement (Silaban et al., 2020; Panggabean et al., 2022).

The use of instructional videos further strengthens the implementation of these learning models by providing dynamic visualizations of scientific phenomena that cannot easily be demonstrated through conventional instruction. Audiovisual learning media have been reported to improve conceptual understanding, increase students' motivation, and significantly enhance learning outcomes in science education (Novita et al., 2020; Nurcahyanti et al., 2022; Nadia et al., 2025). Therefore, integrating instructional videos with student-centered learning models has considerable potential to create more effective and engaging chemistry learning environments.

Although numerous studies have investigated the effectiveness of Project-Based Learning, Problem-Based Learning, and instructional videos independently, comparative studies examining PjBL and PBL assisted by instructional videos in teaching reaction rates remain limited. Moreover, only a few studies have simultaneously examined differences in students' learning motivation and learning achievement while also investigating the

relationship between these two variables within the same instructional context. This research gap highlights the need for further empirical investigation.

Therefore, this study aims to compare students' learning motivation and learning achievement between Project-Based Learning and Problem-Based Learning assisted by instructional videos on the topic of reaction rates. Furthermore, this study examines the relationship between learning motivation and learning achievement. The findings are expected to contribute to the development of technology-supported student-centered chemistry instruction and provide practical recommendations for teachers in improving students' motivation and academic achievement.

2. RESEARCH METHODS

Research Design

This study employed a quantitative approach using a quasi-experimental design with a pretest-posttest two-group design. The research compared the effectiveness of Project-Based Learning (PjBL) and Problem-Based Learning (PBL), both assisted by instructional videos, on students' learning motivation and learning achievement in the reaction rate topic. Two experimental classes received different learning models but were taught using the same instructional media, teacher, learning objectives, and assessment instruments to minimize external variables.

Research Location and Participants

The study was conducted at SMA Negeri 1 Parongil, Dairi Regency, North Sumatra, Indonesia, during the 2025/2026 academic year. The research population consisted of all Grade XI science students (128 students) distributed across four classes. The sample was selected using random sampling, resulting in two experimental classes with 36 students in each class. Experimental Class I was taught using the Project-Based Learning model assisted by instructional videos, whereas Experimental Class II received instruction using the Problem-Based Learning model assisted by the same instructional videos.

Data Collection Techniques

Data were collected using both test and non-test instruments. Learning achievement was measured using a 40-item multiple-choice test administered as a pretest and posttest to determine students' cognitive achievement before and after the implementation of the learning models. Students' learning motivation was measured using a questionnaire based on a five-point Likert scale consisting of 20 statements representing indicators of learning

motivation, including learning interest, persistence, learning needs, future expectations, appreciation, and learning environment.

Before implementation, the research instruments were evaluated for validity, reliability, item difficulty, and discrimination index to ensure the quality of the collected data.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics were used to summarize students' learning achievement and motivation. Prior to hypothesis testing, the data were examined for normality using the Shapiro–Wilk test and for homogeneity of variance using Levene's test. Independent sample *t*-tests were performed to determine differences in learning achievement and learning motivation between students taught using Project-Based Learning and those taught using Problem-Based Learning. Pearson correlation analysis was conducted to examine the relationship between students' learning motivation and learning achievement. All statistical analyses were performed at a significance level of 0.05.

3. RESULTS AND DISCUSSION

Description of the results and discussion of the article. Made descriptively. The learning outcomes in experiment 3 (through the scientific approach) were lower than experiment 1 (using PBL with *Power Point* media through the Scientific Approach) and experiment 2 (with *Power Point media* through the Scientific Approach) with an average learning outcome score of 73.13 (experiment 1), 67.29 (experiment 2), 66.88 (experiment 3) or experiment 1 > experiment 2 > experiment 3.

Asumption Test

The normality (Table 1) and homogeneity tests were conducted before hypothesis testing to ensure that the data met the assumptions required for parametric statistical analysis.

Table 1. Results of the Shapiro–Wilk Normality Test

Variable	Group	Shapiro–Wilk Sig.	Interpretation
Learning Achievement	PjBL	0.090	Normal
Learning Achievement	PBL	0.290	Normal
Learning Motivation	PjBL	0.310	Normal
Learning Motivation	PBL	0.280	Normal

As shown in Table 1, all significance values were greater than 0.05, indicating that the distributions of learning achievement and learning motivation were normally distributed. Furthermore, the homogeneity test indicated that the variances between the two experimental groups were homogeneous (Table 2). Therefore, the Independent Samples t-test was appropriate for comparing the two instructional models.

Table 2. Homogeneity

Variable	Significance	Interpretation
Learning Achievement	>0.05	Homogeneous

Learning Achievement (Table 3)

Table 3. Comparison of Students' Learning Achievement

Learning Model	Mean Score
Project-Based Learning	82.83
Problem-Based Learning	79.15

As presented in Table 3, students who learned through Project-Based Learning assisted by instructional videos obtained a higher mean score (82.83) than those who learned through Problem-Based Learning (79.15). The Independent Samples t-test showed a statistically significant difference between the two groups ($p = 0.026$), indicating that the instructional model influenced students' learning achievement.

The higher achievement observed in the PjBL group suggests that project-oriented learning facilitated deeper conceptual understanding by engaging students in authentic tasks requiring collaboration, investigation, and application of chemistry concepts. Developing project products encouraged students to connect theoretical knowledge with real-life situations, thereby strengthening their understanding of reaction rate concepts.

This finding is consistent with previous studies reporting that Project-Based Learning promotes meaningful learning experiences and improves students' conceptual understanding and academic achievement. Similar findings were reported by Markula and Aksela (2022), who found that authentic project activities enhanced science learning, and by Prajoko et al. (2024), who demonstrated that Project-Based Learning effectively improved conceptual understanding and creativity. Since both groups used identical instructional videos, the superior achievement can reasonably be attributed to differences in the instructional model rather than to the learning media.

Learning Motivation (Table 4)**Table 4.** Students' Learning Motivation

Model	High Motivation	Low Motivation
Project-Based Learning	86.00	40.33
Problem-Based Learning	86.33	33.83

The comparison of students' learning motivation is presented in Table 4. Statistical analysis indicated a significant difference between the two instructional models ($p = 0.043$). Although both groups demonstrated high levels of motivation, students who participated in Project-Based Learning showed stronger engagement throughout the learning process.

The integration of instructional videos with student-centered learning created a more interactive classroom environment and helped students visualize abstract reaction rate concepts. However, Project-Based Learning provided additional opportunities for students to plan, implement, and present project outcomes, promoting greater autonomy and responsibility for learning. These experiences are likely to enhance intrinsic motivation because students become active participants rather than passive recipients of information.

Relationship Between Learning Motivation and Learning Achievement (Table 5)**Table 5.** Results of Hypothesis Testing

Hypothesis	Variable	p-value	Decision
H1	Learning Achievement	0.026	Accepted
H2	Learning Motivation	0.043	Accepted
H3	Motivation–Achievement Correlation	0.000	Accepted

The Pearson correlation analysis revealed a significant positive relationship between learning motivation and learning achievement ($p < 0.001$). This finding indicates that students with higher learning motivation tended to achieve better academic performance.

Learning motivation likely contributed to students' persistence, active participation, and willingness to complete learning tasks, which ultimately enhanced conceptual understanding. Motivated students were more engaged during discussions, more persistent in solving problems, and more committed to completing project activities, resulting in improved learning outcomes.

This result is consistent with Kalsum et al. (2023), who reported that learning motivation positively influenced students' academic achievement by encouraging greater

persistence during learning. The present study further demonstrates that the relationship between motivation and achievement remains significant when student-centered instructional models supported by instructional videos are implemented.

Overall, the findings indicate that Project-Based Learning assisted by instructional videos was more effective than Problem-Based Learning in improving students' learning achievement while also fostering higher learning motivation. The novelty of this study lies in directly comparing two student-centered instructional models using identical instructional video media under the same learning conditions. This design minimizes the influence of instructional media and provides stronger evidence that differences in students' achievement and motivation are primarily attributable to the learning model. These findings provide practical implications for chemistry teachers in selecting instructional strategies for teaching abstract concepts such as reaction rates.

4. CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

This study demonstrates that integrating student-centered learning models with instructional videos provides an effective approach to improving chemistry learning on the reaction rate topic. The findings indicate that Project-Based Learning offers greater potential than Problem-Based Learning in creating meaningful learning experiences because it encourages students to actively construct knowledge, collaborate, and apply scientific concepts in authentic contexts. These findings strengthen the evidence that combining innovative pedagogical approaches with digital learning media can create a more interactive, engaging, and meaningful chemistry learning environment.

SUGGESTIONS

The findings of this study suggest that chemistry teachers should consider integrating Project-Based Learning with instructional videos to enhance students' motivation, participation, and conceptual understanding, particularly for abstract topics such as reaction rates. Schools are also encouraged to support the implementation of technology-assisted learning by providing adequate digital learning facilities and professional development for teachers.

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