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# The Implementation of the Inquiry Lesson Model on Reaction Rate Material to Improve Higher-Order Thinking Skills

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**Abstract:** Higher-order thinking skills (HOTS), particularly the abilities to analyze (C4) and evaluate (C5), are essential competencies in chemistry learning, especially on the topic of reaction rate, which is abstract in nature and prone to generating misconceptions. Various studies indicate that Indonesian students' HOTS achievement, including in the field of science, remains relatively low. This study aims to describe the effectiveness of implementing the inquiry lesson model on the topic of reaction rate in improving students' analyzing and evaluating abilities. This study employed a quasi-experimental method with a non-equivalent pretest-posttest control group design. The population consisted of all eleventh-grade science (MIPA) students at SMA Negeri 3 Bandar Lampung in the 2025/2026 academic year, and the sample was determined through purposive sampling: class XI MIPA 4 as the control group and class XI MIPA 7 as the experimental group. The experimental class received instruction using the inquiry lesson model, while the control class received conventional instruction consisting of lectures, question-and-answer sessions, and practice exercises. HOTS ability was measured using eight essay questions validated by three chemistry education experts; the instrument's reliability was good (Cronbach's alpha = 0.84), and all 8 items were valid, with calculated correlation coefficients (r) ranging from 0.5575 to 0.7798. Data were analyzed using N-gain and an independent-samples t-test after testing for normality and homogeneity. The results showed that the experimental class had an average N-gain of 0.68 (moderate category), significantly higher than the control class at 0.20 (low category), with $p < 0.05$. Improvement in both HOTS indicators, analyzing and evaluating, was also higher in the experimental class, with the generalization and verification stages playing an important role in training students' evaluating ability. Based on these findings, the inquiry lesson model proved effective in improving students' analyzing and evaluating abilities and can therefore serve as an alternative instructional strategy for developing students' HOTS on the topic of reaction rate, as well as other abstract chemistry topics.

**Keywords:** inquiry lesson, higher-order thinking skills, reaction rate.

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## INTRODUCTION

Higher-order thinking skills (HOTS) mean you can analyze, synthesize, and interpret information in ways that help you make decisions and solve problems creatively and critically (Markhamah, 2021). The three stages of analysis (C4), evaluation (C5), and creation (C6) that make up HOTS are outlined in the updated Bloom's taxonomy (Anderson & Krathwohl, 2001). This skill is especially important in chemistry classes, where students need to think critically and observe details to understand the concept of reaction rate, which is abstract, easy to misunderstand, and requires significant mental energy to teach (Yoris, 2017). Because students need to analyze experimental data, evaluate the factors influencing reaction rate, and create scientific explanations for observed phenomena to grasp this topic truly, HOTS is essential. Consequently, students cannot master reaction rate by memorizing concepts and formulas alone.

At the senior high school (SMA) level, the reaction rate topic generally emphasizes students' ability to read and interpret experimental data (concentration-time graphs, reaction rate tables) and to assess the influence of various factors (concentration, temperature, catalyst, surface area) on reaction rate. Both processes essentially correspond to C4 (analyzing patterns/relationships among variables) and C5 (evaluating which factor exerts the greatest influence, or comparing the validity of an explanation). The C6 competency (designing new experiments or creating original reaction models) falls outside the basic curriculum competencies for this educational level and was therefore not employed as a primary measured variable.

Having HOTS is crucial for everyone, especially in our current age marked by fast change and advancement. In line with this view, Miterianifa et al. (2021) assert that HOTS constitutes a fundamental requirement in 21st-century learning, as it is closely linkeded to the development of critical thinking, one of the most sought-after companies today, given that it is among the four components of competition (4Cs) recognized internationally: critical thinking, collaboration, communication, and creativity. This skill helps individuals adapt to various challenges and supports their ability to develop new ideas for innovation and entrepreneurialism, as found by Saptono et al. (2020) 4.0. In addition, solving complex tasks and real-world problems requires HOTS since the capacity to analyze and evaluate circumstances is essential for finding suitable solutions. Mitani (2021) views public education systems as vital in helping students acquire higher-order thinking skills (HOTS) so they can compete globally, since these abilities are demanded by today's economy. Rather than being innate, these talents develop through consistent training, learning, and experience. According to Kusuma et al. (2017), a systematically designed learning process is necessary to develop HOTS. This process should include clear learning objectives, inquiry-based teaching, consistent practice, and constant feedback to reinforce and clarify students' understanding. Consequently, it is necessary to cultivate HOTS systematically throughout the learning process.

According to the 2022 Programme for International Student Assessment (PISA) results, Indonesia ranked 68th out of 81 participating countries, with average scores of 359 in reading, 366 in mathematics, and 383 in science (OECD, 2023). These scores indicate that Indonesian students' performance remains within the low-performance category. Although Indonesia's ranking improved by 5–6 positions compared to PISA 2018, its absolute scores remain below the OECD average, reflecting persistent gaps in higher-order cognitive competencies (Bilad et al., 2024). This low achievement is attributed to the nature of PISA tasks, which demand HOTS such as analyzing, evaluating, and creating (OECD, 2023).

HOTS can be developed through instructional models that involve students in intensive research, organizing data tables, designing and conducting scientific investigations, applying technology and mathematics during inquiry, and understanding relationships among variables (Wienning, 2010). The inquiry-lesson model incorporates these activities. Various previous studies have consistently demonstrated the positive impact of the inquiry lesson model on higher-order thinking skills (HOTS) in high school chemistry learning. Kharismayuni et al. (2021) reported that an inquiry model combined with thinking maps was able to enhance students' HOTS in chemistry learning, as this model encourages students to actively analyze, evaluate, and organize information throughout the investigation process. These findings are reinforced by Arifin et al.'s (2025) meta-analysis of a number of science education studies, which confirmed that inquiry-based learning consistently contributes to the improvement of students' critical thinking skills one of the core components of HOTS although the magnitude of the effect varies depending on the level of scaffolding provided during the inquiry process. In line with this, Mediana et al. (2025), through a meta-analysis of a number of science and mathematics studies, found that inquiry-based learning consistently improves students' conceptual understanding across topics. This finding strengthens the argument that the inquiry approach is generic in nature and can be adapted to various subject-matter contexts, including abstract concepts in chemistry. On a more specific topic, Habiddin et al. (2023) demonstrated that the Interactive Instructional Teaching Method (IITM), an interactive inquiry-based teaching method, contributed to improving students' ability to answer unfamiliar types of buffer solution questions. However, the improvement did not reach statistical significance. Based on these findings, it can be concluded that the inquiry learning model has consistently proven effective as a learning strategy that supports the development of students' HOTS through the processes of investigation, analysis, and problem-solving that characterize it.

The levels-of-inquiry model presents a hierarchical framework for discovery-oriented learning (Wenning, 2005), designed to progressively develop thinking skills from basic to advanced levels. Throughout this process, the focus of learning gradually shifts from teacher-centered to student-centered, enabling students to become more active and reflective learners. The model integrates five stages of the learning cycle observation, manipulation, generalization, verification, and application as proposed by Wenning (2011), grounded in John Dewey's educational philosophy. These stages facilitate structured, comprehensive, and in-depth learning experiences. In this study, the inquiry lesson model was selected because it balances students' autonomy in constructing knowledge with the teacher's role as facilitator and guide. Specifically, the stages within the inquiry lesson model are designed to engage students in analyzing experimental data and evaluating scientific claims activities that are particularly appropriate for the reaction rate topic, in which students must interpret concentration-time graphs, apply collision theory, and assess the factors affecting reaction rates.

The reaction rate topic presents particular challenges for HOTS development. Its conceptual complexity spans macroscopic, submicroscopic, and symbolic levels of representation, requiring students to integrate experimental data, mathematical relationships, and theoretical models (Talanquer, 2011). Various studies in chemistry education indicate that both secondary school and undergraduate students struggle to develop a scientifically accurate understanding of reaction rates; they often confuse the concept of rate with reaction time or the extent of reaction, and exhibit persistent misconceptions regarding how temperature, concentration, surface area, and catalysts affect reaction rates (Cakmakci, 2010; Jusniar et al., 2020; Kolomuç & Tekin, 2011). Understanding reaction rate demands more than procedural knowledge; it requires students to analyze quantitative patterns, evaluate the validity of proposed mechanisms, and interpret results in light of theoretical predictions (Orosz et al., 2023). Despite this, most chemistry classrooms in Indonesia continue to rely on teacher-centered, lecture-based instruction that prioritizes recall over higher-order cognition, leaving students ill-equipped to engage with the conceptual depth this topic requires.

The gap between the cognitive demands of the subject matter and the level of thinking cultivated in instruction has not been adequately addressed for the topic of reaction rate. Accordingly, this study addresses the following research question: How effective is the implementation of the inquiry lesson model in improving students' analyzing and evaluating skills on the reaction rate topic? The hypothesis of this study is that the inquiry lesson model is effective in enhancing students' higher-order thinking regarding the topic of reaction rate.

## METHOD

### Participants

The population consisted of all Grade XI MIPA students at SMA Negeri 3 Bandar Lampung for the 2025/2026 academic year, comprising seven classes. Sampling was conducted using the purposive sampling technique. The underlying rationale was that the classes shared similar characteristics. Consequently, Class XI MIPA 4 was designated as the control group, and Class XI MIPA 7 as the experimental group; this selection was based on the fact that both classes possessed nearly equivalent characteristics specifically regarding cognitive ability as evidenced by the students' Mid-Semester Assessment (PTS) results in chemistry. The equivalence of the two groups was confirmed statistically using an independent sample t-test on the pretest scores, which yielded a sig. value of 0.412 ($p > 0.05$), indicating no significant difference in initial HOTS levels between the groups prior to treatment. This confirms that purposive sampling did not introduce systematic bias between groups.

### Research Design and Procedures

This research employed a quasi-experimental method using a non-equivalent pretest–posttest control group design (Creswell & Creswell, 2017). The experimental class was taught using the inquiry lesson model, while the control class received conventional instruction which was implemented through the lecture method, question-and-answer, and the assignment of practice exercises.

The study began with field observations to gather information about the curriculum, teaching models, learning facilities, student characteristics, and instructional schedules. The field observations revealed that chemistry instruction at the school was predominantly teacher-centered, relying on lectures and textbook exercises with minimal inquiry activities. Students struggled with questions requiring analysis and evaluation, particularly connecting experimental data to theoretical explanations. These findings directly informed the selection of the inquiry lesson model as the instructional intervention, as this model is specifically designed to scaffold students' transition from passive reception of information to active construction of knowledge through structured inquiry activities. Based on this preliminary study, learning materials and research instruments were developed, including a reaction rate teaching module and student worksheets (LKPD).

Both groups were administered a pretest to assess initial HOTs levels, followed by the respective instructional treatments. Throughout the sessions, student activities and implementation fidelity were observed using structured observation sheets. A posttest was administered afterward to evaluate the final HOTs levels.

### Instrument

The instruments consisted of pretests and posttests designed to measure students' higher-order thinking skills, specifically analyzing (C4) and evaluating (C5) skills, in the reaction rate topic. Both tests were developed by the research team based on the revised Bloom's taxonomy indicators (Anderson & Krathwohl, 2001). Each test consisted of eight open-ended essay questions: six questions measured the ability to analyze (covering the sub-indicators of differentiating, organizing, and attributing), and two questions measured the ability to evaluate (covering the sub-indicator of checking). An example analyzing item asked students to interpret concentration-time data from a given experiment to identify trends in reactant and product concentrations; an example evaluating item required students to examine a proposed hypothesis about the effect of temperature on reaction rate and determine whether it was consistent with given experimental evidence. Content validity was established through expert review by three chemistry education lecturers from FKIP Universitas Lampung, all of whom confirmed that each item was valid and aligned with the specified HOTS indicators. Construct validity was assessed through a pilot test administered to 30 students from a class not included in the research sample. Item reliability, calculated using Cronbach's alpha coefficient, yielded á = 0.84, indicating a good level of internal consistency, and all 8 items were valid, with the calculated correlation coefficients (r) ranging from 0.5575 to 0.7798.

### Data Analysis

The inquiry lesson–based learning cycle was considered effective if a statistically significant difference was observed in the mean n-gain between the experimental and control groups, and if the n-gain in the experimental class fell within the medium or high category. Data analysis began by calculating the n-gain for each student using the Hake's (1998) formula, followed by calculating the average n-gain for each class. The results of the average n-gain calculation were then interpreted using the criteria from Hake (1998) as follows: High category if $\langle g \rangle > 0.7$; Medium category if $0.3 \leq \langle g \rangle \leq 0.7$; Low category if $\langle g \rangle < 0.3$.

The hypothesis testing used in this study was the independent sample t-test to determine the difference between two means. Prior to conducting the test, assumption tests were carried out, including the normality test and homogeneity test. The normality test was performed using the Shapiro–Wilk test with SPSS version 25.00, while the homogeneity test was conducted using the Levene's test. The results of the normality and homogeneity tests indicated that the data were normally distributed and homogeneous; therefore, the independent sample t-test was used to analyze the difference between the two means in this study.

## RESULT AND DISCUSSION

The comparison of pretest and posttest scores of students' higher-order thinking skills (HOTS) in the control class is presented in Figure 1. In contrast, the comparison of pretest and posttest scores in the experimental class is presented in Figure 2.

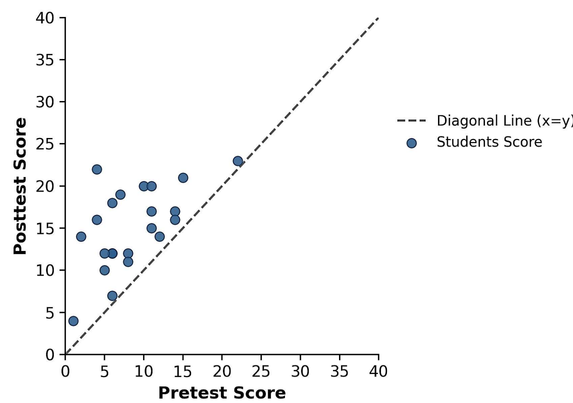



**Figure 1**. Comparison of pretest and posttest scores of students' higher-order thinking skills in the control class

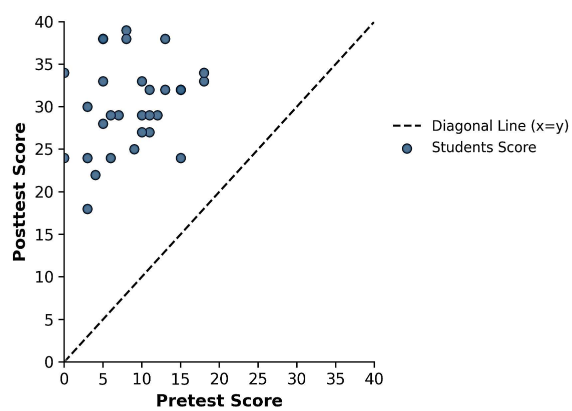



**Figure 2**. Comparison of pretest and posttest scores of students' higher-order thinking skills in the experimental class

The results of the average n-gain calculation of higher-order thinking skills in the control and experimental classes can be seen in Figure 3.

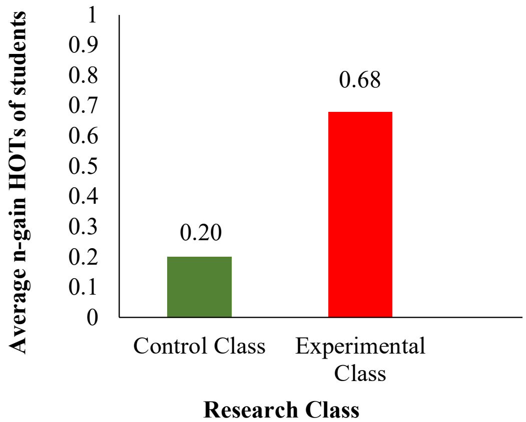
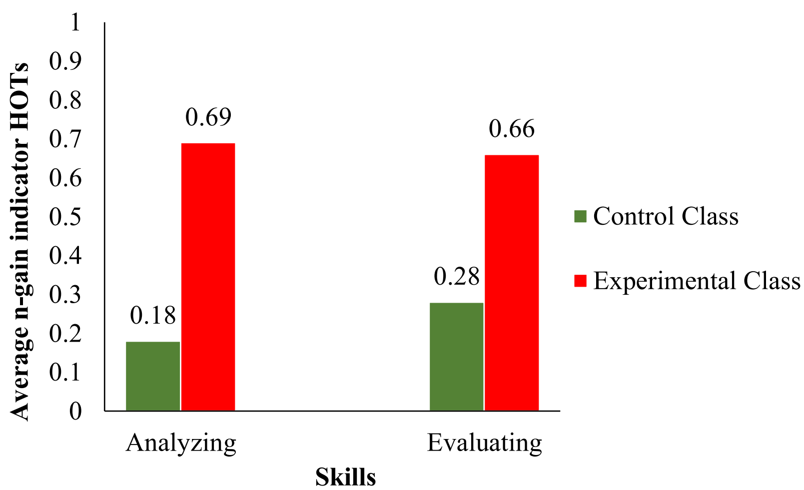



**Figure 3.** Average n-gain of students' higher-order thinking skills in the control and experimental classes

Figure 3 shows that the average n-gain of higher-order thinking skills in the experimental class is higher than that of the control class. The average n-gain of students in the experimental class is 0.68, which falls into the moderate category, while the average n-gain of students in the control class is 0.20, which falls into the low category. The difference between the average n-gain of the control and experimental classes is quite significant, both in magnitude and statistical significance.

The indicators of higher-order thinking skills examined in this study include analyzing and evaluating skills. The average n-gain for each higher-order thinking skill indicator can be seen in Figure 4.

Figure 4 shows that the average n-gain of students' analyzing and evaluating skills in the experimental class is higher than in the control class. The average n-gain for both analyzing and evaluating skills in the experimental class falls into the moderate category, whereas the control class n-gain values for both skills fall into the low category, consistent with the overall n-gain difference reported in Table 3.




**Figurìe 4**. Average n-gain of the analyzing and evaluating indicators in the control class and expìerimìental class

The results of the normality test for the average n-gain of higher-order thinking skills are presented in Table 1.

**Tablìe 1**. Results of the normality test of the average n-gain of high-level thinking skills

| Experiment Class | *Shapiro-Wilk* | | | | Dìescription |
|---|---|---|---|---|---|
| | Statistic Valuìe | df | sig. Value | Tìest Criteria | |
| Expìerimìent | 0.943 | 23 | 0.213 | Accìept $H_0$ if sig.> 0.05 | Accìept $H_0$ |
| Control | 0.934 | 23 | 0.132 | | Accìept $H_0$ |

Based on Table 1, it can be concluded that the samples come from a population with a normal distribution. Subsequently, a homogeneity test was conducted, and the results are presented in Table 2. Based on Table 2, it is shown that the two research samples have homogeneous variances.

**Tablìe 2.** Results of the homogeneity test of the average n-gain of high-level thinking skills

| Experiment Class | *Levìene Statistic* | | | | | Description |
|---|---|---|---|---|---|---|
| | Statistic Value F | df1 | df2 | sig | Test Criteria | |
| Experiment Control | 0.572 | 1 | 51 | 0.453 | Accept $H_0$ if sig.> 0.05 | Accept $H_0$ |

After the normality test showed that the data were normally distributed and the homogeneity test indicated homogeneous variances, an independent sample t-test was then conducted using SPSS version 25.00. The results of the independent sample t-test are presented in Table 3.

**Tablìe 3.** The results of the test of the difference between the two average n-gains of high-level thinking skills

| Class | Average *n-gain* | t Value | Mean Difference | df | sig. Value *(2-tailìed)* | Test Criteria | Description |
|---|---|---|---|---|---|---|---|
| Experiment | 0.68 | 12.113 | 0.48391 | 51 | $p < 0.001$ | Accept $H_0$ if sig. *(2-tailed)* > 0.05 | Rejected $H_0$ |
| Control | 0,20 | | | | | | |

Based on Table 3, the sig. (2-tailed) value is $p < 0.001$, indicating that $H_0$ is rejected and $H_1$ is accepted. This means that the average n-gain of students' higher-order thinking skills in the experimental class is higher than that of the control class. These results also show that the higher-order thinking skills of students in the experimental and control classes differ significantly. Therefore, it can be concluded that the implementation of the inquiry lesson model on the reaction rate topic is effective in improving students' higher-order thinking skills.

This finding is consistent with several recent studies. On the same topic of reaction rate, Herunata et al. (2025) found that guided inquiry learning based on Anderson's learning sketch analysis produced a significant difference in HOTs between the experimental and control groups ($p = 0.002$), with students in the experimental class achieving higher scores than those in the control class, particularly in analysis-related skills. Lubay et al. (2024), investigating the same material, reported that the guided inquiry learning model applied to reaction rate content was effective in improving students' analyzing skills, as reflected in the high-category average n-gain obtained by the experimental class. Beyond the specific topic of reaction rate, broader evidence from science education also supports this pattern; Antonio & Prudente (2024), in a recent meta-analysis of inquiry-based approaches across science disciplines, found medium effect sizes for several inquiry-based strategies, aligning with existing literature on students' development of scientific knowledge, higher-order thinking skills, and problem-solving mindsets. Taken together, these findings reinforce the conclusion that inquiry-based instructional models particularly when applied to conceptually demanding and data-driven topics such as reaction rate consistently and significantly enhance students' higher-order thinking skills compared to conventional instruction.

A comparison of student achievement who obtained scores 4 and 5 on the posttest items for each indicator of HOTS is presented in Table 4. The posttest consisted of 8 items, with a score range for each item from 0 to 5. The data show that across all indicators namely differentiating, organizing, attributing, and checking the percentage of experimental class students achieving high scores was consistently greater than that of the control class. The highest percentage in the experimental class was found in the differentiating indicator (83.33%), while in the control class the highest percentage was also found in the differentiating indicator (30.43%), although with a considerable gap compared to the experimental class. This difference indicates that the implementation of the inquiry learning model in the experimental class had a better effect on students' achievement of analyzing (C4) and evaluating (C5) skills than conventional learning in the control class.

**Tablìe 4.** Percentage of students achieving scores of 4 and 5 on posttest items

| Class | Percentage (%) | | | |
|---|---|---|---|---|
| | Differentiating | Organizing | Attributing | Checking |
| Experiment | 83.33 | 76.66 | 70 | 70 |
| Control | 30.43 | 21.74 | 26.09 | 17.39 |

Based on the results of the lesson implementation observation, the average implementation percentages of the inquiry lesson model at each stage were obtained as follows: the observation stage at 66.6%, manipulation at 68.78%, generalization at 75%, verification at 75%, and application at 75%. All stages fall into the high category, indicating that the syntax of the inquiry lesson model was implemented in accordance with the lesson plan that had been prepared. The high percentages at each stage indicate that the learning process not only proceeded according to the sequence of the model's stages, but that each component within it starting from observing phenomena (observation), manipulating variables or conducting experiments (manipulation), drawing general conclusions (generalization), verifying the findings (verification), to applying the concept in a new context (application) was carried out consistently. Thus, it can be concluded that the learning intervention using the inquiry lesson model was implemented in accordance with the design (fidelity of implementation), so that the learning outcomes or dependent variables obtained in this study can genuinely be attributed to the implementation of the model, rather than to implementation factors deviated from the plan.

The higher-order thinking skills examined in this study are analyzing skills and evaluating skills. The following section discusses how the implementation of the learning cycle stages using the inquiry lesson approach can train and enhance students' analyzing and evaluating skills.

**Analyzing Skills**

According to Anderson and Krathwohl (2001), the analyzing category consists of three specific cognitive processes: differentiating, organizing, and attributing. In general, these three analytical abilities include sorting relevant information, structuring data into a meaningful framework, and linking empirical evidence with conceptual knowledge to draw conclusions (Kania & Kusumah, 2025). These three indicators have long been used as a reference for developing HOTS assessment instruments across various science fields, including chemistry and physics, because they can clearly map students' levels of analytical thinking (Widana, 2017; Kusuma et al., 2017). All three were trained progressively with students through worksheets based on the *inquiry lesson* model on the topic of reaction rate. The use of guided worksheets in this study aligns with meta-analysis results showing that inquiry-based learning positively impacts learning activities, performance success, and student learning outcomes when accompanied by adequate guidance, compared with unguided free inquiry (Lazonder & Harmsen, 2016). The effectiveness of inquiry-based approaches in fostering students' HOTS is further supported by meta-analysis results showing that inquiry-based learning has a positive effect with a large effect size on students' higher-order thinking skills, including specifically in the field of chemistry (Antonio & Prudente, 2024). The following discussion explains how the three skills were trained and students' achievement on each indicator.

**Differentiating Skills**

The differentiating skill is defined as the process of sorting relevant information from irrelevant information, or important parts from less important ones (Anderson & Krathwohl, 2001). When students are trained to identify important differences and details among objects, concepts, or situations, they are essentially being trained at the cognitive level of analysis that forms the foundation for other higher-order thinking skills.

In this study, the differentiating skill was trained through a series of activities observing reaction-rate phenomena in everyday life, such as iron rusting and firework combustion, which were then explored further at the particle level. Students were guided to differentiate the number of particles at low and high concentrations through animations and submicroscopic representations, in line with the conclusion of a research review that inquiry-based learning is the dominant pedagogical approach used to guide students in understanding phenomena at the abstract particle level (Laohapornchaiphan & Chenprakhon, 2024; Berg et al., 2019). Understanding at the submicroscopic level is important as a bridge before students are able to differentiate patterns of concentration change at the macroscopic and symbolic levels in an integrated manner.

The differentiating skill was also trained through the analysis of experimental data, namely determining differences in the trends of reactant and product concentrations over time based on graphs and data tables. The ability to interpret how reaction rate changes over time is one of the conceptual challenges widely highlighted in chemistry education research, as shown by studies on students' construction of graphical models when explaining changes in reaction rate over time (Rodriguez et al., 2020). Students' work in this study shows that they were able to differentiate changes in product and reactant concentrations over time, determine the trend according to the concept, and relate their answers to the experimental observations. Similar ability was also seen when students were asked to determine species with the same and different concentrations from several sets of experimental data, including determining the increase in reaction rate based on given data, as well as differentiating experimental results based on independent and dependent variables and differentiating submicroscopic representations of each factor affecting reaction rate.

The differentiating skill, as part of higher-order analysis, was also trained through an analogy question comparing the surface area of an intact cube with a cube divided into eight parts, which required students not only to recall the concept but also to apply and analyze a new situation to determine which shape has a larger surface area.

Overall, the evaluation results show that 83.33% of students in the experimental class correctly answered questions measuring the differentiating skill. This achievement confirms that learning based on the inquiry lesson model, which combines direct observation with multi-level representations (macroscopic, submicroscopic, symbolic), is effective in training analytical skills in the form of differentiating in chemistry learning on the topic of reaction rate.

**Organizing Skills**

Organizing skill is a cognitive process for determining how sorted pieces of information relate to one another and arranging them into a coherent, meaningful structure, for example by transforming one form of representation into another that is more concise or systematic (Anderson & Krathwohl, 2001). The organizing skill requires students to arrange the sorted information into a complete framework, so that the two skills are interconnected within the analyzing category. The organizing skill is measured through questions that require students to rearrange data or concepts they have understood into a new, more systematic form of representation (Widana, 2017).

In this study, students were trained in organizing skills after first being trained to differentiate trends in reactant and product concentrations and to relate (correlate) these findings to the general definition of reaction rate. Equipped with the definition of reaction rate they had obtained, students were then asked to write the mathematical equation for reaction rate notation, that is, to transform verbal understanding into a coherent symbolic structure. This kind of symbolic representation plays an important role as a link between conceptual understanding and submicroscopic representation, thereby helping students build a more complete connection among the information they have learned (Zhang & Jiang, 2025).

Students' work shows that they were able to write mathematical equations consistent with the concept of reaction rate. This indicates that students were able to organize the information they possessed, namely transforming their understanding of the definition of reaction rate into a logically and systematically structured mathematical rate-notation equation. Students' success in constructing this equation shows that the previously trained processes of differentiating and relating provided sufficient conceptual foundation, enabling students to represent their understanding in more formal and structured form.

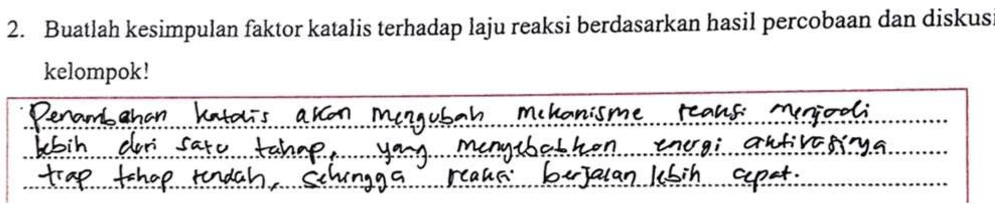
Overall, the evaluation results show that 76.66% of students in the experimental class correctly answered questions measuring the organizing skill. This achievement shows that most students could arrange conceptual information into a coherent symbolic structure. However, the percentage was slightly lower than for the differentiating skill, indicating that arranging and re-representing information requires a higher level of abstraction than simply sorting information (Kusuma et al., 2017).

**Attributing Skills**

Attributing skill is the highest cognitive process in the analyzing category: the ability to draw conclusions or general meanings from a set of information differentiated and organized by linking empirical evidence with conceptual knowledge (Anderson & Krathwohl, 2001; Kania & Kusumah, 2025). Unlike differentiating, which involves sorting, and organizing, which involves arranging, attributing requires students to make generalizations consistent with the data and concepts they have learned, so this process requires more thorough integration of conceptual and procedural knowledge. In various HOTS assessment instruments, questions measuring the attributing indicator are generally among the most demanding items, because students must consider several pieces of information at once before arriving at an appropriate conclusion (Widana, 2017; Kusuma et al., 2017).

The attributing skill was trained, among other ways, by asking students to conclude instantaneous rate and average reaction rate based on the knowledge they had acquired. Students' work shows that most answers had not yet moved toward the concept of instantaneous rate in a chemistry context, but still referred to instantaneous rate in physics. In contrast, the expected answer was that instantaneous rate is the reaction rate measured at a specific point in time. This finding is consistent with research reports revealing that misconceptions about reaction rate, including difficulty distinguishing instantaneous rate from average rate, are a fairly common problem encountered among students across grade levels (Jusniar et al., 2020). This indicates that students still need additional guidance to transfer their understanding of a concept from one context to another when making generalizations.

The attributing skill was also trained when students were asked to conclude the effect of a catalyst on reaction rate. An example of a student's answer is presented in Figure 5.


2. Buatlah kesimpulan faktor katalis terhadap laju reaksi berdasarkan hasil percobaan dan diskusi kelompok!

Penambahan katalis akan mengubah mekanisme reaksi menjadi lebih dari satu tahap, yang menyebabkan energi aktivasinya tiap tahap rendah, sehingga reaksi berjalan lebih cepat.

**Figure 5.** The attributing answer written by the student

The figure above shows a student's written answer to a question on the worksheet: constructing a conclusion about the effect of a catalyst on reaction rate based on the experimental results. The student's answer shows that adding a catalyst changes the reaction mechanism into more than one step, lowering the reaction's activation energy and allowing the reaction to proceed faster.

This answer is correct and consistent with the scientific concept of how a catalyst works: a catalyst provides an alternative reaction pathway with lower activation energy than the uncatalyzed pathway, so more reactant particles have sufficient energy to collide effectively and produce products in a shorter time. This achievement is important to note, given that understanding of the effect of a catalyst on activation energy has long been one of the most common misconceptions in the topic of reaction rate. Jusniar et al. (2020), in their study of high school students in Indonesia, reported that the misconception about the effect of adding a catalyst on activation energy is one of six major misconceptions in the topic of reaction rate, and it even contributes to students' misconceptions in the topic of chemical equilibrium. A follow-up study by Jusniar et al. (2021) also found that this kind of misconception often persists even after students have previously studied the topic, so learning strategies are needed that explicitly connect empirical evidence with the concept of activation energy, as trained through the generalization stage of the inquiry lesson model in this study. Thus, the accuracy of students' answers in this figure indicates that the designed learning was quite effective in helping students overcome this common misconception.

The ability to construct a conclusion that combines experimental evidence with conceptual explanation is a concrete manifestation of the attributing skill as the highest cognitive process in the analyzing category. Wangmo et al. (2025) affirm that students' ability to construct scientific conclusions that combine claim, evidence, and reasoning in chemistry learning plays an important role in developing scientific literacy and higher-order thinking skills, because students are required not merely to state a conclusion but also to explain why the evidence obtained supports that conclusion. The student's answer in the figure implicitly contains all three elements, namely the claim that adding a catalyst speeds up the reaction, the evidence in the form of the reaction mechanism changing into multiple steps, and the reasoning in the form of a decrease in activation energy as the cause of the increased reaction rate.

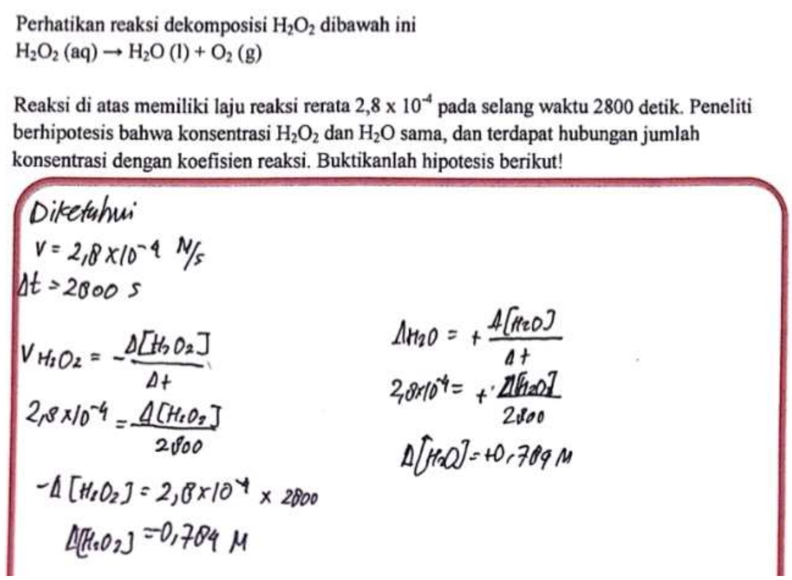
Overall, the evaluation results show that only 70% of students in the experimental class could correctly answer questions measuring the attributing skill, the lowest figure among the three indicators of the analyzing skill. This achievement confirms that students tended to move toward an appropriate conclusion, but not yet fully complete or conceptually precise. This finding is consistent with attributing as the peak cognitive process in the analyzing category, which requires students to integrate all results of differentiating and organizing into one complete conclusion (Anderson & Krathwohl, 2001). It is also consistent with findings that items measuring the attributive aspect generally have a greater difficulty level than other analysis indicators (Kusuma et al., 2017). Thus, continued practice in attributing remains important so that students' ability to conclude becomes increasingly accurate and complete.

**Evaluating Skills**

In addition to analyzing skills, this study also trained evaluating skills, the cognitive process of making judgments based on established criteria and standards, which, in Anderson and Krathwohl's taxonomy (2001), sits one level above analyzing. One of the evaluating indicators trained in this study is checking, the activity of examining inconsistencies or flaws in a process or product. Evaluating skills were trained during the generalization and verification stages of the inquiry lesson syntax.

At the generalization stage, students were asked to re-check their tentative answers to the questions on the LKPD (student worksheet) and determine whether those answers were correct or still inaccurate. One student's written answer is shown in Figure 6.

The student's answer was good; the student identified that "the hypothesis in the question was incorrect." This ability to check an initial


Perhatikan reaksi dekomposisi $H_2O_2$ dibawah ini
$H_2O_2$ (aq) → $H_2O$ (l) + $O_2$ (g)

Reaksi di atas memiliki laju reaksi rerata 2,8 x $10^{-4}$ pada selang waktu 2800 detik. Peneliti berhipotesis bahwa konsentrasi $H_2O_2$ dan $H_2O$ sama, dan terdapat hubungan jumlah konsentrasi dengan koefisien reaksi. Buktikanlah hipotesis berikut!



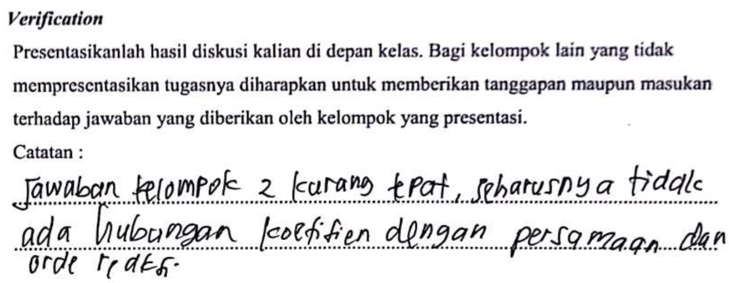
**Figure 6.** Student's answer in the checking activity at the generalization stage

hypothesis against empirical data shows that the student did not simply accept the answer as given, but had begun to develop a critical attitude in assessing how well the initial assumption matched the evidence obtained.

The ability to check as part of evaluating skills is also consistent with the concept of self-monitoring in metacognition research, in which re-checking one's own understanding or work against certain criteria is a core component of formative self-assessment, which has been shown to contribute to students' academic achievement (Andrade, 2019). This strengthens the argument that re-checking tentative answers at the generalization stage not only builds accuracy but also develops students' metacognitive awareness of their thinking process.

In addition to the generalization stage, evaluating skills were also trained at the verification stage. At this stage, groups of students were asked to give feedback and suggestions on other groups' answers. Criticism written by one student can be seen in Figure 7

In Figure 7, the student demonstrates adequate checking skills by identifying an inaccurate part of another group's answer, namely the incomplete notation of positive and negative signs for the rate of change of reactants and products, and by suggesting a more accurate notation as an improvement. This activity of mutually checking and critiquing answers between groups trains students to apply assessment criteria consistently, not only to their own answers but also to others' work, thereby strengthening conceptual understanding while fostering a reflective and collaborative learning culture.


**c.** ***Verification***

Presentasikanlah hasil diskusi kalian di depan kelas. Bagi kelompok lain yang tidak mempresentasikan tugasnya diharapkan untuk memberikan tanggapan maupun masukan terhadap jawaban yang diberikan oleh kelompok yang presentasi.

Catatan :

Jawaban kelompok 2 kurang tepat, seharusnya tidak ada hubungan koefisien dengan persamaan dan orde reaksi.

**Figure 7.** Student's written critique at the verification stage

The role of the verification stage in training evaluating skills through inter-group feedback is also supported by research from Zeng et al. (2024), who concluded that giving and receiving peer feedback encourages students to compare, correct, and reflect on their work based on certain criteria, which is a concrete manifestation of evaluating skills.

Overall, the evaluation results show that 70% of students in the experimental class correctly answered questions measuring checking skills. This result indicates that most students have been able to consistently apply evaluative criteria in identifying the correspondence between hypotheses and empirical evidence. Further reinforcement through more intensive checking practice and more structured feedback is still needed so all students can achieve optimal checking skills in future learning or research.

## CONCLUSION

The implementation of the inquiry lesson model proved effective in improving students' higher-order thinking skills, particularly their analyzing (C4) and evaluating (C5) abilities, on the topic of reaction rate. Both analyzing and evaluating skills showed greater improvement in the experimental class across all five stages of the inquiry lesson model, with the generalization and verification stages playing an important role in training students' evaluating skills.

Given that the sample was limited to two classes from a single school, future research is encouraged to replicate this design across more diverse schools and teachers, balance the proportion of evaluating items in the instrument, and extend the model to the creating (C6) level through open-ended investigative tasks.

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