

Research Article

## Implementation of Differentiated Learning on Acid-Base Material to Improve Learning Motivation and Critical Thinking Skills of High School Students

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**Abstract:** This study aims to analyze significant differences in learning motivation and critical thinking skills simultaneously between students who learn with differentiated learning and those who do not, determine the effective contribution of the implementation of differentiated learning on acid-base materials to learning motivation and critical thinking skills of students simultaneously, to determine the effective contribution of differentiated learning implementation on acid-base material to high school students' learning motivation, to determine the effective contribution of differentiated learning on acid-base materials to high school students' critical thinking skills, to determine the level of achievement of students' critical thinking skills in experimental and experimental studies. control classes. This study used a quasi-experiment model with a pretest-posttest control group design. The sample of this study consisted of two classes, namely experimental class and control class, with random sampling. The experimental class used differentiated learning, while the control class used discovery learning. Critical thinking skills data were obtained from the description test data and learning motivation data through questionnaires. MANOVA test was used to analyze differences in critical thinking skills and student learning motivation in experimental and control classes simultaneously. Test of between subject effects is used to analyze differences in each dependent variable in experimental and control classes. Partial eta square test is used to analyze the effective contribution of differentiated learning to the dependent variable. Descriptive statistics to determine the level of achievement of critical thinking skills. The results showed there were significant differences in learning motivation and critical thinking skills simultaneously and individually between students who used differentiated learning and those who did not, the effective contribution of differentiated learning on acid-base materials to critical thinking skills and student learning motivation simultaneously was 16.9% (high). achievement of critical thinking skills in the experimental class is in the good category, while in the control class is in the sufficient category.

Received: September 25, 2025

Revised: September 30, 2025

Accepted: October 19, 2025

Published: October 23, 2025

Curr. Ver.: October 23, 2025



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**Keywords:** Acid-Base; Critical Thinking Skills; Differentiated Learning; Learning Motivation; discovery learning

### 1. Introduction

Chemistry learning provides a means for students to understand the composition, structure, properties, and changes in matter and the energy that accompany them (Redhana, 2019). Through this learning, students are expected to not only master concepts and theories but also develop scientific thinking and analytical skills (Emda, 2017). Ideally, the chemistry learning process is active and requires student involvement in observing phenomena, asking questions, and linking theory to real-life contexts (Ferdian et al., 2018). However, chemistry learning in secondary schools still faces various obstacles, such as low student participation,

teachers' tendency to focus on memorization, and a lack of variety in learning models (Djarwo et al., 2025). These conditions tend to decrease student interest and motivation in chemistry (Prayunisa, 2022).

With the implementation of the Independent Curriculum, education in Indonesia requires teachers to be more adaptive to the differences in student characteristics (Halimah et al., 2023). This curriculum encourages autonomous, creative, and student-centered learning (Hr & Wakia, 2021). One strategy aligned with these principles is differentiated learning, an approach that adapts the learning process, content, and products to students' readiness, interests, and learning styles (Hadi et al., 2022). Through this strategy, students can gain learning experiences tailored to their needs and potential (Zein, 2021). Unfortunately, teachers still experience difficulties in implementing this curriculum due to limited time, resources, and classroom management skills (Nuryanti et al., 2024).

On the other hand, acid-base material is one of the topics considered difficult by students because it is abstract and requires in-depth conceptual understanding (Munafri et al., 2022). This material contains interconnected chemical concepts and complex mathematical calculations (Hidayanti et al., 2022). Minarni (2024) emphasized that the acid-base concept is included in essential topics that require logical reasoning and high analytical skills (Fitri & Ritonga, 2023). Therefore, teaching acid-base requires a learning model that can foster active involvement and critical thinking skills in students.

Critical thinking is a key competency of the 21st century because it trains students to analyze information, evaluate arguments, and make decisions based on evidence (Hendriana & Soemarmo, 2017). However, various studies show that this ability remains low among high school students because the learning process does not encourage in-depth exploration (Ngaisah & Aulia, 2023). Learning models such as discovery learning can be used as a comparison because they emphasize independent exploration and concept discovery. This model does increase student curiosity and participation, but it does not fully accommodate individual differences (Karismah & Nurcahyo, 2024).

The purpose of this study is to analyze the differences in learning motivation and critical thinking skills between students who participate in differentiated learning and those who do not, determine the effective contribution of differentiated learning to students' motivation and critical thinking skills both simultaneously and separately, and describe the level of achievement of students' critical thinking skills in two different learning conditions.

Thus, differentiated learning is expected to be a solution to optimize chemistry learning outcomes, increase motivation, and foster students' critical thinking skills in acid-base topics. Implementing this strategy will provide learning opportunities tailored to each individual's needs and make learning more effective, adaptive, and meaningful (Azmy & Fanny, 2023).

Based on this background, several emerging problems can be identified, namely chemistry learning that does not actively involve students, acid-base material that is considered difficult, low critical thinking skills and student learning motivation, and the lack of application of differentiated learning in teaching and learning activities. To maintain the focus of the research, the discussion is limited to the application of differentiated learning in an effort to improve motivation and critical thinking skills of high school students in acid-base material.

## 2. Literature Review

### Chemistry Learning

Chemistry learning is a two-way communication process between teachers and students to help students understand chemical concepts and their applications in real life. Gagné and Briggs explain that learning is a series of events designed to facilitate learning, while Redhana (2019) emphasizes that learning consists of human elements, materials, facilities, and procedures that interact to achieve specific goals. In the context of chemistry, this learning aims to connect theory and practice through appropriate strategies, methods, and models so that students can understand the structure, properties, and interactions of various substances (Hakim et al., 2024). Through this approach, chemistry learning helps students think critically about global issues such as energy and the environment that are relevant to everyday life (Yuhana & Aminy, 2019).

### **Differentiated Learning**

Differentiated learning is a teaching approach that adapts learning content, processes, and products to students' needs, interests, and learning profiles. According to Rahmawati (2023) and Purnawanto (2023), this strategy enables teachers to create an inclusive learning environment by providing each student with the opportunity to learn according to their abilities. Fitriyah and Bisri (2023) add that differentiation not only considers learning styles but also student readiness and interests, thus making learning activities more meaningful. The implementation of this model in the Merdeka curriculum has been shown to increase student motivation and activeness in chemistry learning (Rahmi et al., 2024). By understanding student characteristics, teachers can facilitate individual differences effectively (Rohimat et al., 2023).

### **Discovery Learning**

The discovery learning model encourages students to discover concepts or principles for themselves through investigative activities. According to Bruner (in Putri et al., 2020), this learning model focuses on active student participation in searching for and organizing information. Its main syntax includes the stages of stimulation, problem identification, data collection and processing, verification, and generalization. This approach helps students understand scientific concepts independently and strengthens critical and analytical thinking skills. When applied to chemistry learning, this model effectively guides students in exploring the cause-and-effect relationships of chemical phenomena through a structured discovery process.

### **Acids and Bases**

The concept of acids and bases is fundamental material in chemistry that is related to many advanced topics, such as hydrolysis, buffer solutions, and ionic equilibrium. According to Susilarningsih (2014), a proper understanding of this concept is an important foundation for students in studying advanced chemistry. Fessenden (1986) explains that strong acids undergo complete ionization in water, while weak acids only partially ionize. Petrucci (1987) and Chang (2004) add that identifying the properties of acids and bases can be done using indicators such as litmus paper or natural pigments from red cabbage. This material is highly contextual because it is closely related to everyday life, so contextual-based learning can help students understand the concept in depth (Andriani & Dewi, 2019).

### **Learning Motivation**

Learning motivation is an internal and external drive that directs students to achieve learning goals. Sardiman (2016) explains that motivation is an internal energy that fosters enthusiasm for learning, while Fadhilah (2018) emphasizes the importance of motivation in improving academic achievement. Rasyid et al. (2022) state that factors such as the learning environment and the teacher's teaching style influence students' motivation levels. In the context of differentiated learning, Ramdhani et al. (2024) found that an approach that considers individual student characteristics can increase interest and enthusiasm for learning because each student feels their learning needs are met.

### **Critical Thinking Skills**

Critical thinking skills are the ability to analyze, evaluate, and draw conclusions from information logically and reflectively. Ennis (1985, 2011) and Facione (2013) describe critical thinking as a process that requires the ability to interpret, analyze, infer, and evaluate a problem. Fisher (2009) emphasizes that these skills are essential for developing independent and rational learners. In chemistry learning, critical thinking is necessary to understand abstract concepts, solve scientific problems, and connect theory with empirical phenomena (Elfira & Santosa, 2023). Through a differentiated approach, students' critical thinking skills can be optimally developed because learning is tailored to their characteristics and readiness (Winarso et al., 2023).

### 3. Method

This study used a quantitative approach with a quasi-experimental pretest-posttest control group design. The design involved two groups, an experimental class and a control class, each receiving different treatments. The experimental class implemented differentiated learning based on the discovery learning model, while the control class only used the discovery learning model (Ana, 2018). The instruments used included a critical thinking skills test and a learning motivation questionnaire, administered before and after the treatment to assess changes in student learning outcomes.

The research was conducted at SMA Negeri 1 Tarakan, located at Jalan KH. Dewantara No. 18, Karang Balik Village, West Tarakan District, North Kalimantan. The research activities took place from January to the third week of March 2025, with teaching materials focused on the subject of acids and bases. The research population included all grade XI high school students in Tarakan City who had characteristics equivalent to SMA Negeri 1 Tarakan. The sampling technique was carried out by random sampling of classes that had equivalent academic abilities based on ANOVA analysis of the End of Semester Summative Assessment (ASAS) scores. From these results, two sample classes were obtained, namely class XI-B (34 students) as the experimental group and class XI-J (33 students) as the control group.

Data collection techniques were conducted through tests and non-tests. Essay-based tests were used to measure students' critical thinking skills, while non-test data were obtained through a four-level Likert-scale learning motivation questionnaire. Learning motivation indicators were adapted from Uno, which encompass aspects of achievement drive, learning needs, aspirations, appreciation, engaging learning activities, and a conducive learning environment. Prior to use, all instruments were validated by experts and piloted.

### 4. Results and Discussion

#### Research Results

This study used a discovery learning model with and without a differentiated content learning approach for acid-base material in grade XI of SMA Negeri 1 Tarakan. Grade XI-B was designated as the experimental group, while XI-J was designated as the control group. Both underwent six meetings, including a pretest, four learning sessions, and a posttest. The results showed that the implementation of differentiated learning had a positive impact on students' critical thinking skills and learning motivation (Ennis, 1985).

The average n-gain score for critical thinking skills in the experimental group reached 0.55 (moderate category), higher than the control group's score of 0.45. This indicates that the use of a differentiated approach in the discovery learning model can optimize students' ability to understand the concepts of acids and bases through analysis, inference, and evaluation activities. Furthermore, learning motivation also increased significantly in the experimental group, with a higher average n-gain score compared to the control group.

Before conducting the MANOVA test, the researchers ensured that the data met various statistical assumptions. The Shapiro-Wilk normality test showed a significance value greater than 0.05, indicating a normal distribution. The results of the multivariate normality test using the Mahalanobis Chi-Square scatter plot also showed an  $R^2$  value of 0.974, indicating a multivariate normal distribution.

Furthermore, the Box's test obtained a significance of 0.407 ( $>0.05$ ), indicating that the homogeneity of the variance-covariance matrix was met. The linearity test also showed a linear relationship between the dependent variables, while the multicollinearity test produced a tolerance value of 0.994 and a VIF of 1.006, indicating no symptoms of multicollinearity. The Pearson correlation coefficient of 0.539 confirmed a moderate relationship between critical thinking skills and learning motivation (Sugiyono, 2019). With all these assumptions met, a One-Way MANOVA analysis can be conducted to assess differences in the effects of the treatments.

#### Discussion

The analysis results showed significant differences in critical thinking skills and learning motivation, both simultaneously and separately, between students taught with differentiated learning and those who were not. The MANOVA significance value was less than 0.05, indicating that this approach significantly affected both variables.

In the initial stages of learning, the experimental class received different stimuli according to students' learning styles (visual, auditory, kinesthetic), such as the use of videos, text, or images. Meanwhile, in the control class, the teacher provided uniform stimuli without considering the variation in learning needs. As a result, students in the experimental class demonstrated higher engagement and participation, which resulted in improved understanding of acid-base concepts.

The application of differentiated learning also facilitates more adaptive data collection and problem-solving strategies, encouraging students to think critically through problem identification, analysis of relationships between concepts, and drawing conclusions based on evidence. This aligns with Ennis's (1985) theory on critical thinking indicators: interpretation, analysis, evaluation, and inference, as well as research by Kamal (2022) and Hidayati & Sujarwati (2023), which confirms the effectiveness of differentiated learning in improving learning outcomes.

Based on the analysis of effective contributions, the differentiated approach contributed 6.1% to critical thinking skills and 12% to learning motivation, both in the moderate category. This improvement indicates that the content differentiation strategy is able to meet individual student needs, making the learning process more meaningful and encouraging active engagement.

## 5. Conclusion

Based on the research results and discussion presented, several main conclusions were obtained as follows. First, differentiated learning has been proven to have a significant influence on increasing students' learning motivation and critical thinking skills, both simultaneously and separately compared to learning without differentiation. Second, the application of differentiated learning to acid-base material provides an effective contribution of 6.1% to critical thinking skills, which is classified as medium. Third, together, this approach provides an influence of 16.9% on motivation and critical thinking skills, including the high category. Fourth, regarding the variable of learning motivation specifically, the effective influence reaches 12% with a medium category. Finally, the achievement of critical thinking skills of students in the experimental class is in the good category, while the control class only reaches the sufficient category.

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