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High School Chemistry Learning: The Correlation Between Students' Critical Thinking and Self-Efficacy

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Abstract

This study aimed to investigate the relationship between critical thinking skills and self-efficacy in high school chemistry learning. This research investigates the correlation between students' critical thinking skills and their self-efficacy. Conducted at a senior high school in Jayapura, the research involved a sample of 96 students, selected using a random sampling technique. Utilizing a quantitative approach with a correlational research design, data were collected through standardized instruments measuring students' critical thinking and self-efficacy. The instruments used were a self-efficacy questionnaire and a critical thinking skills test in the form of open-ended two-tier multiple-choice questions. The reliability of the critical thinking test was 0.850. The validity test of the self-efficacy questionnaire showed infit and outfit MNSQ values ranging from 0.77 to 1.30 using QUEST, with a reliability coefficient of 0.71. The data were analyzed using descriptive statistics using the Pearson correlation test to determine the correlation between students' critical thinking skills and selthe f-efficacy. The analysis revealed a significant positive correlation between the two variables, indicating that students with higher self-efficacy tend to demonstrate stronger critical thinking skills. Furthermore, the implications of this research align with the United Nations' Sustainable Development Goals (SDG 4 on Quality Education, SDG 9 on Industry, Innovation, and Infrastructure, and SDG 12 on Responsible Consumption and Production), highlighting the contribution of chemistry education to sustainable development through enhanced critical thinking skills.

Keywords: *Chemical equilibrium, Chemistry learning, Critical thinking, Self-efficacy*

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INTRODUCTION

Chemistry holds a vital role in secondary science education, as it helps students make sense of the phenomena occurring in the world around them (Sirhan, 2007). Despite its importance, chemistry is often perceived as a complex and abstract subject, making it challenging for many learners. Research has shown that students frequently struggle to grasp both fundamental and advanced chemistry concepts (Woldeamanuel et al., 2014; Pratama et al., 2024). The subject demands not only a deep understanding but also strong analytical thinking skills. As a result, chemistry is widely regarded as a difficult subject by researchers, educators, and science education experts alike (Nakhleh, 1992).

To address these challenges, fostering students' critical thinking and self-efficacy has become increasingly important in chemistry education. Critical thinking enables learners to analyze, evaluate, and connect concepts, while self-efficacy enhances their confidence in tackling complex problems and persisting through difficulties. When students believe in their ability to succeed, they are more likely to engage actively, apply problem-solving strategies, and overcome misconceptions. Therefore, integrating strategies that strengthen both skills can help transform chemistry learning from a daunting task into an engaging and meaningful experience, ultimately improving students' comprehension and achievement.

Critical thinking allows students to examine, assess, and link concepts, whereas self-efficacy boosts their confidence in addressing challenging problems and persevering through obstacles (Ijirana et al. 2022). But the low level of students' critical thinking skills in learning

chemistry is still a challenge at the high school level, it is caused by the lack of application of learning models (Casmini, Redhana, & Suma. 2024).

Strengthening students' self-efficacy is closely tied to the development of their critical thinking skills, as confidence in their own abilities can encourage them to engage more deeply with complex chemistry tasks. When learners believe they are capable of solving problems, they are more willing to take risks, persist through difficulties, and apply higher-order thinking strategies. Conversely, low self-efficacy often leads to avoidance of challenging tasks and surface-level learning (Vishnumolakala et al. 2017). Therefore, designing learning environments that simultaneously foster critical thinking and build self-efficacy can create a positive cycle, where increased confidence supports deeper reasoning, and improved reasoning further reinforces students' belief in their capabilities.

Chemistry education at the secondary school level faces significant challenges in enhancing students' understanding of the subject. A major obstacle is that many students struggle with grasping chemical concepts due to a lack of sufficient critical thinking skills. The low critical thinking ability of students in chemistry subjects is a complex problem that is influenced by various interrelated factors (Casmini, Redhana, & Suma, 2024). In chemistry, critical thinking is essential for analyzing data, interpreting natural phenomena, and solving problems related to chemical content. As a foundational element of 21st-century education, critical thinking is recognized as a core component of modern literacy, key competencies, and essential skills for lifelong learning (Changwong et al., 2018; Santos, 2023; Zhang et al., 2023). Therefore, it is crucial to cultivate critical thinking skills from an early stage to enable students to approach problems logically and develop the analytical skill necessary for complex decision-making (Ennis, 2011).

Another equally important factor in chemistry learning is self-efficacy, which refers to students' confidence in their ability to complete tasks and overcome challenges, including those encountered in chemistry. Rooted in social cognitive theory, self-efficacy is defined as an individual's self-judgment regarding their capability to perform specific tasks (Bandura, 1993). According to Agustina (2019), individuals with high self-efficacy are characterized by their willingness to take on difficult tasks, a strong belief in their ability to succeed, and consistent performance outcomes. In contrast, students with low self-efficacy often avoid challenging tasks due to a lack of confidence in their abilities, which can negatively affect their academic achievement. Furthermore, research by Raidil et al. (2023) found a significant influence of self-efficacy on students' critical thinking skills, as indicated by a p-value of less than 0.05.

There is a strong connection exists between critical thinking skills and self-efficacy in the context of chemistry learning. Students with high self-efficacy tend to demonstrate enhanced critical thinking abilities, which are reflected in their capacity to make well-reasoned decisions (Salea & Soetjiningsih, 2022). However, a lack of motivation often hinders the development of both self-efficacy and critical thinking. As noted by Dehghani et al. (2011), motivation plays a crucial role in fostering critical thinking skills, making it a key factor in students' overall cognitive development. The research by Riyanto, Waluya, & Mariani (2020) stated that students with high self-efficacy have high critical thinking skills; students with moderate self-efficacy have moderate or low critical thinking skills. Students with low self-efficacy have moderate or low critical thinking skills. This study highlights the significant role of critical thinking skills in shaping students. Therefore, this study holds significant urgency as it underscores the crucial role of critical thinking skills in shaping students (Purwati, *et al*, 2025).

This study aligns with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), which advocates for inclusive, equitable, and high-quality education, as well as lifelong learning opportunities for all (Rahman & Lestari, 2024; Pratama et al., 2025). By integrating self-efficacy and critical thinking into chemistry learning, it also supports SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production) through fostering scientific literacy and responsible decision-making (Prasetyo & Wulandari, 2023).

The novelty of this research lies in its focused examination of the correlation between self-efficacy and critical thinking within the topic of chemical equilibrium among high

school students in Jayapura, Indonesia—a context rarely addressed in prior studies published in *Jurnal Pendidikan Matematika dan Sains* (JPMS). While previous JPMS publications have investigated critical thinking in chemistry (Prasetyo & Wulandari, 2023) or self-efficacy in general science learning (Rahman & Lestari, 2024), few have employed a correlational design to measure both variables simultaneously while considering regional educational challenges and local curriculum implementation. This research therefore contributes a fresh perspective, offering empirical evidence from an underrepresented educational setting that can inform targeted strategies to strengthen both cognitive and affective domains in chemistry education.

This phenomenon forms the basis for the researcher's decision to explore the relationship between critical thinking skills and self-efficacy in chemistry learning. Understanding this connection is essential, as it can contribute to the existing body of knowledge on the factors that influence student achievement in chemistry particularly in relation to critical thinking and self-efficacy. Moreover, the findings of this study may offer valuable insights for educators in developing more effective and targeted teaching strategies to enhance student learning outcomes. Based on this the research question is Is there a significant relationship between students' critical thinking skills and their self-efficacy in chemistry learning?

METHOD

This study employed a quantitative correlational research design to investigate the relationship between students' critical thinking skills and their self-efficacy in learning chemistry at the high school level. Correlational research is appropriate for examining the degree and direction of association between two continuous variables without manipulating the variables (Creswell, 2014).

The research sample consists of 96 high school students enrolled in chemistry courses at a senior high school in Jayapura. The participants were selected using random sampling based on their enrollment in the chemistry class during the current academic year. This method was chosen to ensure that each student had an equal opportunity to be included in the study. The sample size was considered adequate to provide sufficient statistical power for detecting the correlation between critical thinking and self-efficacy.

Data collection was conducted in two phases during regular class hours. First, the critical thinking test was administered under supervised conditions to ensure consistency and minimize external influences. After completing the test, students were asked to fill out the self-efficacy questionnaire. All procedures followed ethical standards, including informed consent and confidentiality assurance.

A self-report questionnaire synthesised from Eggen and Kauchak (2011), Bandura (1994), Santrock (2011), Schunk (2012), and Ormrod (2009). The questionnaire contains 15 items rated on a 4-point Likert scale (1 = strongly disagree to 5 = strongly agree) measuring students' confidence in completing chemistry-related tasks and challenges. A comprehensive breakdown of the questionnaire items is provided in Table 1 below.

Table 2. The aspects of self-efficacy

No	Self-Efficcay Aspects	Indicators	Total Statements
1.	Beliefs	Believe you can achieve success	3
		Confident in overcoming failure and stress	3
2.	Persistence/ Perseverance	Spending a lot of time on assignments	1
3.	Effort	Uses great effort to complete tasks	2
4.	Task Orientation	Accepting a difficult task and doing it	1
5.	Performance	The learning outcomes obtained were very good	3
		Comparing performance between one student and another	2

A standardized test designed to assess students' critical thinking skill specifically related to chemistry concepts. The test includes open-ended two-tier multiple-choice that measure skills such as analysis, evaluation, inference, and problem-solving. The reliability

coefficient of the critical thinking test was 0.850. For the self-efficacy questionnaire, the validity test showed infit and outfit MNSQ values ranging from 0.77 to 1.30 using QUEST, and the reliability coefficient was 0.71. The critical thinking test was adapted from Sadhu and Wijayanti, 2018. A comprehensive breakdown of the questions items is provided in Table 3 below.

Table 3. The aspects of critical thinking

No	Critical Thinking Aspects	Indicators	Total Statements
1.	Able to analyze the meaning of equilibrium in an equilibrium reaction	Identifying arguments based on phenomena by utilizing chemical concepts	1 (2nd question)
2.	Able to determine the quantitative relationship between reactants and reaction products in an equilibrium reaction	Drawing conclusions by utilizing chemical understanding	1 (1st question)
3.	Analyzing the effects of concentration, temperature, pressure, volume, and catalysts on a chemical reaction	Identifying problems based on phenomena by utilizing chemical concepts	1 (3rd question)
4.	Analyzing equilibrium reactions in the chemical industry	Determining solutions based on examples of chemical applications	1 (4th question)
		Reconstructing arguments based on examples of chemical applications	1 (4th question)

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics (mean, standard deviation) were calculated to describe the distribution of scores for both variables. The normality of the data was tested using the Shapiro-Wilk test to determine the appropriate correlational analysis method.

Since both variables were normally distributed, Pearson's Product-Moment Correlation coefficient was used to examine the strength and direction of the relationship between critical thinking skills and self-efficacy. The significance level was set at $\alpha = 0.05$. Additionally, scatter plots were created to visually inspect the relationship between the variables.

RESULT AND DISCUSSION

The objective of this research is to determine whether there is correlation between students' critical thinking skills and students' self-efficacy in learning chemistry, and to understand how these two factors influence each other in supporting students' academic performance and learning outcomes. Why this research is conducted it's because of self-efficacy is a crucial psychological factor influencing student success, particularly within effective learning strategies (Rosiyanti, Priatna, & Turmudi, 2025).

Self-efficacy is one important variable in chemistry learning. Self-efficacy is important factors in improving chemistry learning achievement and these factors must be mastered by students (Putri at al, 2024). According to (Zarkasyi & C Partana, 2020), levels of self-efficacy in learning chemistry, whether high or low are shaped by factors such as motivation, prior experiences, problem-solving confidence, psychological state, emotions, and the surrounding social environment.

Its is not only self-efficcay that can affect the chemistry learning, other variable which is students' critical thinking also has been declared to be a great impact in chemistry learning. Critical thinking skills are essential abilities that must be possessed to meet the challenges of the times (Gumilang, Wahidin, & Tsurayya, 2021). Students' critical thinking ability refers to the cognitive process in which they connect one

event to another in order to solve a problem (Armita & Marsigit 2016).

Before performing the correlation test to examine the significance of the relationship between students' self-efficacy and critical thinking, a prerequisite analysis was conducted to verify that the necessary assumptions were satisfied. The assumptions include the following:

Level of Measurement: The variables must be measured on a ratio or interval scale. In this research, the student self-efficacy data meet this requirement, as they are classified as either ratio or interval data.

Normality: The data in each group should be normally distributed. This assumption was evaluated using the Shapiro-Wilk test. The Shapiro–Wilk test is generally considered more suitable for analyzing small sample sizes (less than 50 observations), though it can still be applied to larger samples. In contrast, the Kolmogorov–Smirnov test is typically recommended for sample sizes of 50 or more (Misrah et al., 2019).

Table 4 displays the results of the normality test, which assesses whether the data meet the assumptions required for applying the t-test. The collected data were statistically analyzed using SPSS, with the Kolmogorov–Smirnov normality test applied to determine whether the data followed a normal distribution and were suitable for subsequent parametric testing. The results of the normality test for both students' self-efficacy and critical thinking yielded significance values above 0.05, indicating that the data for both variables are normally distributed.

Table 4. Normality test

Variable	Sig.
Students Self Efficacy	.200*
Students Critical Thinking	.200*

After the normality test is carried out, the next step is to carry out the homogeneity test. Levene developed this test based on the assumption that the values are independent and follow a normal distribution. Table 5 presents the results of the homogenety test, indicating that the significances value for the variable are 0.332 and 0.356. Since this value exceeds the 0.05 (α) threshold, it can be concluded that the are homogeneously distributed.

Table 5. Homogenity test

Variable	Sig.
Students' Self Efficacy	0.332
Students' Critical Thinking	0.356

The research hypothesis was tested using the Pearson Product–Moment correlation technique to examine the relationship between students' critical thinking skill and students' self-efficacy. The analysis was conducted with the assistance of SPSS Statistics. Table 6 presents the results of the hypothesis testing for the relationship between those two variables.

Table 6. Correlation test result

Research Variable	Pearson Correlation	
	Sig.	Pearson Correlation
Students' Self Efficacy and Students' Critical Thinking	0.002	0.560

Based on table 6 it can be concluded that the significant value from those three classes is below 0.05. It indicated that there is correlation between students' self-efficacy and students' critical thinking in those classes. Based on table 10 the Pearson correlation is 0.560, it shows that there is medium correlation between students' self-efficacy and students' critical thinking in class F1. Based on table 6 the Pearson correlation is 0.560, it shows that there is medium correlation between students' self-efficacy and students' critical thinking. From Table 6, it is observed that the significance value of the correlation test is 0.002 < 0.05. Based on

the decision-making criteria, this indicates that a correlation exists. It is also evident that the Pearson correlation value is 0.560, which, according to the guidelines for the degree of correlation, falls within the category of a moderate correlation.

The results of this study indicate a significant positive correlation between critical thinking skills and students' self-efficacy in chemistry learning in high school. This finding confirms that students who have a high level of self-efficacy tend to show better critical thinking skills. This correlation indicates that cognitive (critical thinking) and affective (self-efficacy) aspects are interrelated and play an important role in supporting learning success, especially in complex subjects such as chemistry (Arthi & Gandhimathi, 2024).

Mundhofar, Issroviatiningrum, & Abdurrouf (2025) on their research stated that the positive relationship is positive with moderate closeness (0.496) and a very low p-value (0.000) which indicates that increasing self-efficacy is related to increasing critical thinking abilities. Hartanaa et al. (2024) indicated that self-efficacy as a crucial factor for enhancing learning strategies and self-monitoring capabilities. The research confirms the beneficial effect of self-efficacy on critical thinking, highlighting its role in fostering key student competencies such as creativity, independence, and scientific inquiry.

Furthermore, self-efficacy can be understood as an individual's confidence in their capability to organize and implement the actions required to attain specific goals (Bandura, 1997). In educational settings, this construct plays a crucial role in shaping students' levels of motivation, their perseverance in the face of difficulties, and the strategies they adopt for learning. Students who possess strong self-efficacy are more inclined to engage with demanding academic tasks, including intricate disciplines such as chemistry (Zimmerman, 2000). Self-efficacy also contributes to how students approach problem-solving tasks. Learners with a strong sense of self-efficacy are more likely to adopt proactive and reflective learning strategies, and they demonstrate resilience when encountering academic challenges. This persistence forms a solid basis for cultivating critical thinking abilities, which necessitate confidence in processing, assessing, and integrating information.

The findings of this study have direct relevance to the United Nations' Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), which emphasizes inclusive and equitable quality education and the promotion of lifelong learning opportunities for all. By fostering students' self-efficacy and critical thinking skills in chemistry, educators contribute to the development of competencies essential for problem-solving, innovation, and informed decision-making. Indirectly, these skills also support SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production) by preparing scientifically literate individuals capable of addressing complex societal and environmental challenges. Strengthening these competencies at the high school level lays the foundation for sustainable scientific literacy, which is vital for achieving broader global sustainability targets (Rahman & Lestari, 2024).

Critical thinking refers to the capacity to assess information in a logical and impartial manner prior to reaching a decision or drawing conclusions (Facione, 2015). In the context of chemistry education, this skill is essential due to the abstract and intricate nature of the subject, which often demands advanced problem-solving abilities. The process of critical thinking encompasses students' competence in recognizing underlying assumptions, interpreting data analytically, and constructing arguments in a structured and coherent way (Ennis, 2011)

There is strong correlation between students' self- efficacy and students' critical thinking showed by Muhtadi, Assagaf & Hukom (2022). This implies that greater self-efficacy is associated with stronger mathematical abilities, while lower self-efficacy corresponds to weaker performance. These results offer a strong theoretical basis for enhancing students' mathematical achievement in the future. Omar & Zoube (2024) also stated that there was strong relationship at ($\alpha = 0.05$) between the critical thinking skills and self-efficacy, because for critical thinking skill it is important to have a confidence in one's ability to solve problems, find a relevant answer or to formulate defensuble conclusion (Vakova, Sedakova, & Kvintova, 2023).

Research has shown a strong and positive relationship between critical thinking and self-efficacy, as students with higher self-efficacy tend to approach complex problems with greater

confidence, persistence, and openness to multiple perspectives. This, in turn, enhances their capacity to apply critical thinking strategies effectively, creating a mutually reinforcing cycle in which critical thinking skills bolster self-efficacy, and strong self-efficacy further promotes deeper, more reflective thinking.

The analysis results from Misbahudin (2019). showed that there is a significant relationship between students 'self-efficacy with students' critical thinking abilities and the effect of self-efficacy on the critical thinking skills of students of Vocational High School class XI which is 19.89% while the remaining 80.11% is influenced by other factors. There is a positive relationship between self-efficacy and students' mathematical critical thinking skills. The higher a student's self-efficacy, the higher their mathematical critical thinking skill (Geovani & Waluya, 2025).

The findings of this research suggest that educators should design instructional strategies that go beyond the mere transmission of knowledge, by also addressing the affective dimensions of student development. This is relate to Simorangkir & Rohaeti (2025), showed that there was pedagogical approach that can enhance students' self-efficacy in their ability to understand and apply chemistry concepts, which was problem based learning. Pedagogical methods such as problem-based learning, inquiry-oriented instruction, and collaborative learning can be effectively utilized to enhance students' self-efficacy while simultaneously fostering critical thinking skills (Johnson & Johnson, 1996). Moreover, offering constructive feedback, establishing explicit learning objectives, and cultivating a supportive classroom environment are vital components in strengthening students' confidence and engagement.

On the other hand, specifically, this research has broader consequences and what insights it offers. An investigation utilizing a STEM-integrated guided inquiry approach can be used in Indonesian high school chemistry demonstrated significant advancement in students' critical thinking abilities and a moderate increase in their self-efficacy (Sutoyo et al. 2023).

CONCLUSION

This research offers empirical support for a notable positive correlation between high school students' critical thinking abilities and their self-efficacy within the domain of chemistry education. The results indicate that learners with higher self-efficacy in their capabilities tend to exhibit enhanced critical thinking skills, which are crucial for comprehending complex scientific material. hese findings emphasize the necessity of incorporating both cognitive and emotional factors into teaching methodologies to improve overall academic achievement. Therefore, it is recommended that educators implement instructional strategies that foster the development of critical thinking alongside self-efficacy, promoting deeper conceptual understanding and better performance in chemistry as well as other science disciplines. Further studies could investigate the causal dynamics and assess intervention approaches that effectively nurture these interconnected competencies. Further studies could investigate the causal dynamics and assess intervention approaches that effectively nurture these interconnected competencies. Furthermore, these findings align with the United Nations' Sustainable Development Goals (SDG 4 on Quality Education, SDG 9 on Industry, Innovation, and Infrastructure, and SDG 12 on Responsible Consumption and Production), highlighting the role of chemistry education in fostering sustainable development through improved scientific literacy and problem-solving skills

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