Self-Efficacy Level of Chemistry Students

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ABSTRACT

This study examined the self-efficacy levels of chemistry students and their impact on academic performance. A quantitative survey was conducted among 168 secondary school students in Johor Bahru and Kulai, using a structured questionnaire with 16 items. The results indicated that most students demonstrated high self-efficacy in performing laboratory experiments and understanding fundamental chemical concepts. However, lower confidence was observed in interpreting chemical equations and linking macroscopic, microscopic, and symbolic representations. The findings suggested that students with higher self-efficacy were more engaged and performed better academically. The study highlighted the importance of effective teaching strategies, hands-on learning, and teacher support in strengthening students' confidence in chemistry. Enhancing self-efficacy could lead to improved motivation and learning outcomes, contributing to a more effective chemistry education framework.

Keywords— self-efficacy, chemistry education, academic performance, conceptual understanding, laboratory skills, learning motivation, teaching strategies

INTRODUCTION

With the advancement of science and technology, chemistry continues to develop rapidly, expanding knowledge and solving complex issues beyond conventional understanding. As a field that studies the properties of matter, energy changes, and interactions between atoms and molecules, chemistry serves as the foundation for understanding science and as a key driver of innovation in various fields, including medicine, industry, and the environment. This is supported by [15], who stated that the application of chemical concepts is widely utilized in numerous career fields, particularly in health and medicine.

Students' self-efficacy is a psychological aspect that refers to their belief in their ability to succeed in academic tasks. In the context of chemistry education, self-efficacy plays a crucial role in influencing students' motivation, learning strategies, and academic achievement. Therefore, understanding and enhancing chemistry students' self-efficacy is essential to creating a positive and motivating learning environment.

Chemistry as a subject present challenges that require deep comprehension and high cognitive abilities. Difficulties often arise due to challenges in understanding fundamental concepts and connecting theories to practical applications. [12] stated that the abstract nature of chemical concepts and the interrelation between topics frequently contribute to students' misconceptions. Consequently, low self-efficacy may hinder the learning process. Investigating and discussing students' self-efficacy levels in chemistry is necessary, as a deeper understanding of this issue can provide holistic insights into developing effective learning strategies, offering support, and fostering an educational environment that encourages students to reach their full potential while strengthening academic growth.

LITERATURE REVIEW

Several previous studies have examined students' self-efficacy levels in chemistry. Bandura's Social Learning Theory (1986) describes self-efficacy as an individual's assessment of their ability to plan and execute actions necessary to achieve desired performance [2]. For instance, students who perceive themselves as weak in solving stoichiometry problems in chemistry are likely to have low self-efficacy, which in turn affects their confidence and performance, making them less inclined to pursue chemistry education at higher levels.

[6] found that students with high self-efficacy often associate their success with motivation to learn, making them more persistent in studying chemistry. Conversely, students with low self-efficacy tend to blame their lack of discipline for poor performance, reinforcing the perception that chemistry is a difficult subject.

Higher self-efficacy is linked to better academic performance, particularly in complex subjects. Research on the relationship between self-efficacy and student achievement in chemistry courses has shown that self-efficacy is a crucial variable in learning assessments [10]. [9] reported that students' confidence in their ability to solve chemistry problems improves over time as they are repeatedly exposed to interconnected chemistry concepts. This continuous exposure helps students relate new concepts to prior knowledge, facilitating the construction of new understanding and increasing their confidence in tackling various levels of difficulty in chemistry problems.

They also suggested that students' self-efficacy is influenced by learning strategies and motivation. A study by [26] on students' learning strategies and self-efficacy found that academic optimism plays a significant role in achieving academic excellence. Students with strong self-efficacy often use effective learning strategies, such as highlighting key facts during revision, demonstrating that they possess essential learning skills that enhance their chemistry understanding.

Teachers play a crucial role in building students' confidence by encouraging them to plan their learning effectively. With proper support, students not only gain confidence in their academic success but also become more motivated to engage in chemistry learning with enthusiasm. [28] emphasized that students' motivation and anxiety levels influence their performance in chemistry. A lack of motivation can lead to disinterest in learning and a decline in self-efficacy. This was supported by [28], who found a significant relationship between students' motivation and their willingness to continue studying chemistry. To enhance students' self-efficacy, they must receive continuous motivational support from all stakeholders involved in the learning process.

Problem Statement

Humans are naturally born with both strengths and weaknesses. However, it is inherent in all individuals to strive for success and personal growth, regardless of their background or behavior. Self-confidence plays a crucial role in shaping one's perception of one's own abilities. Belief in one's capacity to improve and succeed is essential. Self-efficacy, defined as an individual's perception of their ability to perform tasks in specific situations, is a key psychological component in achieving personal and academic success.

Chemistry is widely perceived as one of the more challenging subjects in the school curriculum. This is due to its abstract nature, the need to understand multiple representations (symbolic, macroscopic, and microscopic), and its integration with mathematical reasoning. As a result, many students struggle to stay motivated and often doubt their capabilities in mastering chemistry concepts.

Low self-efficacy among students not only affects their academic performance but also impacts their willingness to engage in learning activities such as laboratory work, where a lack of confidence can lead to anxiety and avoidance. When students consistently experience failure or disengagement, their confidence diminishes further, creating a cycle of underachievement. If this issue is not addressed, it may hinder the development of capable learners in chemistry and affect the broader goal of nurturing skilled individuals for scientific and industrial fields.

Therefore, it is important to examine the role of self-efficacy in chemistry education and explore ways to support students in building a stronger belief in their ability to succeed.

Purpose of the Study

This study aims to examine the levels of self-efficacy among secondary school students in chemistry and to investigate the relationship between their self-efficacy and academic performance. The study aims to identify specific areas in chemistry where students feel confident or struggle, in order to inform teaching strategies that support student learning and enhance motivation.

Research Questions

The research questions of this study include:

1. What is the level of self-efficacy among secondary school students in chemistry?
2. In which areas of chemistry do students report the highest and lowest self-efficacy?
3. Is there a significant relationship between students' self-efficacy and their academic performance in chemistry?

Hypotheses Of The Study

The hypotheses of this study are:

1. H_0: There is no significant relationship between students' self-efficacy in chemistry and their academic performance.
2. H_1: There is a significant relationship between students' self-efficacy in chemistry and their academic performance.

METHODOLOGY

This study employed a quantitative research approach, utilizing structured surveys to gather measurable data on students' self-efficacy in chemistry. The choice of this method allowed systematic data collection and objective analysis of patterns and trends.

A descriptive survey design was adopted to explore students' levels of confidence in performing various chemistry-related tasks. This design is particularly suitable for studies aiming to gather current information and describe existing conditions, especially in areas that have yet to be thoroughly explored.

Data was collected using a structured questionnaire administered online. The instrument consisted of two sections. Section A gathered demographic information, including age, gender, school name, and district. Section B contained 16 Likert-scale items designed to measure students' self-efficacy in chemistry. These items assessed confidence in areas such as understanding chemical concepts, conducting laboratory experiments, interpreting chemical equations, and using laboratory apparatus. Responses were recorded on a four-point Likert scale ranging from 1 (very weak) to 4 (very good). The full list of items is presented in Table 1.

TABLE I List of Likert Scale Questions

List of Likert Scale Questions
Q1: To what extent can you explain chemical laws and theories?
Q2: To what extent can you select the appropriate formula to solve a chemistry problem?
Q3: To what extent can you carry out experimental procedures in a chemistry lab?
Q4: To what extent can you use laboratory equipment?
Q5: To what extent can you relate chemistry to other sciences?
Q6: To what extent can you illustrate the structure of an atom?
Q7: To what extent can you interpret data obtained from an experiment?

Q8: To what extent can you describe the properties of elements using the periodic table?
Q9: To what extent can you read formulas of elements and compounds?
Q10: To what extent can you interpret chemical equations?
Q11: To what extent can you explain the properties of matter particles (atoms, molecules, and ions)?
Q12: To what extent can you use laboratory apparatus to conduct an experiment?
Q13: To what extent can you define basic chemistry concepts?
Q14: To what extent can you interpret graphs or charts related to chemistry?
Q15: To what extent can you collect data while conducting laboratory experiments?
Q16: To what extent can you write a report on an experiment conducted in a chemistry lab?

The sample consisted of 168 Form 4 and Form 5 students aged between 16 and 17, selected through a stratified random sampling technique from schools in Johor Bahru and Kulai, with 84 participants from each district. This method ensured that various subgroups within the population were fairly represented, enhancing the reliability of the findings.

For the data analysis, percentage analysis was used to determine the proportion of students selecting each Likert scale option for each item. To visualize these proportions clearly, the results were presented using bar charts, which effectively display categorical data and make comparisons across items more accessible.

FINDINGS AND DISCUSSION

Overall Self-Efficacy Levels of Chemistry Students

To discuss the study's findings, the number of students who selected scale 4 (very good) and scale 1 (very weak) for each question was recorded and presented in bar graphs. The x-axis represents the individual survey questions, while the y-axis represents the percentage of students selecting each scale. A detailed comparison of the percentages for scale 4 (very good) and scale 1 (very weak) for each question is provided. Fig. 1 and 2 illustrate the percentage of students who rated their self-efficacy as very good and very weak, respectively, for each question.

Fig. 1 Bar Chart Showing the Percentage of Students Who Selected a High Level of Self-Efficacy (Very Good)

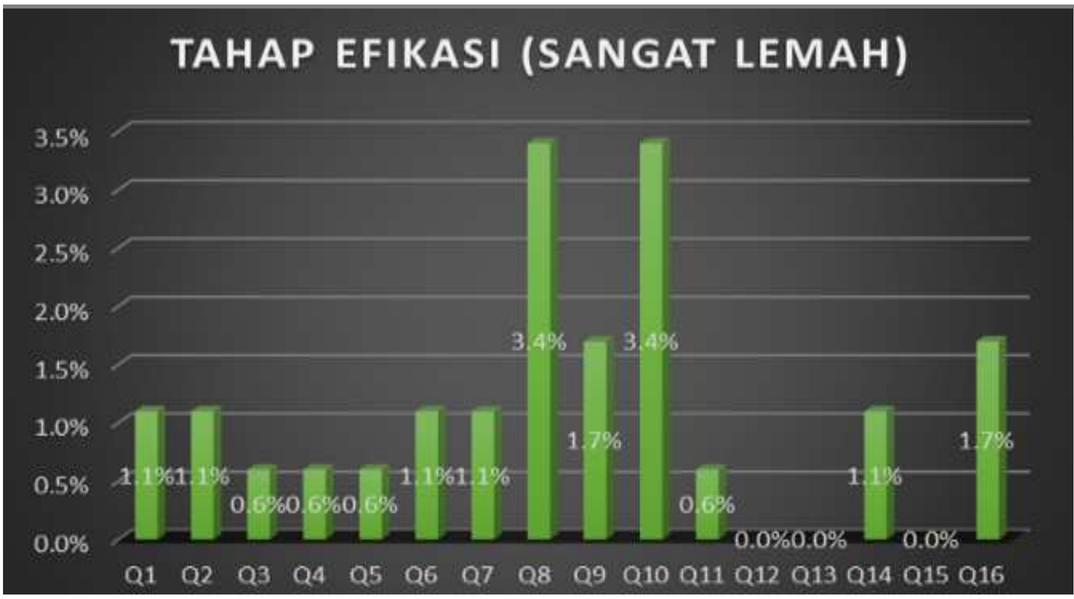

Fig. 2 Bar Chart Showing the Percentage of Students Who Selected a Low Level of Self-Efficacy (Very Weak)

Q1: To what extent can you explain chemical laws and theories?

Based on Fig. 1 and Fig. 2, it can be observed that the percentage of students who chose the "very good" scale is higher than those who chose the "very weak" scale, with 7.3% for the "very good" scale and 1.1% for the "very weak" scale. This indicates that students have good confidence in explaining chemical laws and theories. Similarly, a study by [22] also found that students' efficacy in understanding chemistry subject content is at a good level, with 62%.

Q2: To what extent can you choose the appropriate formula to solve a chemistry problem?

According to Fig. 1 and Fig. 2, 28.1% of students provided a "very good" response, while 1.1% rated themselves as "very weak" in their ability to select the appropriate formula to solve a chemistry problem. This shows that the percentage of chemistry students capable of selecting the right formula is higher than those who are weak. This is because choosing formulas for solving chemistry problems is simpler compared to mathematical formulas [27]. Fig. 2 also shows that 1.1% of students rated themselves as "very weak," possibly because some students are not proficient in or do not have a strong grasp of basic chemistry formulas. Research has also found that students feel they do not fully understand the taught concepts and tend to rely on rote memorization [11]. Therefore, students need to understand basic concepts to facilitate the selection of formulas for solving chemistry problems rather than relying solely on memorization.

Q3: To what extent can you carry out the procedure of an experiment in a chemistry lab?

According to Fig. 1 and Fig. 2, 28.1% of students gave a "very good" response, making it the third highest percentage among all questions, while 1.1% rated themselves as "very weak" in their ability to carry out an experiment in a chemistry lab. This indicates that the percentage of chemistry students capable of performing experimental procedures is higher than those who are weak. This is because students who can execute procedures have a better understanding of using laboratory equipment and lab ethics. According to Kong et al. (2021), learning and teaching skills (PDP) in the laboratory have improved and become more efficient. This shows that this percentage can be utilized. Fig. 2 also shows a 1.1% rating for "very weak," which may be due to students' lack of proficiency in handling procedures, possibly caused by student negligence and unclear instructions from the teacher (Salbiah et al., 2021).

Q4: To what extent can you use laboratory equipment in chemistry?

Based on Fig. 1 and Fig. 2, 39.3% of students responded with "very good," while 0.6% rated themselves as "very weak" in their ability to use laboratory equipment. Indirectly, this question has the highest percentage of

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self-efficacy in using laboratory equipment compared to other questions. This indicates that the percentage of chemistry students who can use laboratory equipment is higher than those who are weak. This is because most students proficient in using equipment have basic knowledge from their primary school years. Additionally, hands-on learning has been introduced to students from an early age because this learning method is more effective than lectures alone [13]. Fig. 2 also shows a low number of students who are weak in using lab equipment. This is because some students do not actively participate in conducting experiments in the laboratory.

Q5: To what extent can you connect chemistry with other sciences?

Based on Fig. 1 and Fig. 2, 12.9% of students responded with "very good," while 0.6% rated themselves as "very weak" in their ability to connect chemistry with other sciences. This indicates that the percentage of students capable of linking chemistry with other sciences is higher than those who are weak. One factor is that chemistry is related to various other sciences, such as physics, health sciences, arts, and biochemistry [1]. In other fields, teaching chemistry through practical applications helps students understand the importance of chemistry and its relation to other sciences, such as pharmaceutical and microbiology concepts [3]. However, based on Fig. 1, the percentage of students who can connect chemistry with other sciences is the third lowest compared to other skills. This shows that, on average, students are still weak in linking chemistry with other sciences. One suggestion to enhance students' confidence in connecting chemistry with other sciences is to relate it to current issues relevant to chemistry. As a result, students can gain a clearer and deeper understanding of chemistry topics and apply them in daily life.

Q6: To what extent can you illustrate the structure of an atom?

Based on Fig. 1 and 2, 24.7% of students rated themselves as "very good" in illustrating atomic structures, while 1.1% lacked confidence in this skill. Chemistry involves three levels of representation: macroscopic, microscopic, and symbolic [14]. Many students struggle to connect these, especially at the microscopic and symbolic levels. [25] found that students have difficulty linking abstract symbolic representations with macroscopic and submicroscopic aspects in physical chemistry concepts. Therefore, diverse teaching methods and technological tools are essential to help students visualize microscopic and symbolic aspects of chemistry.

Q7: To what extent can you interpret data obtained from an experiment?

Fig. 1 and 2 show that 18.5% of students rated themselves as "very good" in interpreting experimental data, while 1.1% rated themselves as weak. This suggests that most students are relatively confident in data interpretation. However, [16] found that students often struggle to differentiate concepts and their relationships in data interpretation. Additionally, Brandriet et al. (2018) reported that students are overly influenced by contextual details, making them susceptible to distractions from irrelevant information [4]. To improve, students need more practice in analyzing data from various experiments to strengthen their analytical skills.

Q8: To what extent can you describe element properties using the periodic table?

Fig. 1 and 2 indicate that 16.9% of students rated themselves as "very good" in using the periodic table to describe element properties, while 3.4% rated themselves as weak. This suggests that most students understand how elements are arranged based on valence electrons, atomic number, and electronegativity. However, some students still struggle. According to [21], difficulty in understanding the periodic table is often linked to teacher-centered learning. Traditional teaching methods, where teachers lecture while students passively receive information, can make lessons dull and reduce student motivation.

Q9: To what extent can you read the formulas of elements and compounds?

Fig. 1 and 2 show that 27.0% of students rated themselves as "very good" in reading element and compound formulas, while 1.7% rated themselves as weak. This suggests that students can recognize elements from the periodic table (e.g., Argon as Ar) and compound formulas (e.g., water as H_2O). Their ability to read formulas indicates a grasp of electron transfer and chemical naming conventions. Mastering this skill is crucial, as it directly affects students' ability to write and balance chemical equations.

Q10: To what extent can you interpret chemical equations?

Fig. 1 and 2 show that 20.8% of students rated themselves as "very good" in interpreting chemical equations, while 3.4% rated themselves as weak. This suggests that most students can identify reactants and products, understanding that the "+" symbol represents substances reacting and the arrow indicates the formation of products. Additionally, students are proficient in balancing equations by adjusting coefficients. Those who excel in this skill will have fewer difficulties explaining the processes involved in chemical reactions.

Q11: To what extent can you explain the properties of matter particles (atoms, molecules, and ions)?

Fig. 1 and 2 indicate that 56.2% of students are confident in explaining the properties of matter particles, while only 0.6% rated themselves as weak in listing these properties. This reveals a significant gap between students with strong and weak conceptual mastery in this topic. Understanding particle properties relies on microscopic representation, enabling students to visualize the abstract characteristics of atoms, molecules, and ions [14]. For example, proficient students can accurately illustrate the structure and arrangement of different types of particles.

Q12: To what extent can you use laboratory apparatus to conduct an experiment?

Based on Fig. 1 and 2, students' confidence in handling laboratory apparatus shows positive results, with 38.8% rating themselves as "very good" and 55.1% as "good." Only 6.2% rated themselves as weak, indicating that most students believe they can effectively handle laboratory equipment during experiments. [18] emphasized the importance of ensuring students' readiness in terms of chemistry knowledge and laboratory skills before conducting practical work. This percentage suggests that most chemistry teachers in the Skudai and Kulai districts conduct discussions before experiments to prevent student mistakes. Laboratory safety is a priority, as even minor errors can be costly and pose safety risks. Therefore, students must be confident and skilled in handling all materials and equipment in the laboratory to minimize potential risks.

Q13: To what extent can you define fundamental chemistry concepts?

Fig. 1 and 2 show that 62.9% of students rated themselves as "good," while 12.4% rated themselves as "very good" in defining fundamental chemistry concepts. The fundamental concepts in this study include defining the basic principles of matter and theories related to chemical bonding. These findings indicate that most students can define chemistry concepts accurately and effectively. Mastering the basics is essential before progressing to more complex topics. Students who struggle with defining these concepts are likely to face difficulties in understanding subsequent topics. Therefore, the 24.7% of students who rated themselves as weak in this survey should be provided with more frequent exposure to chemistry knowledge to maintain their motivation throughout the learning process.

Q14: To what extent can you interpret graphs or charts related to chemistry?

Based on Fig. 1 and 2, the percentage of students who rated themselves as "very good" in interpreting chemistry-related graphs or charts (16.9%) is significantly higher than those who rated themselves as "very weak" (1.1%). This indicates that students generally have strong confidence in analyzing graphs or charts. The considerable gap between high and low efficacy levels suggests that students are capable of analyzing trends, patterns, and relationships in data. Understanding graphical representations helps facilitate the interpretation of experimental results and provides a deeper understanding of chemistry principles.

Q15: To what extent can you collect data during chemistry laboratory experiments?

Fig. 1 and 2 show that 26.4% of students rated themselves as "very good" in data collection during experiments, while 0.0% rated themselves as weak. This indicates that students' ability to collect data is significantly higher than those who struggle with it. In chemistry experiments, data collection involves systematically gathering information, measuring physical quantities, recording observations, and compiling data. Different techniques are used depending on the experiment, but common methods include using various instruments. Accurate and detailed record-keeping is crucial for analysis and drawing meaningful conclusions from experiments.

Q16: To what extent can you write a report on an experiment conducted in the chemistry laboratory?

Based on Fig. 1 and 2, 20.2% of students rated themselves as "very good" in writing chemistry experiment reports, while 1.7% rated themselves as weak. This suggests that most students are confident in writing lab reports, although some still find it challenging. In a study by [24], students' performance was evaluated during the report-writing process. Although experiments were conducted in small groups, each student was required to write their own lab report, which was then graded by the teacher. The study also found that some students perceived lab report writing as difficult. Therefore, greater attention should be given to this skill to ensure students can write well-structured and accurate reports.

Students' Self-Efficacy Levels in Chemistry Based on Districts

Fig. 3 Percentage Graph of Students Who Chose a High Self-Efficacy Level (Very Good) Based on Districts

Fig. 3 shows the percentage of students from schools in the Johor Bahru and Kulai districts who selected scale (4: very good) for questions related to their self-efficacy in chemistry. Based on the graph, it can be observed that students in the Johor Bahru district chose scale (4: very good) more frequently than students in the Kulai district, with a higher percentage recorded for nine questions: Q3, Q4, Q7, Q8, Q11, Q12, Q13, Q15, and Q16. Meanwhile, in the Kulai district, a higher percentage was recorded for six questions: Q1, Q2, Q5, Q6, Q9, and Q10. There was one question, Q14, where both districts had the same percentage. From the given graph, this indicates that the self-efficacy level of students in Johor Bahru is higher compared to those in Kulai. This difference may be influenced by several factors, such as teaching methods, school facilities, and the activities planned for each school.

Fig. 4 Percentage of Students Selecting the Self-Efficacy Level (Very Weak) Based on District

Fig. 4 above shows the percentage of students from schools in the Johor Bahru and Kulai districts who selected scale (1: very weak) for questions related to their self-efficacy. Based on the graph, it can be observed that students in the Kulai district selected scale (1: very weak) more frequently compared to students in the Johor Bahru district. In the Kulai district, percentages were recorded for questions Q2, Q3, Q6, Q7, Q8, Q10, Q11, Q14, and Q16, whereas in the Johor Bahru district, percentages were recorded only for questions Q1, Q4, Q6, Q8, Q9, and Q10. This difference in percentages may be due to variations in the school environment, including factors such as school surroundings, teaching methods, school activities, and the broader community environment.

Study Limitation

This study has several limitations. It focused solely on the self-efficacy levels of chemistry students in Johor, without considering gender as a variable. As a result, the findings do not represent the overall self-efficacy levels of chemistry students nationwide. Additionally, the sample size was relatively small, limiting the generalizability of the results. Furthermore, differences in self-efficacy based on gender could not be determined in this study, which may be an important factor influencing students' confidence and academic performance in chemistry.

CONCLUSION

Based on the study's findings, data analysis, and discussions, it can be concluded that chemistry students' self-efficacy levels are generally high, as indicated by the overall percentage of positive responses. Self-efficacy plays a crucial role in students' motivation, learning attitudes, and academic success. Students who believe in their abilities tend to be more motivated and develop a positive mindset when facing learning challenges [22]. Beyond academic performance, self-efficacy also has psychological effects, influencing students' confidence and persistence in mastering chemistry. Enhancing self-efficacy can be achieved through inclusive teaching strategies, constructive feedback, and manageable tasks that help students build confidence in their abilities.

Although this study has limitations, including a restricted sample size and a focus only on students in Johor, it still provides valuable insights for educators, schools, policymakers, and students. Future research should explore self-efficacy in different regions and among diverse student demographics to further enhance chemistry education. It is hoped that continuous research in this area will contribute to the improvement and advancement of the education system.

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