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A Comparative Study on High School Students' Self-Efficacy Towards Chemistry

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ABSTRACT
This study aimed to investigate high school students' self-efficacy toward chemistry and determine their self-efficacy across grade levels. The participants were 255 high school students from a public senior high school in Blora Regency, Central of Java, Indonesia. A simple random sampling technique was used to choose the respondents. Those are 96 participants of 10th grade, 81 participants of 11th grade, and 78 participants of 12th grade. High School Chemistry Self-Efficacy Scale (HCSS), which consists of a self-efficacy scale for cognitive skills (CSCS) and chemistry laboratory (SCL), was used for assessing high school students' self-efficacy toward chemistry. It has been validated and proven reliable using Confirmatory Factor Analysis and Cronbach Alpha. For analyzing the data, descriptive analysis was used to determine the percentage, means, and standard deviations. One-way ANOVA was also used to compare students' self-efficacy based on the grade level. This study showed that most of the high school students' self-efficacy is on average level. In both CSCS and SCL, the higher the grades, the higher the students' self-efficacy. This finding could be used to predict the students' achievement in chemistry learning.

Keywords: *Chemistry education, High school chemistry, Self-efficacy*

1. INTRODUCTION

Alfred Bandura proposes self-efficacy and describes it as a belief in their ability to manage and do something to achieve [1]. Self-efficacy represents students' belief in their ability to achieve their high achievement [2]. Tang and Neber state that self-efficacy is important for students' participation in the classroom. High self-efficacy students tend to get involved at the school in terms of behavior, cognition, and motivation [3]. According to Hampton and Mason [4], self-efficacy is also an essential factor that positively affects student learning outcomes. As a result, high self-efficacy students will work hard and put more effort when doing tasks or activities than lower self-efficacy students [5]. It is because self-efficacy has a high effect on students' cognitive processes [6]. High self-efficacy is needed to use cognitive skills to filter knowledge from much doubtful information [7]. A high self-efficacy student was likely to use more in-depth processing strategies and be much more likely to understand and think deeply about their schoolwork [3].

In science, students who believe they will succeed in science assignments are more likely to work hard, diligent, and have the confidence to complete it successfully. In contrast, students who do not believe it are more likely to avoid, give up, and feel burdened [8]. Science self-efficacy also correlates with science achievement, and it is a good predictor of engagement and achievement in high school activities about science [9][10]. Applied in chemistry education, if students have good self-efficacy, they will complete chemical tasks that require cognitive skills, psychomotor skills, and their application in daily life [11]. Science self-efficacy can be different for biology, chemistry, and physics. For example, a student could have high physics self-efficacy but have low chemistry self-efficacy [12]. Therefore, it is needed a specific measurement to assess self-efficacy in chemistry.

Researchers often conceptualized science self-efficacy as a single dimension [13], [14]. Still, it might not be enough to understand their self-efficacy correctly. Self-efficacy should be divided into several aspects for a better exploration and not be assumed as one dimension only [15]. Several researchers have analyzed high school students' self-efficacy by dividing it into several dimensions [11], [15], [16]. One of them is Aydin & Uzuntiryaki that explained two dimensions of self-efficacy in chemistry. They differentiate self-efficacy for intellectual skills and laboratory tasks in chemistry [11].

There are many studies about students' self-efficacy toward chemistry in high school. However, in Central Java, Indonesia, especially in Blora Regency, it is underrepresented. This problem is one of the reasons for doing the study in this regency. Knowing students' self-efficacy toward chemistry could predict their achievement in chemistry. High self-efficacy is beneficial for using cognitive skills. Students with higher grades gain more knowledge and experience than those with lower grades. This might affect their cognitive and experimental abilities. Their level of self-efficacy might also be affected by this. Therefore, the purpose of this study was to investigate students' self-efficacy toward chemistry across grade levels in high school.

Furthermore, this study also determines students' self-efficacy based on their grades. This study's research questions are: (1) How are the students' self-efficacy toward chemistry for cognitive skills and chemistry laboratory? Then, (2) Are there any significant differences in self-efficacy toward chemistry for cognitive skills and chemistry laboratory between 10^{th}, 11^{th}, and 12^{th}-grade students?

2. RESEARCH METHODS

This study was descriptive quantitative research that used a questionnaire for assessing self-efficacy toward chemistry. Descriptive and statistical analysis was used for analyzing the data. This study was conducted in October 2020, when the students were in their first semester of the academic year.

2.1. Participants

The participants were 255 high school students from a public senior high school in Blora Regency, Central of Java, Indonesia. The researchers chose the school conveniently, known as a public school placed in Blora Regency, has a chemistry laboratory, has an A score in accreditation, and uses The Indonesian 2013 Curriculum. We used a simple random sampling technique for choosing the class that randomly took three classes from 7 classes in 10^{th} grade, three classes from 8 classes in 11^{th} grade, and three classes from 8 classes in 12^{th} grade. Of 255 participants, 96 participants were 10^{th} graders, 81 participants were 11^{th} graders, and 78 were 12^{th} grade. Data were collected using an instrument with google form.

2.2. Instrument

Many researchers have developed several instruments for assessing self-efficacy toward chemistry. One of them was Aydın and Uzuntiryaki (2009). They developed an instrument that can assess high school students' self-efficacy toward chemistry named High School Chemistry Self-Efficacy Scale (HCSS). HCSS has two dimensions: Chemistry Self-Efficacy Scale for Cognitive Skills (CSCS) and Self-Efficacy Scale for Chemistry Laboratory (SCL), explained in Table 1.

They used Confirmatory Factor Analysis to analyze the validity and got a satisfactory result (NNFI = 0.97, CFI = 0.98, RMSEA = 0.09, 90% CI = 0.09, 0.10). For reliability, they used Cronbach alpha and noted that the reliability coefficients were deemed acceptable (0.90 for the CSCS and 0.92 for SCL). In this study, HCSS was used to assess self-efficacy toward chemistry of high school students on a five-point Likert type. In this Likert-type instrument, item choices were ordered from "very poorly" to "very well".

Table 1. The dimension of HCSS

Dimension of HCSS	Definition	Items
CSCS	Self-efficacy about believing their ability to use cognitive skills in high school chemistry	items 1, 2, 5, 6, 8, 9, 10, 11, 13, and 14.
SCL	Self-efficacy about believing their ability to solve laboratory tasks in high school chemistry	items 3, 4, 7, 12, 15, and 16.

The CSCS consisted of 10 items. Sample items of this factor ask about students' belief in their ability to choose a formula to solve a chemistry problem or find the relationship between chemistry and other sciences. The SCL consisted of 6 items. Sample items of this factor ask about their belief in the ability to collect data during the experiment or their belief in writing a laboratory report.

2.3. Data Analysis and Procedures

For analyzing the data, we use both descriptive and statistical analysis. Descriptive analysis was used to determine the percentage, means, and standard deviations. One-way ANOVA was also used to compare students' self-efficacy based on the grade level. The Likert-scale score was converted from qualitative (ordinal) to quantitative (interval) data and then categorized using category in Table 2. The percentage distribution was used to analyze how many students at every level of self-efficacy.

Table 2. Students' self-efficacy categorization

Score Range	Category
$x > x_i + 1.80\ SB_i$	Very High
$x_i + 0.60\ SB_i < x \leq x_i + 1.80\ SB_i$	High
$x_i - 0.60\ SB_i < x \leq x_i + 0.60\ SB_i$	Average
$x_i - 1.80\ SBi < x \leq x_i + 0.60\ SB_i$	Low
$x \leq x_i - 1.80\ SB_i$	Very Low

The statistical analysis used was One-way ANOVA. We used it to compare students' self-efficacy based on the grade level. The normality test and the homogeneity test are checked before using ANOVA. This study hypothesizes a difference in means between students' self-efficacy toward chemistry in high school. The statistical hypothesis is written below.

H_0: $\mu_{10} = \mu_{11} = \mu_{12}$ (1)
H_a: some $\mu_i \neq$ some μ_j (2)

3. RESULT AND DISCUSSION

High school students' self-efficacy toward chemistry can be divided into two dimensions: self-efficacy for cognitive skills (CSCS) and chemistry laboratory (SCL). Figure 1 presents the percentage distribution of self-efficacy of high school students toward chemistry for CSCS and SCL. Most of the students' self-efficacy criteria are average (52.94% for CSCS and 45.49% for SCL). The CSCS scale shows that percentage of students who have a high level of self-efficacy (21.18%) is lower than the rate of students who have a low level of self-efficacy (21.57). Still, in the SCL scale, the percentage of students who have a high level of self-efficacy (26.27%) is higher than the rate of students with a low level of self-efficacy (17.25%). The percentage of students at a very high level in CSCS (2.75%) is also lower than in SCL (6.27%), and the rate of students at very low level in CSCS (1.57%) is even lower than in SCL (4.71). Besides, the mean of CSCS is also lower than the SCL (see Table 2). This finding could represent that students are more confident in their ability to do chemistry experiments than to believe in their cognitive skills.

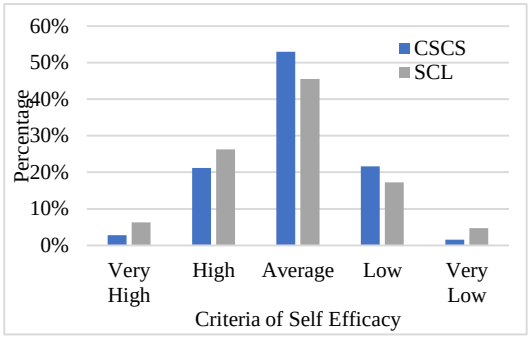

Figure 1 Percentage distribution of high school chemistry self-efficacy for CSCS and SCL

From 10 items of CSCS (items 1, 2, 5, 6, 8, 9, 10, 11, 13, and 14), the item with the most significant score is item 9, which asked about their ability to interpret chemical equations. The lowest score is item 14, which asked about their belief in reading chemical graphs/charts. This finding shows that they are more confident about their ability to solve chemical equations than to interpret chemical graphs/charts. From 6 items of SCL, the item with the most significant score is item 16, which is about their belief in writing a laboratory report. The lowest score is item 12, which is about their belief in constructing a laboratory apparatus. This finding means they believe that they are better at writing a laboratory report than constructing a laboratory apparatus.

Figure 2 presents the percentage distribution of 10^{th}, 11^{th}, dan 12^{th} graders' responses to the CSCS. It explains the distribution of students' self-efficacy level in five criteria from very high to very low. It shows that the 10^{th}, 11^{th}, and 12^{th} grader majority have an average category of self-efficacy. In the 10^{th} and 11th grades, the percentage of students who have a high level is lower than the percentage of students who have a low level. However, in the 12^{th} grade, the percentage of students who have a high level is higher than the percentage of students who have a low level.

Even, the 12th grade has 0% student who has a very low category.

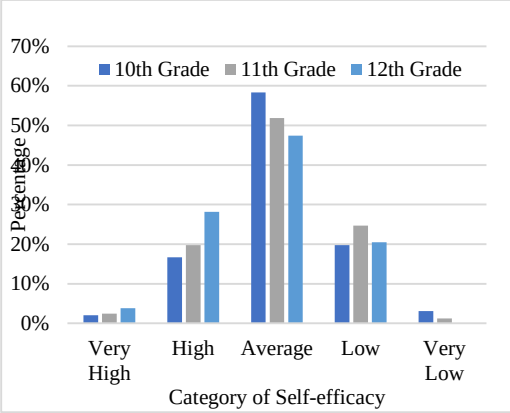

Figure 2 Percentage distribution of 10th, 11th, and 12th Grade for CSCS

From 10 items of the CSCS scale, in 10th grade, the item that got the most significant score was item 13, which is about their belief in explaining concepts in chemistry. The lowest score was item 14, about their belief in reading chemical graphs/charts. In 11th graders, the item that got the most significant score was item 9, about their belief in reading the formulas of elements and compounds. The lowest score was item 14, about their belief in reading chemical graphs/charts. For 12th graders, similar to 11th graders, the item that got the most significant score was item 9 about their belief in reading the elements and compounds' formulas. The lowest score was item 14, about their belief in reading chemical graphs/charts. Even though every item's most significant score in every grade is different, the lowest score is the same: item 14. They have a low belief in their ability to read chemical graphs/charts. Nugraha, Darsikin, and Saehana explained that the students' difficulties in interpreting graphs are because their mathematical ability is low [17].

Figure 3 presents the percentage distribution of 10th, 11th, dan 12th graders' responses to the SCL scale. Equal to the CSCS scale, the SCL scale also shows a similar result. Figure 3 shows that the higher the grade, the percentage of students with a very high and high level of self-efficacy in the chemistry laboratory increased. The low level and very low level of 12th grade also have the lowest rate among the three grades. From 6 items of the SCL scale in all grades, the most significant score is item 16, which is about their belief in writing laboratory reports. The lowest score is item 12, which is about their belief in constructing a laboratory apparatus. This finding shows that all of those graders have a better efficacy about their ability to write laboratory reports than to construct a laboratory apparatus. They have confidence in writing laboratory reports because reports may be done at home and done by their groups. However, to construct the apparatus, the student needs to understand how the apparatus works and its purpose. However, it needs more qualitative and quantitative study methods to find the real reason for this finding.

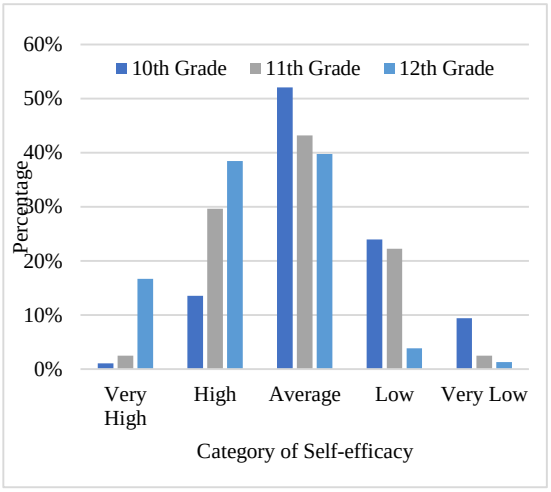

Figure 3 Percentage distribution of 10th, 11th, and 12th Grade for SCL

Table 3. Descriptive statistical data of self-efficacy on CSCS and SCL according to grades

Dimension	Grade	N	Mean	Std. Deviation
CSCS	10th Grade	96	59.10	11.723
	11th Grade	81	60.22	11.415
	12th Grade	78	63.77	11.948
	Total	255	60.89	11.815
SCL	10th Grade	96	55.28	13.728
	11th Grade	81	62.06	13.256
	12th Grade	78	69.70	13.085
	Total	255	61.84	14.595

Table 4. The ANOVA results of the self-efficacy on CSCS and SCL according to grades

		Sum of Squares	df	Mean Square	F	Sig.
CSCS	Between Groups	988.897	2	494.449	3.615	0.028
	Within Groups	34470.804	252	136.789		
	Total	35459.702	254			
SCL	Between Groups	8958.412	2	4479.206	25.003	0.000
	Within Groups	45145.152	252	179.147		
	Total	54103.564	254			

Table 3 presents the descriptive statistical data about means and standard deviations of CSCS and SCL for grade levels. Then, Table 4 shows the ANOVA result of the self-efficacy on CSCS and SCL according to grades. Normality and homogeneity test obtained that the data are distributed normally and homogeneous. Table 3 shows the difference mean between 10th, 11th, and 12th-grade students' self-efficacy toward chemistry. The result shows that the highest chemistry self-efficacy in cognitive skills is 12th graders' (mean = 59.10), the second one is 11th graders (mean = 60.22), and the last is 10th graders (mean = 63.77). The result for self-efficacy for the chemistry laboratory also shows that the highest is 12th graders' (mean = 55.28), the second one is 11th graders (mean = 62.06), and the last is 10th graders (mean = 69.70). Table 3 also explains the standard deviation that describes the dispersion of data from its mean. The three grades' standard deviation has a similar number in each CSCS and SCL, except standard deviation from the total student for SCL. This high number explains that the 10th, 11th, and 12th grades mean should be calculated separately and not mixed.

According to ANOVA results in Table 4, there are significant differences between grades for self-efficacy in both CSCS ($F_{(2.252)}$= 3.615, sig = 0.028 < 0.05) and SCL scale ($F_{(2.252)}$ = 25.002, sig = 0.0 < 0.05). In both CSCS and SCL, the 12th graders had the highest mean score among the three graders. This finding is different to the study of İçöz [18]. In his research, he investigated how self-efficacy changes across grade levels (9th, 10th, 11th, and 12th) of secondary school students in Turkey. He found that the highest self-efficacy was 9th graders, then followed by 11th graders, 12th graders, and the last was 10th graders [18]. The study by Kan and Akbaş was also not similar. Their research investigates the difference of self-efficacy towards chemistry in high school students based on grades. Among the 1st, 2nd, and 3rd grades in high school (equal to 10th, 11th, and 12th grades), they found that 2nd graders had the highest score, followed by the 1st and 3rd graders [19].

This study found that the higher the grade, the higher students' self-efficacy. Indeed, the most effective way to get better self-efficacy is through experience [7][20]. 12th graders experienced much more chemistry lessons and laboratory tasks than 10th graders. They had learned to overcome the obstacle in learning chemistry. In the laboratory, they experienced more about doing experiments, reading data, constructing apparatus, or writing the laboratory report. For 10th graders, chemistry is a new subject. The early chemistry topic in the 1st semester of 10th grade is about an abstract matter such as atomic structure, the periodic table, and chemical bonding. So, 10th graders rarely do chemistry experiments. Even though experience has an essential role in high school students' self-efficacy, and this study's finding supported it, there are many factors affecting self-efficacy. Besides, this study was based on self-reported data. Other multi-method approaches studies should be done. This study was also limited by the school chosen. Other qualitative and quantitative studies in this area should be conducted to understand more about their self-efficacy.

4. CONCLUSION

This study showed that most of the high school students' self-efficacy is on average level. In both CSCS and SCL, 12th graders had the highest mean of self-efficacy, followed by 11th graders and 10th graders. It showed that the higher the grades, the higher students' self-efficacy. This finding could be used to predict the students' achievement in chemistry learning. Another study should be conducted to understand more about their self-efficacy toward chemistry.

AUTHORS' CONTRIBUTIONS

H.K. collected and analyzed the data and also wrote the manuscript with support from E.W.L.

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