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VARK-based Chemistry Learning to Improve Students' Critical Thinking Skills in Learning Molecular Geometry

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Abstract: Learning that does not accommodate the learning styles of all students will experience boredom and a decrease in the critical level of students. This study aims to determine the effect of VARK learning style-based chemistry learning on improving students' critical thinking skills. The study used a quantitative method with a pre-experimental design and one group pretest-posttest design. The research was conducted on 65 students of the State Islamic Senior High School in Bogor. The instrument used was an essay test of ten questions that met the criteria for critical thinking indicators. The instrument trials used were validity and reliability tests. Next, the Paired T-Test and N-Gain Tests were carried out. Based on the Paired T-Test, a significance value of 0.00 was obtained, indicating that Ho was rejected, so there were differences in students' critical thinking skills before and after the VARK-based chemistry learning was implemented. The results of the N-Gain test increased students' critical thinking skills on average by 0.68 in the moderate category. This study concludes that VARK-based chemistry learning on molecular geometry material can improve students' critical thinking skills.

Keywords: chemistry learning, VARK, critical thinking, molecular geometry

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INTRODUCTION

Chemistry learning is one of the important subjects in education. However, many students have difficulty understanding chemistry material because they do not have a learning style that follows the teaching method applied in class. This can reduce students' interest and motivation to learn chemistry (Ahiakwo & Ene, 2022; Tsaparlis et al., 2020) and reduce their ability to think critically (Ennis, 2013c, 2013a). Therefore, a learning approach is needed that can adapt to students' learning styles so that they can understand the material more easily and effectively (Astuti et al., 2020; Hassan et al., 2021). Critical thinking skills are one part of the 21st century skills that must be possessed by students besides Creative Thinking, Communication, and Collaboration. Critical thinking, according to Fisher (2011), is a skillful activity performed in the mind. Good critical thinking meets a variety of intellectual standards, such as clarity, relevance, and coherence. These 4C skills are also part of the fundamental skills recommended by a team of experts in the World (Pacific Policy Research Center, 2010) then the learning process must be planned and effective (Larsson, 2017; Rotherham & Willingham, 2020).

Facione (2020) suggests that there are seven different aspects of someone who thinks critically, namely truth seekers, open-minded, analytical, systematic, confident, always curious, and cognitively mature. Critical thinking skills play an important role in carefully analyzing thoughts, arguments, and problems based on the credibility of data sources, and being able to make decisions based on consideration of relevant evidence and facts (Larsson, 2017). The same thing is also stated by Halpern (2014) that critical thinking is a situation where cognitive abilities and strategies are used to produce the desired goals. Critical thinking is useful to help solve problems, draw conclusions, and make decisions on a rational and objective basis.

The importance of critical thinking skills and chemistry learning that needs to be trained in students requires learning methods and approaches that suit the students' character. The VARK-based learning method is an approach that can be applied to improve students' understanding of chemistry material. it is suggested that teachers need to fully equip themselves in various subjects and teach based on the different learning styles of students in their class for a better understanding (Kumo et al., 2023). The VARK learning style is a theory that explains that there are four different types of learning styles, namely visual, auditory, kinesthetic, and verbal (Amaniyan et al., 2020; Espinoza-Poves et al., 2019; Husmann & O'Loughlin, 2019; Mozaffari et al., 2020). This theory was developed by Neil Fleming in 1987. Every individual has a different learning style, and knowing one's learning style can help in choosing the right learning method and improving learning outcomes (Dariyanti et al., 2021; Farhan & Risdianti, 2021; Ali, 2019; Nengsih, 2021). Visual learning style refers to a

person's ability to learn by using visual information such as graphs, tables, or diagrams. Auditory learning style refers to a person's ability to learn by listening to information, such as through lectures or group discussions. Verbal learning style refers to a person's ability to learn using language, both orally and in writing. Kinesthetic learning style refers to a person's ability to learn by doing something directly, such as through practice or simulation (Mirza & Khurshid, 2020; Taheri et al., 2021). This study aims to apply the VARK-based chemistry learning method to improve students' critical thinking skills. The hypothesis that will be put forward in this study is that the application of the VARK-based chemistry learning method can improve students' critical thinking skills. The results of this study are expected to provide benefits for teachers and students in the process of learning chemistry at school.

METHODS

This study used a quantitative method with a pre-experiment design and one group pretest posttest design (Cresswell & Cresswell, 2003). The design table design is shown in Table 1.

Table 1. Research design (Gall et al., 1996)

Class	Pre-test	Treatment	Posttest
Experiment	O_1	X	O_2

The research population consisted of 65 students consisting of 30 students and 35 students in different science classes. The research instrument used was an essay of ten questions that had been adapted to the indicators of critical thinking skills that had been compiled by Ennis (2013b) and its sub-indicators developed by Facione (2020). The indicators and sub-indicators of critical thinking skills are summarized in Table 2.

Table 2. Indicators and Sub-indicators of Critical Thinking Skills (Facione, 2020)

Indicator	Sub-Indicators
Interpretation	Categorize and clarify meaning
Analysis	Check ideas
	Identify arguments
	Identify reasons and claims
Inferences	Query proof
	Provide alternatives
	Draw a conclusion
Evaluation	Assess the credibility of the claim
	Assess the quality of arguments made using inductive or deductive reasoning
Explanation	Declare results procedural justification
	Present arguments
Self-Regulation	Self-correction
	Self-monitor

The essay question instrument was tested for empirical validity using the moment product correlation formula. The instrument reliability test was analyzed using Cronbach's Alpha, which was then compared to the question reliability criteria table (Fraenkel, 2012). The inferential analysis technique for testing the hypothesis uses the sample Paired T-Test, but beforehand it is pre-requisite tested, namely the normality test using Kolmogorov Smirnov with a significance level of 5%, the normality test aims to assess the distribution of data and find out whether further testing is carried out in a parametric or non-parametric way (Gall et al., 1996). After that, test the hypothesis using a paired T-test with a significance level of 1%, aiming to test the hypothesis whether there is an effect of increasing critical thinking skills from VARK-based chemistry learning. The N-Gain test is used to see how much the students' critical thinking skills have increased from the pretest and posttest scores. values are interpreted against the N-Gain test table as shown in Table 3.

Table 3. N-Gain Criterion (Hakes, 1999)

Gain index	Interpretation
$g > 0.70$	Tall
$0.70 > g > 0.30$	Currently
$g < 0.30$	Low

RESULT AND DISCUSSION

The results of the research on critical thinking skills were obtained from the analysis of the pretest and posttest values in the form of essay questions, the questions consisted of 5 indicators, namely the ability to interpret, the ability to analyze, the ability to explain, the ability to make conclusions and the ability to evaluate. The pretest questions are given at the beginning of the lesson before getting VARK-based chemistry learning, after the lesson is finished the Posttest questions are given to find out the learning outcomes. The pretest and post-test results were tested using inferential statistics in the form of a normality test, Paired T-Test, and N-gain.

Normality test

The normality test is calculated using the SPSS 16 application to find out whether the data is normally distributed or not, the results of which are presented in Table 4.

Table 4. Normality Test Results

	Shapiro-Wilk		
	Statistics	df	Sig
Results	.934	65	.756

The result of the pretest calculation is 0.756 > 0.05, meaning that the sample is said to be normally distributed.

Paired T-Test

Paired T-Test test to prove whether the hypothesis can be accepted or rejected which is denoted by H0 if there is no difference after VARK-based chemistry learning, while Ha if there is a difference after VARK-based chemistry learning.

Table 5. Paired T-Test Test Results

	t	df	Sig. (2-tailed)
Pair 1 (pretest-posttest)	-3,628	65	0.000

Based on the results of the Paired T-Test, it obtained a significance value of 0.000 < 0.05, meaning that H0 was rejected and Ha was accepted, so it was confirmed that there was a difference between the pretest and posttest values after the treatment with VARK-based chemistry learning. These results are consistent with research conducted by Cetin and Turgut (2020) which shows that the t-count is greater than the t-table which means that students' critical thinking skills increase after being given problem-based learning chemistry.

N-gain test

The N-gain test was used to measure the improvement of students' critical thinking skills after being treated with VARK-based chemistry learning. The N- Gain achievement is presented in Figure 1.

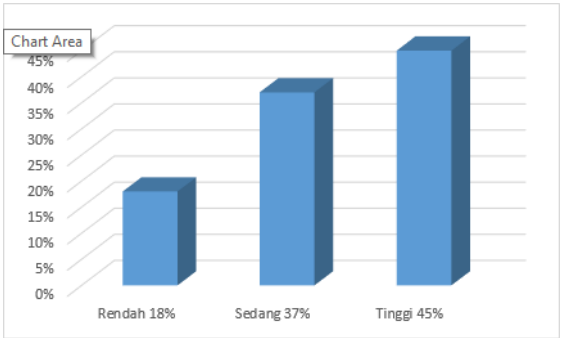

Figure 1. Student N-Gain achievement

The results of the N-gain test showed that 18% or 12 students had an N-gain less than 0.3, which means that the increase has low criteria, as many as 37% or 24 students have an N-gain between 0.3 to 0.7, which means the increase has criteria medium and as many as 45% or 29 students have an N-gain greater than 0.7, which means the increase is high. Based on the results obtained, it can be seen that the highest percentage is in the high N-Gain criteria. This shows that there is a high increase in students' critical thinking skills by using VARK-based chemistry learning. Meanwhile, the N-Gain analysis for each indicator is presented in Table 7.

Table 7. N-Gain per indicator

Critical Thinking Skills Indicator	Average Pretest score	Average Posttest scores	N-Gain	Gains Category
Interpreting ability	45,76	84,72	0.72	Tall
Analytical ability	67,87	88,23	0.63	Currently
Ability to explain	64,83	92.34	0.78	Tall
Ability to draw conclusions	52,58	86.52	0.72	Tall
Evaluating ability	52,73	79,47	0.57	Currently
	Average		0.68	Currently

Based on the table above, it can be seen the criteria for each indicator of critical thinking skills. On the ability to interpret indicators, the average pretest score is 45.76, the posttest is 84.72, and the N- Gain is 0.72, which is a high criterion. On the ability to analyze indicators, the average pretest score is 67.87, posttest is 88.23 and N-Gain is 0.63, which is a medium criterion. On the ability to explain indicators, the average pretest score was 64.83, posttest was 92.34 and N-Gain was 0.78, which is a high criterion. On the indicator of the ability to make inferences, the average pretest score was 52.58, posttest was 86.52 and N-Gain was 0.72, which is a high criterion. On the ability to evaluate indicators, the average pretest score is 52.73, posttest is 79.47 and N-Gain is 0.57, which is a moderate criterion. All of these indicators have an average N-Gain score of 0.68, which means that the average increase is in moderate criteria. The impact of the VARK learning style on critical thinking skills has a high category on three indicators, the ability to interpret, the ability to explain, and the ability to make conclusions. This is in line with research conducted by Shirazi and Heidari (2019), whereas on the two indicators, the ability to analyze and the ability to evaluate has a moderate N-Gain category, this can also be caused by a lack of priority or focus on the process of analysis and evaluation when learning in class. To increase the influence of the VARK learning style on critical thinking skills, a holistic and integrated approach is needed in the learning process. Educators need to accommodate diverse VARK learning styles by providing learning experiences that suit individual learning preferences (Naila & Nadeem, 2023).

Molecular geometry material can be studied more easily by students with a visual learning style because molecular geometry can be demonstrated with 3D visualization which can help students understand the concept better. Students with a kinesthetic learning style can also learn more easily by using molecular geometry models or demonstrations because they can learn by touching and feeling, this is in line with research results (Aw et al., 2020). Students with an auditory learning style can also learn more easily if the material is taught with the help of audio or video that explains the concept of molecular geometry. In this case, the use of 3D visualizations, molecular geometry models, demonstrations, audio, and video can be effective tools in helping students understand concepts related to molecular geometry. With the right approach, learning molecular geometry can be more interesting and effective for students with various learning styles.

The results of this study have important implications for chemistry teachers in implementing VARK learning style-based learning. By understanding students' learning styles and integrating molecular geometry concepts into appropriate teaching methods, teachers can assist students in gaining a better understanding. This can have a positive impact on student learning outcomes in molecular geometry, as well as reduce the level of stress students may experience when learning abstract and imaginative concepts (Basit et al., 2023). In addition, by encouraging the development of student's critical thinking skills through VARK-based learning, teachers can provide a strong foundation for students to face complex challenges inside and outside the classroom. Therefore, this research makes a valuable contribution to the development of a more effective and inclusive learning approach to teaching chemistry.

CONCLUSION

Based on the results of the study, it can be concluded that there is a significant influence of the use of the VARK learning style in chemistry learning on improving the critical thinking skills of students majoring in Mathematics and Natural Sciences at school. This study has limitations regarding the initial diagnostics of student learning styles so that the dominance of learning style planning is not adjusted to the dominance of student learning styles in the class. Preliminary diagnostic disclosures about students' learning styles can lead to even higher criteria for improving students' critical thinking skills.

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