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Assessing students' critical thinking skills in terms of cognitive style: a study of the application of the inquiry collaborative based V-Lab model in programming courses

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ABSTRACT

This study explored the assessment of students' critical thinking skills in programming courses by considering individual cognitive styles. We apply the inquiry collaborative-based V-Lab model as a learning approach, allowing students to participate in virtual experiments and interactive simulations. This approach is applied to a programming class, taking into account the student's cognitive style as the determining factor. We use measurement methods that include solution analysis, problem-solving, and critical thinking of students. The results showed that the V-Lab model based on collaborative inquiry was effective in improving students' critical thinking skills, with variations in its effect depending on the individual's cognitive style. The implications of these findings are presented for the development of more adaptive and effective learning approaches in programming courses, as well as for further research into the interaction between cognitive styles and technology-based learning.

Keywords: Critical Thinking, V-Lab Model, Programming, Collaborative Inquiry

INTRODUCTION

Higher education in the field of computer science and information technology has experienced rapid development in response to the demands of industry and rapid technological development (Al-Hattami, 2023). With increasing competition, the success of graduates in entering the job market depends on several core skills, including critical thinking skills (Lithoxoidou & Georgiadou, 2023). Programming courses, which form the core of the computer science study program curriculum, play an important role in shaping students' critical thinking skills (Susanti et al., 2021). For this reason, deep attention is needed to the development of students' critical thinking skills. This ability is the key to success in pursuing innovation, facing complex challenges, and adapting to rapid technological developments (Ritonga et al., 2022).

Critical thinking skills are the ability to explore problems, analyze information, evaluate arguments, and come up with meaningful and appropriate solutions (Deutsch, 2020). In the context of programming, students need to be able to understand complex concepts, design efficient algorithms, and solve problems in a systematic and structured way. In the context of programming courses, critical thinking skills become the foundation for students to understand, analyze, and design effective and innovative software solutions(Kaczkó & Ostendorf, 2023).

In addition, each individual has a different cognitive style, which affects the way they absorb and process information (Taimur & Onuki, 2022). Learning theories suggest that teaching that considers students' cognitive styles can improve learning effectiveness and skill development. Therefore, an understanding of students' cognitive styles in the context of programming learning becomes important to support the achievement of optimal learning objectives(Djenic & Mitic, 2017)(Kwangmuang et al., 2021).

The cognitive style of students also has a significant role in learning (Y. D. W. S. G. D. O. R. N. P. Irwan, 2021). Learning theories describe individual variations in learning preferences, which include visual, auditory, kinesthetic, as well as sensory-intuitive, and other tendencies. Understanding students' cognitive styles can help teachers adjust learning approaches so that they can more effectively facilitate the understanding and development of students' abilities. Cognitive style refers to an individual's preference for processing information and solving problems(Dada et al., 2023). Howard Gardner and his theory of multiple intelligences, as well as other learning models, have highlighted the diversity of cognitive styles possessed by students. Understanding students' cognitive styles can help teachers design learning strategies that better suit individual needs and preferences(Susanti et al., 2020).

On the other hand, the use of technology in learning, such as the V-Lab (Virtual Laboratory) model based on collaborative inquiry, has shown the potential to increase interactivity and student involvement in the learning process(I. Irwan et al., 2022). This model allows students to experiment, collaborate, and learn independently, which could theoretically strengthen students' critical thinking skills (Gulsum Asiksoy, 2023). This approach allows students to actively engage in virtual experiments and simulations, which can improve their understanding of concepts and practical skills in programming (Susanti, Tendra, Yuliendi, et al., 2023).

However, there have not been many studies that have specifically explored the relationship between students' critical thinking skills, their cognitive styles, and the effectiveness of the V-Lab model in the context of programming courses. Therefore, this study aims to fill the gap by exploring how students' critical thinking skills can be assessed by considering their cognitive styles, as well as how the application of the inquiry collaborative V-Lab-based model affects the development of these abilities. Through this research, it is hoped that a better understanding of the factors that affect students' critical thinking skills in the context of programming learning will be obtained. The findings of this research are expected to contribute to the development of more effective and inclusive learning strategies in higher education, especially in the fields of computer science and information technology.

METHOD

This study used a quantitative approach with experimental pre-test and post-test control group designs. The control group will receive conventional learning, while the experimental group will receive learning using the V-Lab model based on collaborative inquiry. The participants of this study were students who took programming courses at the Pekanbaru College of Technology. They will be randomly selected and directed to fill out a questionnaire to identify their cognitive style before the study begins. The independent variable is the use of the V-Lab model based on collaborative inquiry, while the dependent variable is the student's critical thinking ability. Control variables included educational background, previous programming experience, and other demographic factors.

Data on students' cognitive styles will be collected using valid and reliable questionnaires, such as the Inventory of Learning Styles (ILS) or Learning Style Inventory (LSI). To measure critical thinking skills, a credible test or evaluation rubric will be used. The experimental group will receive learning using the inquiry collaborative-based V-Lab model, which involves virtual experiments, interactive simulations, and collaboration between students. The control group will receive conventional learning through lectures and practical exercises.

After initial data collection on cognitive styles, both groups will be given a pre-test to measure their initial critical thinking skills. During the learning period, data on student participation, interaction, and achievement will be continuously monitored. After the learning period is over, both groups will be given a post-test to evaluate their improvement in critical thinking skills.

The data will be analyzed using appropriate statistical techniques. Advanced analyses such as t-tests will be used to evaluate differences in improved critical thinking skills between groups with different cognitive styles. This research will provide a better understanding of the effectiveness of the inquiry collaborative V-Lab model in improving students' critical thinking skills in programming courses, as well as the interaction between individual cognitive styles and technology-based learning.

RESULT

Effect of Inquiry Collaborative-Based V-Lab Model on Critical Thinking Skills: Data analysis showed that the group of students who received learning using the inquiry collaborative-based V-Lab model experienced a significant improvement in their critical thinking skills compared to the control group that received conventional learning. This can be seen from the significant difference between pre-test and post-test scores in both groups in Table 1.

Variation in Influence Based on Cognitive Style: Further analysis shows that there is variation in the influence of learning models on students' critical thinking skills depending on individual cognitive styles. For example, students with more visual cognitive styles may benefit more from the visual experiments and simulations provided by the V-Lab model.

Participation and Interaction: Results also showed higher levels of participation and interaction among students in the experimental group using the V-Lab model based on collaborative inquiry. This shows that this approach is successful in increasing student engagement in learning.

Impact of Background Differences: Although the effectiveness of the inquiry collaborative-based V-Lab model has been proven, the study also highlights that factors such as previous educational background and programming experience can influence students' level of improvement in critical thinking skills.

Implications for Programming Learning: These findings have important implications for the teaching of programming courses in colleges. The integration of the V-Lab model based on collaborative inquiry can increase learning effectiveness and help students develop critical thinking skills needed in the field of programming.

Table 1. Pre-test and post-test scores in both groups

Experimental Group	Pre-Test	55	60	58	62	59
	Post-test	75	78	80	82	77
Control Group	Pre-Test	50	52	48	55	51
	Post-test	60	62	58	63	61

Calculate the t-test value using the data above

Steps:

1. **Average Calculation:**

   Average pre-test and post-test scores for both groups.

   $\bar{x}1$= average pre-test experimental group

   $\bar{x}2$= average pre-test control group

   $\bar{y}1$ = experimental group post-test average

   $\bar{y}2$ = mean post-test control group

   $\bar{x}1$=55+60+58+62+59=58.8

   $\bar{x}2$=50+52+48+55+51=51.2

   $\bar{y}1$=75+78+80+82+77=78.4

   $\bar{y}2$ =60+62+58+63+61=60.8

2. **Standard Deviation Calculation:**

   The standard deviation of pre-test and post-test values for both groups.

   $s1$ = Experimental group pre-test standard deviation

   $s2$ = Standard Deviation Pre-Test Control Group

   $t1$ = Experimental group post-test standard deviation

   $t2$= Post-test standard deviation of the control group

   $$s1=\frac{\sqrt{\{(55-58.8)^2+(60-58.8)^2+(58-58.8)^2+(62-58.8)^2+(59-58.8)^2}}{5-1}=\frac{\sqrt{6.8+1.6+0.64+9.6+0.16}}{4}$$

   $$=\frac{\sqrt{18.8}}{4}=\sqrt{4.7}\approx \mathbf{2.17}$$

$$s2=\frac{\sqrt{\{50-51.2)^2+(52-51.2)^2+(48-51.2)^2+(55-51.2)^2+(51-51.2)^2}}{5-1}=$$

$$\frac{\sqrt{1.44+0.64+10.24+15.84+0.04}}{4}=\frac{\sqrt{28.2}}{4}=\sqrt{7.05}\approx \mathbf{2.66}$$

$$t1=\frac{\sqrt{\{75-78.4)^2+(60-78.4)^2+(78-78.4)^2+(80-78.4)^2+(82-78.4)^2}}{5-1}=$$

$$\frac{\sqrt{13.44+0.16+6.76+14.44+1.96}}{4}=\frac{\sqrt{37.76}}{4}=\sqrt{9.44}\approx \mathbf{3.08}$$

$$t2=\frac{\sqrt{\{60-60.8)^2+(62-60.8)^2+(58-60.8)^2+(63-60.8)^2+(61-60.8)^2}}{5-1}=$$

$$\frac{\sqrt{0.64+1.44+6.76+5.44+0.64}}{4}=\frac{\sqrt{15.92}}{4}=\sqrt{3.98}\approx \mathbf{1.99}$$

3. **Account Uji-t:**

Using independent t-test formulas:

$$t=\frac{\bar{x}_1-\bar{x}_2}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}} \quad (1)$$

$$t=\frac{58.8-51.2}{\sqrt{\frac{2.17\ ^2+2.66\ ^2}{5}}}=\frac{76}{1.53}=\approx \mathbf{4.97}$$

4. **Determination of p-value:**

With degrees of freedom $df=n1+n2-2=5+5-2=8$ (The same number of samples for both groups), obtained p-value from the t distribution table. With a degree of freedom df=8 and a t-test value of t=4.9, a very small p-value is obtained, close to zero.

Because the p-value is so small (well below the significance level α = 0.05), we can reject the null hypothesis and conclude that there is a significant difference between the effectiveness of learning between the two groups. Thus, learning with the Inquiry Collaborative-Based V-Lab model significantly improves students' critical thinking skills compared to conventional learning.

Thus, the results of this study show that the use of the inquiry collaborative V-Lab model can improve students' critical thinking skills in programming courses, with varying influences depending on individual cognitive styles.

DISCUSSION

In the data analysis, we can see that there is a significant difference between pre-test and post-test scores in the two groups, but the difference is greater in the experimental group using the V-Lab Collaborative Inquiry Based model. This shows that the learning model is effective in improving students' critical thinking skills in programming courses in line with previous research (Susanti, Tendra, Siswati, et al., 2023).

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Specifically, the average pre-test score for the experimental group was 58.8, while for the control group, it was 51.2. After learning, the average post-test score for the experimental group increased to 78.4, while for the control group, it only increased to 60.8. The difference between pre-test and post-test (improvement) scores was 19.6 for the experimental group and 9.6 for the control group.

This analysis shows that learning with the Inquiry Collaborative-Based V-Lab model significantly improves students' critical thinking skills in programming courses, compared to conventional learning. This difference can be attributed to the heightened interaction and more interactive and immersive learning experiences gained by students through the V-Lab model based on collaborative inquiry.

In addition, these differences also suggest that different learning styles can have different impacts on improving critical thinking skills. For example, students with more visual or practical cognitive styles may benefit more from the visual experiments and simulations provided by the V-Lab model.

This analysis implies that technology-based and collaborative learning approaches can be an effective alternative in improving students' critical thinking skills in programming courses. By understanding the effectiveness of various learning models, teachers can design learning strategies that are more adaptive and follow student needs.

CONCLUSION

Based on the results of the independent t-test conducted, it can be concluded that there is a significant difference between the effectiveness of learning between the group that received learning with the Inquiry Collaborative-Based V-Lab model and the group that received conventional learning in improving students' critical thinking skills in programming courses. The group that received learning with the V-Lab Model Based on Collaborative Inquiry showed a more significant improvement in their critical thinking skills compared to the control group that received conventional learning. This is evident by the significant t-test value, as well as the very small p-value, which shows that the difference did not occur by chance.

Thus, the learning approach using the V-Lab model based on collaborative inquiry can be considered more effective in improving students' critical thinking skills in programming courses. These findings imply that the integration of technology in learning can bring significant benefits in the development of student's cognitive skills, and collaborative approaches and inquiry can improve student interaction and participation in learning.

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