Virtual Programming Laboratory in Collaborative Inquiry Learning to Improve Higher Order Thinking Skills for Work Readiness in the Industrial World

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ABSTRACT
This study aims to determine the effectiveness of using Virtual programming Lab software as a practicum tool in inquiry learning, collaboration, and increasing the ability of higher-order thinking skills (HOTS) students who take programming courses. Pseudo-experimental studies are designed with experimental and control groups. This research was attended by 35 first-semester students from the Pelita Indonesia Informatics Engineering Study Program. Quantitative methods are used to determine students’ HOTS levels and their acceptance of the use of virtual programming labs as computer practicum tools. The data analysis technique used is the Kolmogorov Smirnov technique. For inquiry-based collaborative learning using 7 stages of learning. The effectiveness of virtual programming with collaborative inquiry learning through HOTS questions is tested with the N-gain test. Based on the findings, it is stated that virtual programming applications with collaborative inquiry learning in programming courses are quite effective in improving students’ higher-order thinking skills with an average N Gain of 60%. The ability of students to do HOTS questions in C4, C5, and C6 has increased after post-tests in experimental classes.

KEYWORDS: HOTS; Virtual programming; Inquiry collaboration

1. INTRODUCTION
In the 21st century, employability skills are necessary for graduates to become successful employees in the industrial world. According to Phuong et al. (2023), to be a successful employee requires communication skills, information handling, problem-solving skills, working in a team, confidence, and critical thinking. This is also expressed by Shamsudin et al. (2023). For graduates to be ready for the future, it is necessary to be equipped with innovative critical thinking skills and digital literacy. For this reason, stakeholders need to prepare an agenda so that graduates are worthy of working in the industrial world (Winterton & Turner, 2019). Learning is the process of changing behavior to gain information, skills, and something new with a specific purpose. Computer labs play an important role in distinguishing practical (hands-on) learning from theoretical learning. The main objective of laboratory courses is to establish a link between theoretical learning and the same practical application in knowledge (Al Ahmad & Obeidallah, 2022). For this reason, careful planning is needed, dynamic in practice related to the use of technology that changes the role of teaching in managing learning in higher education (Ideris et al., 2019). Online learning platforms are an option to improve students’ ability to learn (Jin & Li, 2020). MOOCs are used as virtual platforms for internet-based environments (García et al., 2021). The use of virtual laboratories provides experiences to develop students’ active, reflective, thinking, and creativity skills (Hao et al., 2021). So virtual labs are designed to be effective and student-centered (Armah et al., 2023). Despite the unfortunate disruption of the COVID-19 pandemic, teachers and universities were “forced” to change their teaching methods. Most students can cope with these changes quite easily without much guidance (Verawardina, 2020). Most people consider programming education as an important way for students to acquire higher-order thinking skills (Misorli & Komis, 2023). Teachers should further consider how digital technology can make student learning more flexible and can improve
higher-order thinking skills (Limniou et al., 2021). Learning higher-order thinking skills includes three components of thinking: critical and creative thinking, problem-solving, and knowledge transfer. The Importance of higher-order thinking Skills (HOTS) to the demands of the 21st century (Nowlan et al., 2023).

Critical thinking is a cognitive process used to analyze knowledge (Jarvis & Baloyi, 2020). The grid of questions should include cognitive levels that fall under the category of higher-order thinking skills (HOTS). HOTS includes logic and reasoning, analysis, evaluation, and creation, problem solving, and judgment skills (Mispani et al., 2021). Collaborative-based learning allows for knowledge transfer and does not designate lecturers as the only learners in the classroom (Krismadinata & Susanti, 2021). Over the past twenty years online teaching using inquiry has developed students' critical thinking (Kaczkó & Ostendorf, 2023) and is a student-centered, active learning approach that focuses on questions (Eppes et al., 2020). Collaborative inquiry can teach students to reorganize knowledge through shared discussion and analysis, reconstruct through collaborative action, and build shared knowledge through experience and learning from multiple sources (Sipayung et al., 2018). However, there are still students who are less active in developing their potential to solve programming problems (Febrian & Lawanto, 2018). Learning programming requires students to be more creative, teamwork, and innovative, as well as able to solve algorithm problems (Nair, 2020). Research results by Khaleeli et al. (2017) stated that students do not have enough interest or motivation in programming lessons, which shows that this is the reason why they have low grades. Another problem that students face in programming learning is the practicum part, which involves the need for students to practice thoroughly to acquire better programming skills (Susanti et al., 2021).

Several studies use collaborative models or use virtual laboratories in programming learning, such as research conducted by Wang & Hwang (2017). To support the development of collaborative learning activities in computer programming practice courses, Wang and Hwang suggest problem-posing-based practice strategies. This strategy leads students to solve computer programming problems to improve interaction between teams. However, this model in its application is still limited to solving problems in coding programs. Research by Idris et al. (2019) stated that collaborative learning environment, successfully improved test scores and higher-order thinking skills with the use of Scratch software as a teaching aid (Udayana et al., 2024). Lack of student knowledge when studying independently is due to limited learning tools (Achuthan et al., 2011). For this reason, lecturers must be able to develop learning models that can increase student confidence. Learning can run well if students are given the freedom to do self-development. Inquiry is considered a collaborative-constructivist process model that describes a successful online learning experience (Wang & Zhang, 2023). Virtual worlds can offer a new environment to engage students in constructionist activities (Girvan & Savage, 2019). In virtual learning environments, students can think reflectively and creatively (Huizinga et al., 2022). Cognitive learning theory, that the learning process needs to understand concepts and have experience interacting with the environment (Kaczkó & Ostendorf, 2023). Cognitive outcomes (i.e., cognitive knowledge and strategies) and behavioral outcomes (i.e., skills and engagement) can be measured, one of which is by tests (Guo et al., 2020). The inquiry method utilizes students’ emotions and motivation to motivate them to learn (Rodríguez-Triana et al., 2020). According to research findings, inquiry learning by emphasizing collaborative learning and facilitating discussion and cooperation between students for programming learning through virtual programming can improve student learning outcomes through HOTS-based test questions, namely at levels C4, C5, and C6.

2. LITERATURE REVIEW

So virtual labs are designed to be effective and student-centered (Joyce, et al., 2016) with the ability to organize data, solve problems, concepts built by planning, and solve problems in the use of symbols in the environment. This is related to the learning approach used where students are directed to understand the material by illustrating problems faced in everyday life in the second syntax of presenting information. Based on the theoretical foundation (Febrian & Lawanto, 2018; Ansari & Khan, 2020), the characteristics of a collaborative learning environment should involve students in the exchange of ideas and information. Students will develop to a higher cognitive level, able to relate or associate a concept with one another. The concept can also be used to solve problems ranging from simple to more complex problems in identifying problems. Based on theoretical foundations according to Geven & Attard (2012) and Schnaider (2023), online learning refers to the use of Internet technology to deliver a series of solutions that can improve knowledge and skills so that constructivist learning models and collaborative activities can be realized in the learning environment Online discussion groups. This collaborative learning allows students can be discussed with peers. Research conducted by Idris et al. (2019) stated that collaborative learning environment, successfully improved test scores and higher-order thinking skills with the use of Scratch software as a teaching aid (Udayana et al., 2024). Lack of student knowledge when studying independently is due to limited learning tools (Achuthan et al., 2011). For this reason, lecturers must be able to develop learning models that can increase student confidence. Learning can run well if students are given the freedom to do self-development. Inquiry is considered a collaborative-constructivist process model that describes a successful online learning experience (Wang & Zhang, 2023). Virtual worlds can offer a new environment to engage students in constructionist activities (Girvan & Savage, 2019). In virtual learning environments, students can think reflectively and creatively (Huizinga et al., 2022). Cognitive learning theory, that the learning process needs to understand concepts and have experience interacting with the environment (Kaczkó & Ostendorf, 2023). Cognitive outcomes (i.e., cognitive knowledge and strategies) and behavioral outcomes (i.e., skills and engagement) can be measured, one of which is by tests (Guo et al., 2020). The inquiry method utilizes students’ emotions and motivation to motivate them to learn (Rodríguez-Triana et al., 2020). According to research findings, inquiry learning by emphasizing collaborative learning and facilitating discussion and cooperation between students for programming learning through virtual programming can improve student learning outcomes through HOTS-based test questions, namely at levels C4, C5, and C6.
to work in groups, and each member contributes knowledge, experience, ideas, attitudes, points of view, skills, and understanding among all members. Based on rational theories about inquiry-based learning approaches developed by Armah et al. (2023), learning must provide teaching to students to be able to identify problems and classify phenomena, processes, skills, and knowledge in a certain way. Learning is the process of building knowledge, and give students the freedom to use the experience of designing and conducting experiments, reading, discussing, asking questions, listening, and thinking in the inquiry process. Based on theoretical foundation (Jansson et al., 2021), learning is a process of building knowledge. Students participate in the learning process and undergo the reconstruction process by implementing the knowledge. Inquiry-based learning stages can train algorithmic processing skills and implement this knowledge into programs. Based on a theoretical foundation by Nowlan et al. (2023) stated that the ability of learning outcomes obtained is observed by students and is divided into three stages including cognitive, emotional, and psychomotor fields. Bloom’s classification of cognitive behavior, classification of affective behavior, and classification of psychomotor behavior from learning outcomes in the cognitive domain is mastery of concepts, ideas, factual knowledge, and intellectual abilities.

3. METHODOLOGY

Two groups were involved in this study, namely the treatment group and the no-treatment group. Both groups were given a pre-test and post-test. Pre-tests are given to both groups to determine students’ initial knowledge. After completing the pre-test, the experimental group was specifically asked to learn how to use virtual programming applications. The control group was asked to learn how to use ordinary labor. After both groups underwent the prescribed teaching, a post-test was given to students from both groups to assess their achievement. The independent variable in this study is a collaborative inquiry learning model using a virtual laboratory. The dependent variable is higher-order thinking skills (HOTS). The data includes students’ higher-order thinking skills (HOTS). The collection technique uses the instrument test method used in this study, which is in the form of high-level thinking skills test questions. The data analysis technique used is the Kolmogorov Smirnov technique. For inquiry-based collaborative learning using 7 stages of learning (Krismadinata & Susanti, 2021). A trial of 50 objective, formative, and summative questions was conducted to obtain questions that are suitable for measuring students’ high-level skill knowledge. The results of the next trial analyzed include the distinguishing power of the question items, the level of difficulty of the question items, the validity of the question items, and the reliability of the question items. Based on the analysis of the trial data of objective, formative, and summative questions, 32 questions were obtained that were worth using. To determine the students’ high-level skills in programming learning, the experimental group and the control group on the basic competencies of the programming course were given the HOTS objective question test for further descriptive analysis. Effectiveness on programming problem-solving skills is achieved if ≥ 70% of students achieve the minimum good score category. The effectiveness of virtual programming with collaborative inquiry learning through HOTS questions is tested with the N-gain test.

3.1 Sample Preparation

The study participants were 35 students (21 experimental groups, 14 control groups) of the IBTPI informatics engineering study program. Research students are specially selected among freshmen. In addition, the research topic and application procedure are the objectives of the course as it aims to improve students’ knowledge and problem-solving skills. In this study, participants’ ages ranged between 18 and 27 years, with an average of 19 years. As the main objective of the study, the course is designed for two groups of students. Students were randomly divided into both groups. Therefore, to identify study participants, sampling techniques are used.

3.2 Data Analysis

By the realm of student competence, the targets and learning models used are expected to produce graduates with at least C4 (Analysis) as stated in Bloom’s Taxonomy level. The application of questions C4, C5, and C6 is a matter of the HOTS domain. A new test has meaning if it consists of question items that have a purpose and represent all the material tested. To make it easier for lecturers to make tests, a grid is needed, the grid itself contains information, namely the scope of the material, competence, level of difficulty of the questions, and the number of question items needed. Application of C4 Bloom’s Taxonomy C4 Analysis is the ability to decompose information faced into its components so that the structure of information and the relationship between the components of the information becomes clear. The application of the C5 Bloom Taxonomy question Evaluation (Evaluation) referred to as the evaluation level is the ability to consider the value of a statement, description, or work, based on certain criteria set. Application of question C6 For example, choosing a formula that is supported by data. The HOTS question grid is shown in Table 1. The construct domain of HOTS questions is applying (C3) (7 questions), analyzing (C4) (10 questions), evaluating (C5) (20 questions), and creating (C6) (thirteen questions). Analysis of the reliability value of HOTS question items using the validity results of the test questions calculated.
using the SPSS application showed that 34 questions were valid. This result is known because each item in the question is rtable of 0.349. Overall, the HOTS test questions are valid, and the reliability of the HOTS test questions is 0.396, meaning it is very high and can be used.

<table>
<thead>
<tr>
<th>Basic Competencies</th>
<th>Indicators</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Able to understand Algorithms and Programming for several types of activities related to daily life</td>
<td>1. Able to understand the definition of algorithms and programming.</td>
<td>C3, C4, C5, C6</td>
</tr>
<tr>
<td>2. Able to apply selection to algorithms and apply to programming languages</td>
<td>2. Able to understand Repetition on algorithms</td>
<td>C3, C4, C5, C6</td>
</tr>
<tr>
<td>3. Able to understand functions/functions in programming</td>
<td>1. Able to understand functions/functions in programming</td>
<td>C3, C4, C5, C6</td>
</tr>
<tr>
<td>4. Able to understand search algorithms</td>
<td>1. Able to understand the definition of algorithms and programming.</td>
<td>C3, C4, C5, C6</td>
</tr>
</tbody>
</table>

### 4. RESULTS AND DISCUSSION

Learning activities are carried out with a collaborative inquiry learning model through 7 stages of learning steps based on Programming practices are implemented using virtual laboratories designed to make it easier for students to collaborate virtually. To determine the effectiveness of the model using a virtual laboratory on higher-order thinking skills (HOTS), a test method is used. The test is conducted before and after the learning process (pre-test-post-test). Programming practices are implemented using virtual laboratories designed to make it easier for students to collaborate virtually. To determine the effectiveness of the model using a virtual laboratory on higher-order thinking skills (HOTS), a test method is used. The test is conducted before and after the learning process (pre-test-post-test). Multiple choice questions that are feasible to use are then used to test students’ abilities against programming course material. After the assessment is carried out on the question test carried out, the results obtained by students after answering the given test are analyzed again with a homogeneity test, normality test, and independent sample T-test (Test T). The question is given to measure students’ HOTS ability before learning programming courses (pre-test) and after learning programming in the form of summative evaluation (post-test). The results of the normality test show that sig. > α. Therefore, the subjects of the study came from a normally distributed population. The normality test results are shown in Table 2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.346</td>
<td>0.000</td>
</tr>
<tr>
<td>Experiment</td>
<td>0.145</td>
<td>0.096</td>
</tr>
</tbody>
</table>

# Table 2: Data Normality Test Results

Before conducting the independent sample T-test (Test T), the necessary condition is to carry out the homogeneity test. This test aims to determine whether or not the sample variance taken from the population is uniform. In this homogeneity test, the decision-making of whether or not the sample is homogeneous is based on: 1) If the Significance (Sig) is Based on a Mean value > 0.05 then the data variance is homogeneous. 2) If the Significance (Sig) value is Based on Mean < 0.05 then the variance of the data is inhomogeneous. The results of the homogeneity test can be seen in Table 3.

<table>
<thead>
<tr>
<th>Class</th>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.76</td>
<td>1</td>
<td>29</td>
<td>0.798</td>
</tr>
<tr>
<td>Experiment</td>
<td>0.06</td>
<td>1</td>
<td>29</td>
<td>0.93</td>
</tr>
</tbody>
</table>

The homogeneity results were carried out in the control class and experimental class, obtained (Sig) Based on
Mean >0.05 so that the data variance was declared homogeneous. The independent sample t-test (Test T) aims to see the level of difference in learning outcomes between the control class and the experimental class after carrying out the pretest and posttest. The hypotheses proposed in this test are:

Ho: There was no difference in the average pretest results of control and experimental class students
Ha: There was a difference in the average pretest results of control and experimental class students

The basis for decision-making: 1) If the value of signification or sig. (2-tailed) > 0.05, then Ho is accepted and Ha is rejected. 2) If the value of signification or sig. (2-tailed) < 0.05, then Ho is rejected and Ha is accepted. Table 4 shows the results of the independent sample t-test on posttest data for experimental and control classes. The results obtained independent sample t-test with sig.909 > 0.05, so it has the same variance. Then the calculated value on equal variance assumed is 5.178 with a probability of significance 0.000 (two-tailed) and in t table = 1.703. Then calculate > t table or 5.178 > 1.703. It was concluded that there were differences in the results of HOTS students taught using a model developed between the experimental class and the control class. The results of the study were obtained by providing pre-test and post-test in the form of objective HOTS questions that have been tested for validity, reliability, and level of difficulty. The improvement of students’ higher-order thinking skills was also analyzed descriptively using the n-gain equation. Table 5 shows the results of the calculation of the average pre-test and post-test.

Increasing the effectiveness of students’ HOTS abilities is obtained from media use strategies, methods, and assessment strategies, this is also in line with research conducted by Shanti et al. (2022). High-level thinking skills students obtained high-level thinking skills scores with an average n-gain of 60% showing improved learning outcomes with moderately high criteria. This is evidenced by the acquisition of the average score of high-level thinking skills with an average pretest score of 73 and an average post-test score of 82. When viewed from Figure 1 of the average analysis results of each HOTS question domain, namely C4 (analysis), C5 (evaluation), and C6 (creating), the average value of each domain has increased. Based on Figure 1 it can be seen that students’ skills in solving HOTS problems with the C6 cognitive realm are higher than the C4 and C5 cognitive domains even though the difference is not too far.

This is because the C6 question is required to create a program and translate the program from a flowchart so that students can solve the problem easily. Thus, it can be said that a collaborative inquiry learning approach with virtual laboratory practice can be applied in programming practicum learning, especially in basic programming algorithm courses. The results of this study are in line with the results of the study by Hollenbeck (2020), that inquiry learning can improve communication and strengthen the learner experience. This is in line with research by Jansson et al. (2021) that online tutoring is proven to have a positive impact on student learning in education. According to Handayani et al. (2023), the ability to solve HOTS questions depends on learning independence and is one of the determining factors for learning outcomes. The learning experiment in the virtual laboratory made in this study is that students actively participate through 7 stages of the learning process, namely (1) providing goals and motivation, (2) presenting information, (3) identifying problems, (4) conducting an inquiry process, (5) applying new knowledge, (6) conducting evaluations. Students who actively participated in experiments showed improvements in the domains of analysis, evaluation, and creation. In line with research by Cusipag et al. (2023), Learning virtually, teachers are decisive in balancing student attitudes about work-life balance and job satisfaction.

### Table 4: T Test Results

<table>
<thead>
<tr>
<th>Independent Samples Test</th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>t</td>
<td>df</td>
<td>Lower</td>
</tr>
<tr>
<td>HOTS Post-</td>
<td>Equal assumed</td>
<td>.013</td>
<td>.909</td>
<td>5.178</td>
<td>.000</td>
</tr>
<tr>
<td>Test</td>
<td>Equal variances not assumed</td>
<td>5.181</td>
<td>28.932</td>
<td>.000</td>
<td>982.929</td>
</tr>
</tbody>
</table>

### Table 5: Pre-test and Post-test Average Calculation Results, and N-Gain

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-test Average</th>
<th>Post-test Average</th>
<th>Average Gain</th>
<th>Average Gain Index</th>
<th>Average N-Gain (100%)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOTS</td>
<td>73</td>
<td>82</td>
<td>49</td>
<td>1</td>
<td>60</td>
<td>Effective</td>
</tr>
</tbody>
</table>
5. CONCLUSION

Based on the results of research and hypothesis testing that has been done, it can be concluded that virtual programming applications with a collaborative inquiry learning process are effective methods that allow students to actively participate and cooperate in finding information or solving problems during the learning process. This process also allows students to discover new ideas and improve higher-order thinking skills while learning programming about logic flow concept programming. Learning programming virtually provides opportunities and experiences for students to solve problems. At this stage, students learn to seek knowledge by analyzing and collaborating with peers. The results obtained in the HOTS assessment of students in the treatment class show an increase in the realm of analysis, evaluation, and creation. This is needed by graduates to be able to work in the industrial world which requires high-level skills to be ready for the future.

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REFERENCES


