

**THE EFFECT OF USING INTERACTIVE VIRTUAL LABORATORY ON HIGH SCHOOL STUDENTS CRITICAL THINKING SKILLS ON BLOOD CIRCULATION SYSTEM MATERIAL*****Pengaruh Penggunaan Laboratorium Virtual Interaktif terhadap Keterampilan Berpikir Kritis Siswa SMA pada Materi Sistem Peredaran Darah*****Nisa Rahmasari**

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e-mail: [raharjo@unesa.ac.id](mailto:raharjo@unesa.ac.id)**Abstract**

The laboratory's involvement in education can enhance abilities, especially those related to the scientific method like analyzing, evaluating, and thinking. One of the thinking skills is high-level thinking involving complex judgment skills, such as critical thinking, but students' critical thinking skills in Indonesia need to be improved. One of the Biology materials that can be carried out in practice is the Human Circulatory System, including the blood group system and heart organ function concepts. It requires expensive tools and materials and avoids disease transmission, so an interactive virtual laboratory medium is needed, one of which is the Howard Hughes Medical Institute (HHMI). The research aimed to determine the impact of using HHMI interactive virtual laboratory on ability to think critically of XI Senior High School students in the Human Circulatory System Material Heart Organ Subchapter. The research used the experimental method and quantitative research. The research design was a Post-Test-Only Control Design, providing a post-test for the experimental and control groups after treatment. The statistical analysis was non-parametric to test the Mann-Whitney U hypothesis with a significance level of 0.05 with SPSS 23. According to data analysis outcomes, there was a significant difference between the outcomes of critical thinking abilities and those of hypothesis testing, with a Sig value of 0.010 at a significant level of 5%. These findings indicate that interactive virtual laboratories impact students thinking critically.

**Keywords:** critical thinking skills, interactive virtual laboratory, human circulatory system**Abstrak**

Peranan laboratorium dalam pendidikan dapat meningkatkan keterampilan diantaranya keterampilan proses ilmiah seperti menganalisis, mengevaluasi, dan keterampilan berpikir. Salah satu keterampilan berpikir yaitu berpikir tinggi dengan melibatkan keterampilan menilai yang kompleks seperti berpikir kritis namun keterampilan berpikir kritis siswa di Indonesia tergolong rendah. Salah satu materi Biologi yang dapat dilakukan praktikum adalah Sistem Peredaran Darah Manusia pada sistem golongan darah maupun konsep fungsi organ jantung, namun membutuhkan alat dan bahan yang mahal serta menghindari penularan penyakit maka diperlukan media yaitu laboratorium virtual interaktif salah satunya Howard Hughes Medical Institute (HHMI). Tujuan dari penelitian ini adalah mengetahui pengaruh penggunaan laboratorium virtual interaktif HHMI terhadap keterampilan berpikir kritis siswa XI SMA pada Materi Sistem Peredaran Darah Manusia Subbab Organ Jantung. Metode penelitian yang digunakan adalah metode eksperimen dan jenis penelitian kuantitatif. Desain penelitian yaitu Post-Test Only Control Design dengan memberikan post test untuk kelompok eksperimen dan kontrol setelah diberi perlakuan. Analisis statistik penelitian yaitu non parametrik uji hipotesis Mann-Whitney U dengan taraf signifikansi 0,05 menggunakan SPSS 23. Berdasarkan hasil analisis data diperoleh bahwa hasil keterampilan berpikir kritis memiliki perbedaan yang signifikan didasarkan pada hasil uji hipotesis dengan nilai Sig, 0,010 pada taraf signifikan 5%. Berdasarkan data yang telah dianalisis, penggunaan laboratorium virtual interaktif berdampak kepada keterampilan berpikir kritis siswa.

**Kata Kunci:** keterampilan berpikir kritis, laboratorium virtual interaktif, sistem peredaran darah manusia

## INTRODUCTION

A science laboratory in schools is becoming increasingly vital in the 2013 Curriculum, which significantly emphasizes students' scientific approaches, skills, character, and psychomotor aspects of learning. The limited number of laboratories, tools, and practicum materials in schools can affect student learning processes. Practicing is one of the activities to understand concepts and theories in biology learning. It is the condition in one of the public schools with an accelerated program in the science department in Sidoarjo, namely SMA Negeri 1 Taman. Based on interviews with the Biology teacher, Mudjiastutitik, only one laboratory room is available for practicum because the other laboratory rooms are unsuitable.

The role of laboratories in education can improve skills, including scientific process skills that must be mastered, including observing, classifying, formulating hypotheses, planning research, concluding, and thinking skills (Agustina, 2018). Bloom's Taxonomy approach divides the level of cognition into lower-order thinking and higher-order thinking skills (Anderson and Krathwohl, 2001).

Higher-order thinking is a person's skill, including mathematical thinking skills, such as: analyzing, evaluating, and applying concepts in solving the right problems (Dinni, 2018). The National Education Association (n.d.) has identified 21st-century skills as "The 4 Cs." "The 4Cs" includes critical thinking, creativity, communication, and collaboration. Critical thinking is analyzing circumstances based on facts and evidence to obtain a conclusion. Paul and Elder (2020) describe critical thinking as the art of analyzing and evaluating thinking processes to increase their critical thinking and self-corrective thinking.

Critical thinking skills indicators, according to Facione (2015), are divided into several aspects, including: (1) interpretation; (2) conclusions or inferences; (3) evaluation; (4) explanation; (5) analysis; and (6) self-regulation or self-regulation. Although there is a lot of agreement in the academic field, critical thinking at least can infer and evaluate, in addition to analysis, interpretation, explanation, and self-control (Thomas and Lok, 2015). In social studies and learning process, the ability to analyze, evaluate can be very applicable, for example, teachers present descriptions of the problems being discussed so that students can analyze and provide solutions to these problems (Mislia et al., 2019). Based on the indicators, components, and definitions of critical thinking skills from experts,

including Paul and Elder (2020), Thomas and Lok (2015), and Facione (2015), researchers adopted two indicators, namely analysis, and evaluation.

According to the Program for International Student Assessment (PISA), critical thinking skills in Indonesia are classified as very low. PISA issued the assessment results to measure literacy levels, including reading, mathematics, and science in 2018, proving that Indonesia is ranked 74th out of 79 countries (OECD, 2019).

In problem-solving, systematic procedures are needed, namely scientific methods that can be carried out through research activities or practicum. In conducting practicum, critical thinking skills are also used by students so that practicum results can be accounted. Based on the statement of Bustami et al. (2019), critical thinking skills are the focus of current biology learning. Critical thinking skills have the impact in learning is on abilities in the process of analysis, evaluation, inference, and explanation. Critical learning in Biology can be done when teachers provide practicum or scientific approaches, projects, and case studies.

Some materials for the Circulatory System that can be practiced include the blood group system, which can be done in the laboratory, but to avoid transmission of diseases through blood, it can use a virtual laboratory. The concept of heart organ function, heart abnormalities, and disorders can also be carried out in real practicum in the laboratory, but this involves expensive practicum tools such as stethoscopes, echocardiogram machines, MRI (Magnetic Resonance Imaging) machines, so virtual practicum is necessary.

Virtual laboratories have many benefits, including saving funds for developing laboratory infrastructure, being free from hazardous substances or materials, being used by many people simultaneously, and being accessed anywhere and anytime (Sypsas and Kalles, 2018). The purpose and advantages of using a virtual laboratory are technology-based media with a personal and special learning approach. Students can access and set the virtual time variable by speeding up, slowing down, or repeating and time flexibility that allows them to access it at any time (Wibawanto, 2020).

Interactive virtual laboratories can improve critical thinking, problem-solving, science process, and higher-order thinking skills (Ramadhan and Irwanto, 2017; Sutarno et al., 2018; Alneyadi, 2019). Virtual laboratories can increase critical thinking skills; the research of Muliawati and Norra (2021) positively impacts students' critical thinking skills in virtual laboratories. Virtual laboratories can motivate and make students active and independent in the learning process

to improve students' critical thinking skills (Musyaillah and Muhab, 2020).

Based on the limited laboratory space and practicum tools and the low ability to think critically, which can be trained through practicum using the scientific method, a facility or media is needed namely a virtual laboratory. One of the virtual laboratories that can be accessed easily and freely is The Howard Hughes Medical Institute's Biointeractive virtual laboratory on subject Human Circulatory System, especially in the Cardiology Subsection. The virtual laboratory is in the form of a website that can be accessed using a browser or known as a laptop or smartphone. Therefore, the researcher wanted to analyze the critical thinking skills of high school students in the use of the Howard Hughes Medical Institute's interactive virtual laboratory on the Material of the Human Circulatory System in diagnosing rhythm, abnormalities, and heart disorders in the hope that students can think critically in analyzing problems.

Based on the description of the problem, the researcher hoped to ascertain the impact of the use of the Howard Hughes Medical Institute's interactive virtual laboratory on the critical thinking skills of class XI Senior High School students in the Material of the Human Circulatory System in the Heart Organ Subchapter.

## METHOD

The method was experimental research and quantitative research. The research was conducted in the even semester, in April to May 2023, at SMAN 1 Taman Sidoarjo. The subjects of this study were class XI IPA 1 students as the experimental class and XI IPA 2 students as the control class. The research design was the post-test-only control group.

The assessment of critical thinking skills scores was based on the critical thinking assessment rubric with indicators of critical thinking skills namely analysis, and evaluation. The data analysis technique was a non-parametric hypothesis test (Mann-Whitney U), which had previously carried out prerequisite analysis tests, namely the normality test (Kolmogrov-Smirnov) and homogeneity test (Levene test) with the help of SPSS 23. The data collection technique in this research was observing practicum performance as supporting data and post-test of critical thinking skills in the form of essays.

## RESULTS AND DISCUSSION

The score of students' critical thinking skills in the experimental and control groups was obtained by implementing a post-test in the form of essays with the

distribution of instruments that had been tested for validation and reliability and were given after treatment.

From 36 students of an experimental class in class XI IPA1, after being given an initial English diagnostic companion test, seven students scored below 75 (Minimum Completeness Standards), so only 29 could be declared experimental class research subjects.

The results of students' critical thinking skills in the experimental and control groups are able to be seen in Table 1.

Table 1. Critical Thinking Skills Post-Test Results

Data	Class XI IPA 1 Group Experiment N= 29	Class XI IPA 2 Group Control N=36
The highest score	100	95
Lowest score	65	55
Average	82,41	77,22

In the control group, the average post-test results for critical thinking skills were 77,22, lower than those for the experimental class, with a score of 82,41.

Table 2. Statistical Results of the Critical Thinking Skills

### Hypothesis

Data	Biology Learning Outcomes
Mann-Whitney U	333,500
Wilcoxon W	999,500
Z	-2,564
Asymp. Sig. (2-tailed)	,010

a. Grouping Variable: Class

Based on the analytical prerequisite test on the critical thinking skills test, the research hypothesis will be carried out using non-parametric statistics with the Mann-Whitney U test to determine the effect of using an interactive virtual laboratory on high school students critical thinking skills on Circulatory System Material.

In Table 2, a U value was produced with a value of 333.500 and a W value of 999.500, and if converted to a Z value, then the value was -2.564. Sig value 0.010 < 0.05. If the Sig value < Sig limit is 0.05, the difference existed between the experimental and control groups.

Critical thinking skills are required in analyzing and evaluating a problem during the learning process. This is reinforced by the statement of Mislia et al. (2019) that in social studies and learning, analyzing and evaluating can be good if presented through a description of the problem. Ennis (2018) also added that if critical thinking can be applied in the learning process, thinking critically in various materials helps students practice and appreciate their critical thinking skills.

Critical thinking skills are able to be identified through several indicators, including analysis and evaluation. Analysis indicators, namely identifying problems that connect a statement, concept, or

description, analyze a statement's arguments. Evaluation indicators provide logical arguments and solutions. This is by the definition of critical thinking skills Teklay et al. (2019); Paul and Elder (2020), that critical thinking skills are the art of analyzing and evaluating thinking processes as part of cognitive skills and intellectual dispositions as well as several indicators from Facione (2015); Thomas and Lok (2015) that analysis and evaluation are abilities that at least critical thinkers have.

The analysis indicators were contained in the HHMI (Howard Hughes Medical Institute) interactive virtual laboratory media, the Heart Organ Sub-Section, which trains students when analyzing differences in various types of patient's heart health conditions and healthy heart conditions with several tools and methods such as a stethoscope for auscultation examinations, echocardiographic examinations, MRI, and genealogy analysis. Evaluation indicators were trained when students made a final diagnosis of symptoms or disorders suffered by patients after carrying out several stages of examination. This is by the research of Sutarno et al. (2018) that the virtual laboratory fulfills the characteristics of learning that are oriented towards higher-order thinking skills, including practicum activities with virtual laboratories, which can be used as a potential to provide critical thinking skills.

According to the results of the hypothesis testing showed that the H1 hypothesis is accepted, which means that the use of the HHMI (Howard Hughes Medical Institute) interactive virtual laboratory significantly impacts the level of students' critical thinking skills in the Circulatory System Material. The findings of this study are consistent with the research of Ramadhan and Irwanto (2017); Aripin and Suryaningsih (2020) that practicum activities with virtual laboratories can be a facility to improve critical thinking skills.

Interactive virtual laboratories have a role in critical thinking skills, some of which is because students are trained to have science process skills and thinking skills by analyzing and evaluating problems and providing conclusions through virtual practice activities. The outcomes of this study are consistent with the statement of Haka et al. (2021), which stated that interactive multimedia integrated with scientific values was very appropriate and effective for use as an abiology learning medium to improve critical thinking skills.

When doing practicum using a virtual laboratory, students were trained to become someone facing problems; the problems obtained were related to daily life problems, especially in the health of the human Heart Organ. Students were given several choices in analyzing

or evaluating the analysis results through a final diagnosis, requiring them to collaborate in solving problems. This description is to the statement of Sutarno et al. (2018) that the HOT virtual laboratory model contains problems in practicum, namely in the form of questions and guides that are applied as directions for practicum activities that can stimulate critical thinking skills.

During practicum implementation, students can access the browser anytime and anywhere if the practicum duration has been completed, students or schools are free from using expensive or dangerous materials and tools, and help students visually represent problems like real situations. The benefits of virtual laboratories is described by Sypsas and Kalles (2018); Mirdiyantu and Murni (2017); Wibawanto (2020) that virtual laboratories are free from the use of hazardous substances or materials, accessible anytime and anywhere by many people at the same time so that students can carry out practicum using a visual laboratory as if it were real.

The effect of using the HHMI (Howard Hughes Medical Institute) interactive virtual laboratory is also supported by the existence of guides or instructions for using virtual laboratories so that students can carry out practical exercises correctly. Calculating from the average percentage of practical implementation of the 12 groups, a value of 89% was obtained with excellent information; this shows that students have carried out practicum according to the instructions for using the virtual laboratory.

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#### **CLOSING**

##### **Conclusion**

The use of the HHMI (Howard Hughes Medical Institute) interactive virtual laboratory in the Heart Organ Subsection provides a substantial impact on high school students' critical thinking abilities, with a Sig value of 0.010 at a significance level of 95% ( $\alpha$ ) = 0.05 in the non-parametric hypothesis test. The number of research subjects (N = 65) refers to the research objectives.

##### **Suggestion**

The researcher hopes that the teacher or researcher should first explain the purpose and provide a brief description of the use of a virtual laboratory for students

who have never used a virtual laboratory, even though a guide has been prepared for using a virtual laboratory and becoming a responsive facilitator if students have problems operating a virtual laboratory.

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