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Physics Virtual Learning Simulation to Enhance Students' Critical Thinking Skill: Virtual Learning during the COVID-19 Pandemic

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Abstract: Developing critical thinking skills has been set as an educational goal in Senior High School for many years. This goal is increasingly important because by improving critical thinking, students can get higher-order thinking skills (HOTS). Even more, during this current Covid-19 pandemic, learning activities at schools are limited and replaced with virtual learning. Many simulations must be carried out that impact critical thinking skills in the learning subject, especially in Physics. This study investigates the relationship between virtual physics simulations and critical thinking skills of High School students in Indonesia. It is quantitative research with 69 regular students at SMA Negeri 3 Pati selected as the participants. The research shows that virtual simulation impacts students' critical thinking skills, and its subdomain can explain nearly half of the variants of critical thinking skills. This thesis is expected to provide an overview needed for students in online learning during the Covid-19 pandemic.

Keywords: critical thinking skill, virtual learning, virtual simulation, COVID-19 pandemic.

提高学生批判性思维技能的物理虚拟学习模拟：新冠肺炎大流行期间的虚拟学习

摘要：多年来，培养批判性思维技能已被定为高中的教育目标。这个目标越来越重要，因为通过提高批判性思维，学生可以获得更高层次的思维技能。更重要的是，在当前的新冠肺炎大流行期间，学校的学习活动受到限制，取而代之的是虚拟学习。必须进行许多模拟，这些模拟会影响学习科目中的批判性思维技能，尤其是在物理方面。本研究调查了印度尼西亚高中生的虚拟物理模拟与批判性思维技能之间的关系。这是一项定量研究，选择了州立高中3淀粉的69名普通学生作为参与者。研究表明，虚拟模拟会影响学生的批判性思维技能，其子域可以解释近一半的批判性思维技能变体。本论文有望为学生在新冠肺炎大流行期间在线学习提供所需的概述。

关键字：批判性思维技能、虚拟学习、虚拟模拟、新冠肺炎大流行。

1. Introduction

One of the teachers' challenges in the teaching and learning process in the 21st century is to provide students of the 21st century with some competencies, which aim to prepare them to be successful individuals [1]. Students must have higher order thinking skills in this 21st century. These skills are related to critical thinking, creativity, collaboration, innovation, and communication skills [2], [3], [4].

On the other hand, the rapid development of technology has both positive and negative sides on its users. In this case, technological advances and the use of technology by the millennial generation become opportunities and challenges in education. Agustini [5] stated that information and communication technology had been widely used in the teaching and learning process; one of the goals is the quality of education to be one step further along with technological advances. The role of teachers is expected to make innovations

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that are capable of optimizing the positive influence of technology progress. As a country that currently has one of the best education systems globally, Finland highly appreciates the role of creativity. It supports the quality teaching staff for the future of its country [6].

Furthermore, the Ministry of Education and Culture of Indonesia has promoted technology-based learning. Educational innovation can be done by choosing technology that is suitable for learning. This innovation is expected to improve the teaching and learning process that is fun for students. One of the innovations is the digital literacy movement.

Bawden [7] asserts that skills-based literacy arises to meet the needs of a more complex information environment with new technologies equipped and a wider variety of media and services. Teaching materials are not only in printed form. The millennial generation must be able to understand and assimilate teaching materials in new forms. Literacy in the digital era means understanding the information presented and involves the skills to interpret images, sounds, etc.

Based on the Minister of Education and Culture's Circular, the Implementation of Education Policies in an Emergency of the Spread Covid-19 stated in point 2a, learning is carried out online from home. During the Covid-19 pandemic, teachers and students must limit their learning activities at school so that experimental or practicum activities cannot be done as usual. In addition, the available print and electronic modules cannot support distance learning activities as has been implemented during the current Covid-19 pandemic.

Limitations in learning will also have an impact on the limitations of students' critical thinking skills. Critical thinking skill is a skill need in the 21st century. Abed, Davoudi, and Hoseinzadeh [8] showed that "critical thinking skills" play a vital role in various aspects of life, even humans. Ananiadou and Claro [9] suggest that "2nd century skills" are becoming a major focus of educators. In this 21st century, human resources with critical thinking are now needed. These critical thinkers are people who can explore new ideas, make difficult decisions, engage dynamically with active and positive activities, be creative, and understand the relationship between theory and practice [10]. Based on related literature, improving critical thinking skills is an important feature of students' abilities to be involved in a dynamic learning process [11].

The observations and interviews result on the online Physics learning process carried out in January 2021 show that there still are weaknesses in online learning. Physics learning is done without practicum activities in it. Students only hear what the teacher said—meaningful learning links new information to relevant concepts in a person's cognitive structure. Cognitive structures include facts, concepts, and generalizations that students have learned and remembered. It can be found in students through the practicum process. Based on the pretest result, there is only one indicator that reached critical thinking skills.

Thus, the researcher examines the relationship between five sub-domain indicators of critical thinking skills with virtual simulations on online physics learning during the current Covid-19 pandemic.

2. Literature Review

2.1. Critical Thinking Skills

Ennis [12] argues that critical thinking is a process to make reasonable decisions about what to believe and do. Another opinion stated by Webster [12] critical is applying or practicing evaluation that is accurate and objective, so it can also be said that critical thinking is a thought that requires precision in making a decision.

Edward Glaser [13] defines critical thinking as 1) An attitude of thinking deeply about problems and things that are within the scope of one's experience; 2) Knowledge of logical examination and reasoning methods; and 3) kinds of skill to apply these methods. Critical thinking is one side of being a critical person where the mind must be open, clear, and based on facts. A thinker has to give reasons for the choice of decisions they make, be open-minded with the different decisions and opinions, and listen to the reasons why others have different opinions or decisions [14].

According to Bonnie and Potts, there are several different abilities related to critical thinking skills [12]. It is finding analogies and relationships between pieces of information, finding relevance and validity of information for the problem formation and solving, finding and evaluating solutions, or problem-solving.

2.2. Virtual Simulation

Virtual practicum means conducting experiments using the help of computers or other electronic devices with available software that is ready to operate [15]. Virtual laboratories can be used to transfer both conceptual and procedural knowledge, especially in triggering the active role of students in developing their critical thinking patterns. Based on research by Gerald W. Meisner, Harol Hoffman, and Mike Turner [16] in the title "Learning Physics in a Virtual Environment: Is There Any? It concluded that students who learn using virtual laboratories are more interactive than in traditional classrooms.

2.3. Virtual Learning

Dabbagh and Ritland [17] indicated that virtual learning is an open and distributed learning system using pedagogical tools (educational aids) through the internet and network-based technology to facilitate the formation of learning and knowledge processes. Meanwhile, according to The Report of the Commission on Technology and Adult Learning [18] in Bonk Curtis J. [19] defines virtual learning as

"instructional content or learning experiences delivered or enabled by electronic technology".

Based on several experts stated above, it can be concluded that virtual learning is an interactive learning process between students and teachers by utilizing information and communication technology in implementing virtual learning supported by technology.

3. Methods

3.1. Sample

This study is quantitative research with descriptive methods. It was conducted in the 2020/2021 school year at high schools in Pati Regency. The participants are 69 students, consisting of 35 students of class XI MIPA 3 as the experimental and 34 students of class XI MIPA 4 as the control class.

3.2. Instrument

There are ten essay questions as the instruments test. They cover five indicators of critical thinking: providing a basic explanation, giving a basis for a decision, making a conclusion, creating further explanations, providing feedback, and integration. For virtual simulation assessments, the writer uses a media assessment questionnaire developed by Kustadi and Sutjipto, a closed questionnaire. Furthermore, the relationship between the test results of critical thinking skills using virtual simulations was assessed using the SPSS 25 program.

4. Result

Data from the test results of students' critical thinking skills are measured and checked using predetermined guidelines. The scores results of descriptive analysis for each aspect of critical thinking skills without using Virtual Simulation can be seen in Table 1.

Table 1 Achievement scores on critical thinking skills

Skill	The use of virtual simulation	Mean	Max.	Min.
Critical Thinking	Apply	73.31	92	50
	Does not apply	59.26	83	35

Based on Table 1, it can be seen that the average value of critical thinking skills of students who use virtual simulations in the virtual learning process is 73.31. In contrast, the average value of 59.62 is found on students who do not use virtual simulations in the virtual learning process. The result shows that the value of critical thinking skills of students who use virtual simulations is higher than students who do not use virtual simulations. Thus, it can be concluded that the critical thinking skills scores of students who use virtual simulations are higher than students who do not use virtual simulations in the virtual learning process during the Covid-19 Pandemic.

Furthermore, an analysis is done to determine whether there are differences in students' critical thinking skills who use virtual simulations and without using virtual simulations. This analysis uses the SPSS 25 program, and the test used is the Independent Sample T-Test. Several conditions must be conducted before carrying out the Independent Sample T-Test; that is, the data must be normally distributed and homogeneous. The normality test was performed using the Kolmogorov-Smirnov test, while the homogeneity test was carried out using the Levene test. The normality and homogeneity test results of this study can be seen in Tables 2 and 3.

Table 2 Normality test results

Kolmogorov-Smirnov			
	Statistic	**df**	**Sig**
Pretest Control MIPA 4	.124	34	.200
Pretest Experiment MIPA 3	.130	34	.158
Postest Control MIPA 4	.118	34	.200
Postest Experiment MIPA 3	.140	34	.054

Table 3 Homogeneity test result

Test of Homogeneity of Variances (Pretest)				
	Levene Statistic	**df1**	**df2**	**Sig**
Based on mean	.017	1	67	.895
Based on median	.046	1	67	.831
Based on median and with adjusting df	.046	1	66.933	.831
Based on trimmed mean	.021	1	67	.886
Test of Homogeneity of Variances (Postest)				
	Levene Statistic	**df1**	**df2**	**Sig**
Based on mean	.213	1	67	.646
Based on median	.305	1	67	.583
Based on median and with adjusting df	.305	1	66.967	.583
Based on trimmed mean	.220	1	67	.640

Based on the data in Table 2, it can be seen that the significance value of the Kolmogorov-Smirnov normality test is ($p > 0.05$) means that it is normally distributed. The homogeneity test in Table 3 shows the results of the significance value ($p > 0.05$) so that the data is homogeneous. After conducting the prerequisites test, then the Independent Sample T-Test is carried out using the SPSS 25 program, the conclusion is drawn by using the Independent Sample T-Test, with the following conditions:

1) Ha: There is a difference in the average critical thinking skills before and after using Virtual Simulation.

2) H0: There is no average difference in critical thinking skills before and after using Virtual Simulation.

The results of the Independent Sample T-Test are shown in Table 4.

Table 4 Independent sample T-Test results for critical thinking skills based on the use of virtual simulation

Independent Sample T-Test

Levene's test for Equality of variances			t-test for Equality of Means		
	F	Sig	t	df	Sig. (2 – tailed)
Equal variances assumed	.213	.646	3.983	67	.000
Equal variances not assumed			3.978	66.082	.000

From Table 4, it can be seen that the effectiveness of using virtual simulations to enhance critical thinking skills at a confidence level of 5% (0.05) obtained a significance value of 0.000, which means that Ha is accepted. It shows that the increase in critical thinking skills after using virtual simulations.

5. Discussion

Critical thinking has become a crucial learning outcome to ensure the quality of students. Critical thinking, identified by Scheffer and Rubenfeld [20], is an important skill that leads to an "expansion of the mind during the use of cognitive skills that support the development of reflection, mental flexibility, and open awareness". All the learning itself is closely related to experience. One of the formations of experiences is through practicum or simulation, and experience is gained no matter how or where the learning occurs [21], especially during the Covid-19 pandemic faced by this world of education where face-to-face learning is limited. Through visuals, one of them is through virtual simulations, and it can be used to challenge students to think at a level that requires higher order thinking skills [22].

Based on the study results, it was concluded that students' critical thinking skills in Physics were different in terms of learning with and without using virtual simulations. Several previous studies are in line with this study. As stated by O'Flaherty, J., & Costabile, M. [23] that based on their research, students who participate in virtual simulations admit that these activities help them think better through self-exploration of problems in simulation experiences and clarify their ideas before submitting a critical assessment of a problem faced and answers to questions from the case studies encountered. Another research result by Chang [24] found that online learning supports and enhances critical thinking.

In detail, this study indicated a difference in the critical thinking skills between students who used virtual simulations and those who did not use virtual simulations in the virtual learning experience. This difference can be seen from the average value obtained by students who used virtual simulations is 73.3, while students who did not use virtual simulations are 59.62. These results showed that the critical thinking skills of students who used virtual simulations are better. Supported by this significance value, this study resulted in 0.000 ($p < 0.05$).

That is proved by a study conducted by Koory [25], which found that some students are more successful when they use virtual materials and simulations. The interview results showed that students were more focused, independent, task-oriented, and interested in solving problems. According to Facione [26], the core elements of critical thinking are interpretation, analysis, evaluation, inference, explanation, and self-regulation. Another study conducted by Saaleh, Tasir & Sukhor [27] suggests that a combination of virtual simulation-based learning can be used as teaching material to build critical thinking skills. In line with this, the research results from Anisa, Permana, and Nova [28] reveal that the use of virtual simulation media in learning Physics can improve students' higher order thinking skills. One of them is critical thinking skills.

As Hawkins [29] stated, virtual simulation serves to help students access information and interact in different ways. Virtual Simulation or Virtual Lab can give students a better understanding, especially at the molecular level, because this media can visualize an experiment that cannot be carried out in a laboratory. Students are expected to learn using the Virtual Lab because students run this media. In addition, Virtual Lab can save time and money, which has been an obstacle for not carrying out practicum activities. A similar opinion comes from Tatli and Ayas [30], which stated that the Virtual Lab is a supporting factor for real laboratories in improving student learning experiences and facilitating students to do practicum interactively, control tools and materials, and collect data. In addition, according to Davenport et al. [31], Virtual Simulation can help create interactive learning activities that can help students understand the difficulties of Science concepts. One of them is the concepts in Physics in senior high school.

6. Conclusion

Virtual simulation affects critical thinking skills in learning Physics. The results revealed that students who used virtual simulations in virtual learning during the Covid-19 pandemic had a higher average score in critical thinking skills. Therefore, this research needs to be informed to teachers who teach in schools. With this information, the author hopes that teachers can plan lessons that can accommodate students' critical thinking skills during the Covid-19 learning period. Teachers must stimulate students' skills, one of which is critical thinking skills because these skills are important in the 21st century.

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