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# Potential of Self-Organised Learning Environment E-Module (SOLE) to Enhance Students' Critical Thinking Skills and Cognitive Learning Outcomes

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**Abstract**

*The objective of this study was to ascertain the impact of critical thinking skills on the learning outcomes of junior high school students, with the Self-Organized Learning Environment (SOLE) learning model serving as the experimental framework. The research methodology employed was quasi-experimental, with a research design of nonequivalent control group design. In this study, the experimental class was Grade 8 A Class, while the control class was Grade 8 C class. The SOLE learning model demonstrated a statistically significant effect on critical thinking skills and learning outcomes, as evidenced by the t-test results with a value of 0.05 < 0.000. The N-gain score for the SOLE learning model revealed that 51.5% of the learning outcomes were less effective, while 56.8% of the critical thinking skills were moderately effective. In contrast, the control class in the Discovery Learning learning model achieved 32.3% in learning outcomes and 38.2% in critical thinking skills, both of which were ineffective. The results of the research indicate that critical thinking skills and junior high school science learning outcomes are significantly influenced by the SOLE learning model.*



## Introduction

One of the fundamental goals of education is to develop critical thinking skills, particularly in the context of the current era of information technology. Critical thinking enables students to analyze information intelligently, make accurate choices, and perform tasks rationally and thoughtfully (Novianti, 2020). A positive correlation was identified between critical thinking and learning outcomes, as reported in several previous studies (Husnah, 2017). In groups of learners with high and medium levels of critical thinking, a relationship between critical thinking and learning outcomes was observed. Learning outcomes encompass the extent to which learners comprehend the learning process, including knowledge acquisition, comprehension, understanding, and mastery of the content (Armenia & Andin, 2023). Science learning affords students the opportunity to engage in critical thinking (Makhrus et al., 2018). This learning environment facilitates the acquisition of declarative knowledge, including concepts, laws, principles, and facts. Furthermore, it enables students to solve problems through creative discussions and enhances their

abilities in critical thinking. Despite the potential benefits of science learning, it continues to yield unsatisfactory outcomes for students. The use of numerous scientific terms and the perceived difficulty of memorization contribute to this outcome (Seftiami et al., 2023). To address these challenges, a learning model that aligns with the characteristics of students is essential.

The Discovery Learning (DL) model conditions students to get used to finding, searching, and discussing the aspects related to teaching. As described by (Adelia & Surya, 2017), discovery learning comprises learning activities designed in such a way to facilitate students to find concepts and principles through their own processes. Furthermore, (Maharani & Bekti, 2017) define DL as a learning process with incomplete delivery of learning material to students. This is because DL requires students to be actively involved in learning to find a concept or principle. Further, the DL model contains a syntax. (Muliyati et al., 2018) describe that DL syntax consists of stimulation, problem identification, data collection, data processing, proof, and generalization. These syntax or stages direct students to have better learningexperiences in order to achieve the desired learning objectives. TIMSS learning questions are designed to test students' higher-order reasoning skills, including critical thinking.

Trends in International Mathematics and Science Survey (TIMSS) is a comprehensive international comparative study of mathematics and science (Supriana & Rahmat, 2022). TIMSS generally seeks to monitor the results of systems related to learning outcomes, particularly in Mathematics and Natural Sciences (Hadi & Novaliyosi, 2019). The questions of TIMSS learning are designed to test students' higher-order reasoning skills, including critical thinking (Martyanti & Suhartini, 2018). The results of TIMSS indicate that Indonesia ranked 44th out of 49 countries with 397 points (Hadi & Novaliyosi, 2019). A number of previous studies also reveal low critical thinking skills among students. For instance, (Govan & Elisabeth, 2020) described reduced ability among students to explain a concept because learners are unable to analyze or ask questions to improve their understanding. In line with the results of observations conducted at State Junior High School 1 Karangploso, Malang, only some teachers utilize the Internet as a source of learning information. Furthermore, science learning activities still follow a one-way learning model, where the teacher only provides knowledge, with a lack of participation from students in every learning activity. Meanwhile, students' learning is reported to improve if they are involved and have direct interaction in every learning process. The selection of the right learning model serves as the attempt to provide learners to hone their critical thinking skills (Azzahra et al., 2023). As the primary objective of education is to facilitate the acquisition of knowledge by learners, the Self-Organized Learning Environment (SOLE) learning model has the potential to enhance the learning experience by creating a more engaging and active learning environment. Furthermore, the use of smart devices enables individuals to engage in independent learning, expanding the scope of those who can benefit from educational opportunities (Rahayu, 2021). The SOLE learning approach facilitates learners to learn in groups, conduct internet searches, and present the learning results in class collectively (Firdaus & Mutmainah, 2022). This learning model comprises three stages for students (Koesnandar, 2020). Meanwhile, the instructor or teacher only conducts an introduction in the form of suggestions questions related to the material discussed, and students are asked to respond to these questions (Marlina, 2021). SOLE is a learning technique that can be applied to encourage students' technological independence in learning (Firdaus et al., 2021).

With the recent rapidly progressing technology advancement, everyone involved in the education sector must be able to keep up with the latest developments in technological advances. Accordingly, the field of education must implement positive innovations to improve the progress of schools and education (Maritsa et al., 2021). Therefore, the education field is becoming increasingly dependent on information and communication technology connected to the Internet (Hakim et al., 2021). An active, creative, and interactive learning model is highly beneficial in the modern era. One suitable learning model is the SOLE model, which aims to assess the impact of critical thinking skills on junior high school science learning outcomes. The application of the SOLE model is expected to enhance the learning process and outcomes. The material taught by the instructor is expected to engage students and facilitate even more effective learning through the application of the SOLE learning model. As indicated by the studies from Handayani et al. (2023) and Amit et al. (2022) have demonstrated that the SOLE model can positively impact learning outcomes and critical thinking skills in students. Building upon this evidence, researchers are interested in exploring the potential of SOLE-based e-modules to enhance critical thinking abilities and cognitive learning outcomes.

## Methods

This research employed quasi-experimental with a nonequivalent control group design. The students of State Junior High School 10 Malang, Indonesia, were involved as the research participants, with

one experimental and one control class. The sample taken for this study was 2 classes with a total of 64 students, namely the experimental class 8A and the control class 8C using the purposive sampling technique. A pre-test was conducted to determine the initial situation, and then the experimental class was treated with SOLE-based e-modules, while the control class completed the learning using textbooks as usual. After the treatment, both groups underwent a post-test.

**Table 1. Nonequivalent control group design**

| Sample | Pre-test | Treatment | Post-test |
|---|---|---|---|
| Experiment group | $O_1$ | $X_1$ | $O_2$ |
| Control group | $O_3$ | $X_2$ | $O_4$ |

Source: Sugiyono (2017)

Description:
X1 = Experimental class treatment
X2 = Treatment for control class
O1 = Pre-test of experimental class
O3 = Pre-test of control class
O2 = Post-test of experimental class
O4 = Post-test of control class

Data was garnered using a test technique. The instrument for measuring critical thinking skills contained 10 descriptive questions formulated according to Robert Ennis' critical thinking indicators (1995) and indicators of students' cognitive abilities from Bloom's revised taxonomy. The indicators of cognitive ability encompassed remembering, understanding, applying, analyzing, evaluating, and creating. Data analysis was carried out with normality, homogeneity, and test tests using the SPSS v.26 application.

**Table 2. Critical Thinking Rubric**

| Stages | Critical Thinking Skills | Indicators |
|---|---|---|
| 1 | *Elementary clarification* | 1. Utilizing questions<br>2. Analyzing arguments<br>3. Asking and answering classification questions |
| 2 | Building Basic Skills | 4. Consider whether the source can be trusted or not<br>5. Observing and considering the results of observations |
| 3 | *Inferencing* | 6. Making deductions and considering the results of deductions<br>7. Making induction and considering the results of induction<br>8. Making and considering value decisions |
| 4 | *Advanced Clarification* | 9. Define terms and consider definitions<br>10. Identifying assumptions |
| 5 | *Strategies and Tactics* | 11. Determine the course of action<br>12. Interact with others |

Source: Modified from Finken and Ennis (1993)

## Results and Discussion

In the normality and homogeneity test, the obtained data from the SOLE learning model class and DL learning model class have a normal distribution with homogeneous variants. Following these results, a t-test was performed; while the test results are presented in Table 3.

**Table 3. Results of T-Test on Critical Thinking Skills.**

| Critical Thinking | Sig.(2-tailed) | a | Conclusion |
|---|---|---|---|
| *Pre-Test* Experiment – *Pre-Test* Control | .000 | 0.05 | H0 is rejected |
| *Post-Test* Experiment – *Post-Test* Control | .000 | 0.05 | H0 is rejected |

The data in Table 3. signify the Sig value. (2-tailed) value of 0.000 <0.05, thereby, the H0 is rejected. Therefore, there is an effect of the SOLE learning model on students' critical thinking skills.

As illustrated in Figure 1, the experimental class gained a higher level of critical thinking skills than the control class. The highest score has been identified in the critical thinking skills indicator of giving a simple explanation with a percentage of 88% (very good). This result indicates that students understand

the problem based on the results of their answers. Further, this high score appears because students are trained to identify problems when responding to questions from the teacher. Additionally, SOLE learning activities also help students develop a habit of progressively learning critical thinking by creating problems and providing explanations for the questions (Salbiah, 2017). For the control class, the highest score is attained in the indicator of strategy and tactics, reaching a percentage of 77% (good). This finding implies that students have the ability to recognize and obtain the required information to draw conclusions.

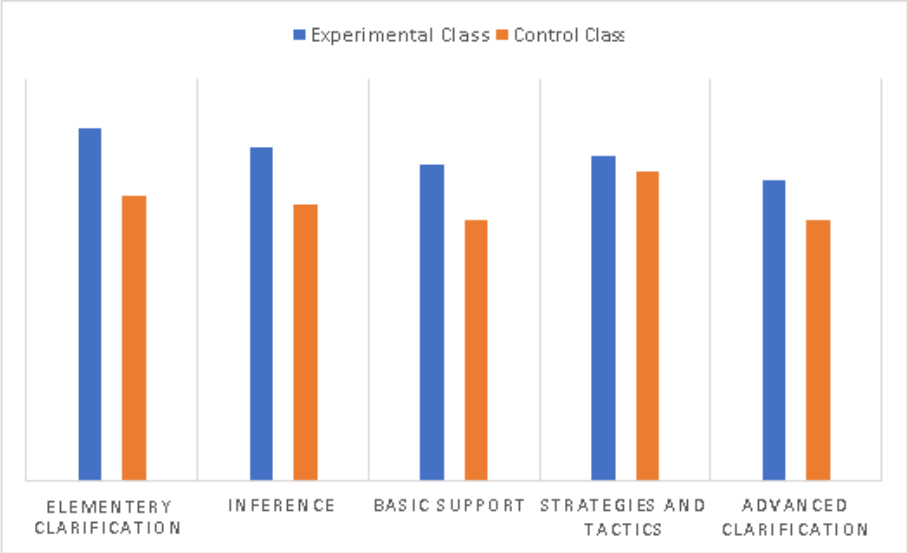


**Figure 1. Comparison of Critical Thinking Skills Indicators**

**Table 4. Results of T-test on Students' Learning Outcomes**

| Learning Outcomes | Sig.(2-tailed) | a | Conclusion |
|---|---|---|---|
| *Pre-Test* Experiment – *Pre-Test* Control | .000 | 0.05 | H0 is rejected |
| *Post-Test* Experiment – *Post-Test* Control | .000 | 0.05 | H0 is rejected |

In addition, a significance value of 0.000 <0.05 has been obtained for the learning outcomes variable, thereby, the H0 is rejected. This finding indicates that the SOLE learning model affects student learning outcomes.

**Table 5. Criteria for N-Gain Effectiveness**

| Percentage (%) | Interpretation |
|---|---|
| <40 | Not effective |
| 40-55 | Less effective |
| 56-75 | Relatively effective |
| >76 | Effective |

**Source: (Supriadi, 2021)**

The calculation of the gain score ensures the level of effectiveness of the SOLE learning model with DL on the student's critical thinking skills and learning outcomes (Supriyadi, 2021).

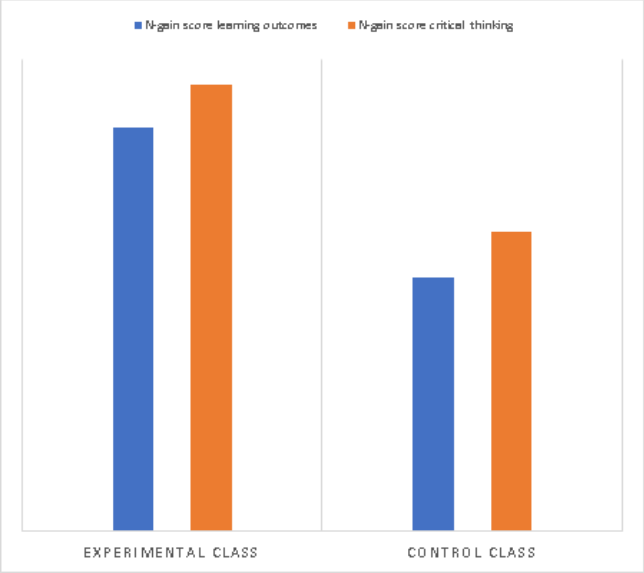


Figure 2 illustrates that the effectiveness of the implementation of the SOLE learning model on learning outcomes is in the less effective criteria with a percentage of 51.5%. In the DL learning model, the effectiveness of learning outcomes includes less effective criteria with a percentage of 32.3%. For the results of the critical thinking skills gain score, it is known that the effectiveness of the implementation of the SOLE learning model includes moderately effective criteria with a percentage of 56.8%. The DL learning model, however, is less effective in the criteria of less effective, with a percentage of 32.3%.

To identify the correlation between critical thinking skills and learning outcomes, a regression test was conducted. The results of this test are shown in Table 6.

**Table 6. Results of Regression Test**

| R | *R Square* | *Adjusted R Square* | *Std. Error of the Estimate* |
|---|---|---|---|
| .716a | .513 | .497 | 2.808 |

Table 6 suggests the obtained correlation value (R) of 0.761 which is in the strong criteria. Following these results, the correlation between learning outcomes and critical thinking skills is 51%. The progression of students' critical thinking skills in the experimental class is observed to be higher than those in the control class. This is evidenced by the obtained 56.8% average value of N-gain in the experimental class, which is included in the moderately effective category. Meanwhile, the control class obtained a 32.3% average N-gain value, categorized as less effective. Further, the investigation on the SOLE syntax application also suggests increasing students' critical thinking skills. Essentially, this learning model is designed to provide opportunities for students to conduct learning through discussion, develop critical thinking skills, and improve problem-solving skills. In comparison, the control class attended learning using a lecture from the teacher and working on problems contained in the student book. This is in line with the results of research conducted by (Ana, 2019), reporting an increase in critical thinking skills through the Self-Organized Learning Environments (SOLE) learning model as indicated by higher completion of student tasks during learning activities which are reviewed from several aspects, including aspects of response preparation, higher order thinking skills, processes and results, and depth of material. Besides, the SOLE learning model enables students to construct knowledge and investigation through group discussions, as well as learning the learning resources, which in turn aids students in enhancing their conceptual mastery and scientific reasoning skills with independent learning as they discover the knowledge by themselves.

In the experimental class, the critical thinking skills indicator of giving simple explanations received the highest average score of 88%, categorized as very good. The attainment of this high score is attributed to the learning activities that train students to identify a problem before solving it. Further, in this learning, students are directly involved in the learning process. Therefore, they learn to think critically gradually through trained habits such as formulating problems and answering questions that require explanation (Salbiah, 2017). For the control class, the highest score has been attained in the indicator of strategy and tactics, reaching a percentage of 77% in good criteria. This finding implies that students can identify and obtain the required elements for drawing a conclusion. The students attending the learning with the SOLE learning model secure a greater level of critical thinking skills than those in the DL learning model due to differences in the learning stages applied.

In SOLE learning activities, the teacher presents a question to challenge students' critical thinking skills by asking them to solve it. Therefore, learners tend to feel challenged to solve the questions given by the teacher. Whereas in DL learning activities, learners are encouraged to find problems and solve them themselves. Therefore, students tend to be less interested in finding problems and solving them themselves. A study by (Niode et al., 2022) revealed that the use of the SOLE learning model improves students' critical thinking skills.

Furthermore, the results of the research and data analysis conducted indicated that there was an increase in learning outcomes from the initial conditions and after the action was taken. The N-Gain value of learning outcomes for the SOLE learning model, which is included in the less effective category, and the DL learning model, which is included in the ineffective category, were also evaluated. From the learning outcomes, the SOLE learning model is less effective than the DL learning model. This is due to several factors, including a lack of understanding of the questions posed by some students, which results in low learning outcomes. Additionally, in the DL learning model, many students are hesitant to discuss with their group members, relying on one individual to complete all their group assignments. It appears that students remain reticent to present their work in class, which impedes the optimal conveyance of information related to the results of their work (Grasela et al., 2016). Additionally, some learners were less active because other learners with faster comprehension left them behind. Consequently, some of the less active learners only copied answers from examples of problems that had been provided by other learners. The application of varied learning affects students' material understanding, thereby, resulting in different learning outcomes among students attending the learning with SOLE and DL learning models.

The results of the regression analysis test indicate a 0.761 score on the relationship between critical thinking skills and learning outcomes, which is categorized as a strong correlation. Further results suggest a 51% contribution of critical thinking skills to learning outcomes. Therefore, higher critical thinking skills indicate an increase in learning outcomes. The relationship between critical thinking skills and learning outcomes emerges due to the suitability of the SOLE model, which emphasizes the process of self-learning, thereby facilitating improvement in both students' critical thinking skills and learning outcomes. (Saparuddin et al., 2021) described that cognitive learning outcomes and critical thinking skills are insparable since they both rely on students' thinking ability to solve problems.

In the SOLE learning model, students perceive learning as enjoyable, enabling them to explore new knowledge through their personal devices in a relaxed manner and engage in casual discussions with their peers in class. However, the limitations of this study necessitate more efficient time management to ensure timely completion of learning and optimal outcomes from the SOLE learning model. The application of the DL learning model is less effective for critical thinking and learning outcomes due to the continued reliance on individual learning and a lack of full learner-centeredness. One of the shortcomings of the DL learning model is that it relies heavily on textbooks, which are often perceived as a source of boredom. This is because textbooks are not an effective tool for students to collect data and fulfill their curiosity about learning (Simu, 2019).

## Conclusions and Recommendations

The results of the study indicate that the application of SOLE e-modules affects the critical thinking skills and cognitive learning outcomes of students. This is evidenced by the results of the t-test, which reject the null hypothesis H0. Meanwhile, the student's critical thinking skill indicator, namely the ability to provide simple explanations, obtained an excellent category in the experimental class, while in the control class, the indicator of strategies and tactics obtained an excellent category. Consequently, the findings of this study offer insights into the potential of SOLE e-modules to enhance students' knowledge of basic skills and cognitive learning outcomes. Further research is expected to provide more efficient time management to ensure timely completion of learning and optimal learning outcomes from the SOLE learning model.

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