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# The implementation of Discovery-Based Multiple Representations Learning (DMRL) to enhance student's critical thinking skills

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**Abstract**

The objective of this study is to analyse the effectiveness of DMRL model's in enhancing students' critical thinking skills (CTS) on environmental change topics. Futhermore, we use a one-group pretest-posttest research design to examine this effect. There were sixty students in 7th-grade selected using the randomised sampling technique at MTs 2 Sleman as the sample. The instrumen consist of 14 questions of the essay test to obtain the student ability Students score then analysed using Analysis of Variance (ANOVA). This study showed that implementing the DMRL model on environmental change material had significant effects on enhancing students' CTS. An enhancement in students' CTS is indicated by an average normalised gain score of 0.35 or in the middle category. Students have the most significant increases in aspect reasoning and analysing while in gender comparison, the female students have more significant improvement than male students with gain of .38 > .28. For further research, the aspect needed to be improved is the clarity assumption. The student still has difficulties even after treatment with gain categories low. However, the DMRL could be optimazed students' CTS on environmental change material as an alternative learning model.



## Introduction

The educational paradigm of the twenty-first century has implications for modifications to the educational process and a focus on improving thinking skills. (Ledward & Hirata, 2011). This problem needs to be solved in developing and enabling students to compete in a globalised world. Students are required to identify problems, think critically, creatively, and cooperatively in order to solve them (Greenstein, 2012; Zakwandi, & Istiyono, 2022). Hence, it is possible to design the scince learning to practice these complex skills that also can help student to mastering the basic competences of longlife learning

Critical thinking skill (CTS) important for students as part of 21st century skils (Forum, 2018). As a basic competences, CTS can help student to master another competences such as decomposing stuctures, problems-solving, and curriosity (Mahmudah, 2014). CTS has an impact on how students' conceptual systems form. Learning by prioritising CTS can support students in gaining understanding, long-lasting memory, and working on problem-solving-based problems (Hung et al., 2008). Hence, CTS is necessary to empower students acitivity in learning process.

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However, science education continues to emphasize conceptual knowledge. It disregards additional factors like procedural expertise and sophisticated reasoning as applied to the scientific method process. This finding was confirmed by Silberman (1996), who stated that learning science is more addresed in master the conceptual understanding. Besides, the teacher was not paying the same attention to the another aspect of nature science, the scientific method process. This is unfortunate, because learning based on scientific methods can practice CTS students because students will have good literacy and be able to solve problems more effectively. Hence, it can affect the success of student learning outcomes (Roser et al., 2013). Due to the lack of emphasis on the scientific method and from the 2018 PISA results, Indonesia has low literacy, math, and science performance skills (OECD, 2019). Even from the National Science Examination results for the 2019 academic year at the National level, the junior high school level of Yogyakarta Special Region Province is still relatively low, with an average of 56.57. For the provincial level, the junior high school level in Sleman Regency reaches a CTS average value of 59.31, which is also classified as low. In addition, At the Islamic Junior High School in Sleman, 118 students received the preliminary test results. The mean CTS after completing the description questions was 37.89, in low category.

In numerous State MTs in the Sleman district, a preliminary study was conducted between September 2019 and February 2020. In order to ascertain the science learning process and students' utilization of common models and approaches, questionnaires were given to 14 science teachers. A science instructor at MTs 2 Sleman claims that multiple representations were not given attention in order to offer educational activities. This has an effect on students' inability to interpret and comprehend scientific ideas, for instance in teaching materials about environmental change. Delivering stimuli at the start of learning allowed for the creation of multiple representations that did not present data in various form with unusual contexts. When answering exercises' questions, students frequently use formulae and computations to express themselves mathematically. The instructor had not assisted pupils in maximizing new literacy skills during the data gathering phase (digital literacy, improving reading, analysing and using information) (Sujiva et al., 2020). In addition, the teacher had not practiced students to anlyse data and give conceptual feedback in that caused incompetences in interpreting the results i.e. mathematical model on a diagrams or graphs. Therefore, the learning process need to be changed from teacher-centered to students-centerd by use the capalble model that can practice of student CTS with multiple respresentation. According to the previos research, the DMRL model can be practiced student CTS with the multiple representation context (Chusni et al., 2020).

Through a series of exercises, such as introduction, simulation-based multiple representations embodies hands-on and minds-on syntax. Hence, this study aimed to establish the DMRL model 'effects' in enhancing students' CTS on environmental change materials. The DMRL model has advantages, especially in terms of creating a suitable learning environment for practicing CTS. Various stimuli are expected to facilitate students to analyze problems, plan solutions, and make generalizations of solutions. By using the DMRL model, the provision of CTS in science learning will be more optimal.

## Literature Review

Discovery learning model (DLM) focuses on active learning and give an opportunities to act when a person is involved in using his mental processes to uncover some concepts, scientific principles in science (Kun, 2013). Discovery learning embraces the learning principle that students are encouraged to identify what they want, seek information, organise knowledge, and understand teaching material independently. Learning with the discovery approach, also known as constructivist, is where students develop high-level skills to build a deep understanding of the main concepts by applying several stages in learning activities, namely the stimulation, problem statement, data collection, data processing, verification, and generalisation stages (Arends, 2012).

Science learning is also dominant in mathematics, visual, and symbolic representations, while understanding concepts is less of a concern. This difficulty can occur due to the abstract characteristics of science learning materials. It also requires the ability to master and manage changes between different representations. Therefore, we need a way to improve the ability of students to master science concepts by using various science languages in learning, for example, verbal (spoken and written), visual (pictures, graphics, encouragement), symbols, equations, body movements, and role-playing. Various science languages will enable students to learn science through developing mental abilities to think well, called multiple representations. Multiple representations are defined as presenting a concept or process on the same object in several different formats (Angell et al., 2007; Kohl et al., 2007; Waldrip et al., 2006).

The combination of the two learning models, the discovery model and the multiple representation model, resulted in the Discovery-based Multiple Representation Learning (DMRL) model. The discovery-based DMRL model is stimulated from multiple representation data/data representation dissertation problems and requires an active role from students to carry out scientific exploration through literature studies or experiments (Chu et al., 2017; Raamkumar et al., 2017). DMR is a constructivist, authentic, problem-solving, and contextual (hands-on and mind-on) model.

The DMRL model is predicted to optimise students' CTS because of the relationship between the model syntax and the CTS indicators. Students are trained to think critically, analyse, and be able to evaluate problems and find solutions. Student knowledge is built from both direct and indirect student-centred experiences. The orientation stage in the DMRL model syntax aims to practice critical thinking skills on aspects of interpretation and self-regulation. The stimulation based multiple representations stage trains aspects of clarity assumption, interpretation, and analysis. The identification and problem statement stage practices aspects of analysis, inference, and evaluation. The exploration stage practices the evaluation and self-regulation aspects. The data literacy stage trains clarity assumption, interpretation, analysis, and reason. The present and verification stage trains the clarity assumption and reason aspects, and the evaluation stage trains the inference, evaluation, and self-regulation aspects.

## Methodology

This study utilised a pre-experimental method with one group pretest-posttest design type where there was no control group as a comparison.

### *Samples*

The 7th-grade students at MTs 2 Sleman were the research population. They were selected randomly to obtain 60 students as a sample of this study.

### *Data Collection*

Data were collected from 14 essay questions to measure student critical thinking skills (CTS). CTS indicator modified from Facione (1990), Ennis (2011), and Watson and Glesser (1980) that provide seven indicators as synthesis, (Clarity assumption (C1), Interpretation (C2), Analysis (C3), Inference (C4), Evaluation (C5), Reason (C6), and Self-regulation (C7)). Each indicator has two questions that provide for the student using an online platform.

### *Data Analysis*

The test was scored, and the means and standard deviations for each question were computed. By comparing the average scores and standard deviations ideals, the score was then translated into some groups, as shown in Table 1 (Permatasari et al., 2019).

Then, we estimate the improvement of student's CTS by using N-Gain (Hake, 1998), and hypothesis testing was conducted using paired sample *t*-test.

## Results

### *'Students' CTS*

The summary of student CTS score is provided in Table 2.

According to Table 2, improvement of student ability for each indicator of CTS is at low throught medium levels. Generally, student CTS has increased of .35 of medium level. The details numbering students in each category of CTS improvement and the category (high, middle, and low) are shown in Table 3.

**Table 1** Category of Students CTS

| Score | Category |
|---|---|
| $X > Mean + SD_i$ | High |
| $Mean - SD_i < X \leq Mean + SD_i$ | Middle |
| $X \leq Mean - SD_i$ | Low |

**Table 2** Student Summary Score

| Score | Indicators | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | |
| Pre-Test | 45 | 28.33 | 33.75 | 32.5 | 40 | 42.08 | 46.67 | 38.33 |
| Post Test | 50.83 | 48.75 | 60 | 58.33 | 62.08 | 67.5 | 63.75 | 58.75 |
| N-Gain | 0.11 | 0.28 | 0.4 | 0.38 | 0.37 | 0.44 | 0.32 | 0.35 |
| Category | Low | Low | Middle | Middle | Middle | Middle | Middle | Middle |

**Table 3** The Summary of Student CTS

| CategoriyS | *N* | | Score of 100 | | <g> |
|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | |
| High | 10 students | 7 students | 16.67 of 100 | 11.67 of 100 | 1.67 |
| Middle | 42 students | 44 students | 70.00 of 100 | 73.33 of 100 | 58.33 |
| Low | 8 students | 9 students | 13.33 of 100 | 15.00 of 100 | 40.00 |

Table 3 shows that while students in the medium and low categories increased but not in high category. These results fall into the correct category, where the post-test mean and standard deviation were 58.75 and 17.27, respectively. It increased from the pre-test level (38.33 and 10.66). Additionally, Figure 1's breakdown of the students by gender demonstrates that female students improved more than male students.

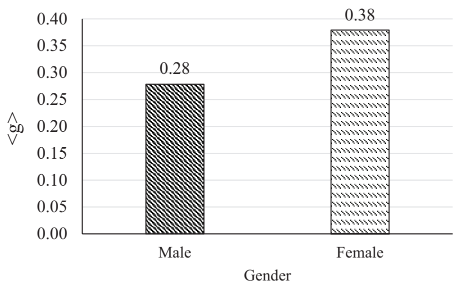


**Figure 1** <g> based gender

### *The Effectiveness of the DMRL Model*

Hypothesis testing was used to evaluate the effectiveness of DMRL model by determined how the treatments affected CTS improvement. Hence, it is necessary the prerequisite analysis as present in Table 4.

Table 4 show that the post-test score is higher than the pre-test that also in St.Dev wnd Std. Error. This leads to the conclusion that the post-test distribution data or range of values are more diverse than those from the pre-test. This increases the likelihood of calculation errors when using post-test data. The error value for pre-test and prost teast is still in the accepted range where of 1.38 for pre-test and 2.23 for post-test.

The significance and sample correlation values were.792 and.00, respectively. Hence, there is no correlation for these groups statistically by sig. value of .792 >.05. Now, we can use *t* score to examine the hypothesis testing where if $t_{count} > t_{table}$ or if $t_{count} < -t_{table}$, then the treatment has a significant effect on the results. Hence, by the score of sig. of .00 < .05, it indicates that there is a significant difference of score in the tested groups. Consequently, the treatments significantly impact student CTS.

## Discussion

### *Enhancing of Students' CTS*

The increase in students' CTS on the overall environmental change material is listed in Table 3. According to these results, the DMRL modeel can increase students' CTS effectively. This finding is confirm a findings by Ningsih et al. (2012) and Vong and Kaewurai (2017), which stated that the guided discovery-oriented learning model and another instructional model development can improve students' CTS.

The N-gain value of the reason aspect, at.44, is the highest of the seven CTS-used aspects (in the medium category). This was due to the fact that students were taught to provide arguments for explanations based on experiments and discovered concepts. Rahmawati (2014) Added that students learn to study and solve problems based on ideas developed from the outcomes of experimental group activities when they use discovery-based learning. Additionally, during learning activities, students are always required to rebuild knowledge and information in order to solve an issue, as well as to broaden their understanding by consulting more sources. In contrast, the clarity assumption aspect's N-gain value is the lowest, at .11 (in the low category). Students who did not do well in identifying assumptions related to the subject matter had an impact on the low category. After all, by exchanging ideas in groups to solve challenging problems, students can more effectively build and connect their knowledge (Ningsih et al., 2012).

**Table 4** Hypothetical testing

| | Mean | KS *p* | *p* Paired Correlation | Correlation Coefficient | *t* | *p* (2-tailed) |
|---|---|---|---|---|---|---|
| Pre | 38.33 | .051 | .792 | .000 | 14.43 | .000 |
| Post | 58.75 | .090 | | | | |

Table 3 also show the increases of students CTS in numbers. Since students and teachers are still restricted in how they can use the DMRL model, such as at the orientation stage it seems that most of the growth is for the middle category, at 58.33 percent, and the low category, at 40.00 percent, was due to this. The majority of students are less adept at pinpointing presumptions pertaining to environmental changes. This rating reflects how poorly students connected ideas together in their thinking. Before learning begins, the prerequisite material should be briefly explained by the teacher for maximum effect. Despite the fact that this material was covered in elementary school, the majority of students frequently forget or don't understand it. Moog & Spencer (2008) declare that teacher design the learning by introduce student by transmission of facts or data and be directed by questions to reach a temporary conclusion.

The distribution of students' abilities according to gender classification is another piece of data that can be analyzed. Male students are either at the bottom or have a lower effective CTS score than men, while female students are disproportionately at the top. The results of this study support those by Ricketts and Rudd (2004), which demonstrate that female students place a higher value on critical analysis thinking skills than do male students. According to a different study, female students were superior to male students at drawing conclusions. That means that female students more effectively recognised the aspects needed to build a conclusion or form hypotheses. This finding can be explained in that female students have brain regions related to language function that can operate more optimally, which results female student having higher language skills than boys. Female students have more ability in conveying their opinions to others. Male students generally perform better on visual-mathematical while females students on verbal skills (Guiller et al., 2005; Jatunam et al., 2021). Previous studies also found that male students can manipulate visual images and numerical test. In contrast, females students has a good score in verbal ability tests ( Halpern & LaMay, 2000; Wilder & Powell, 1989).

### *The Effectiveness of the DMRL Model*

The outcomes of hypothesis testing show how well the DMRL model works to raise students' CTS. The value obtained was $t_{count}$ = 14.43 with a significance level of.05, and the value for the table was $t_{table}$ = 2.000 based on the calculation of the hypothesis test using the paired sample t-test.This indicated the value $t_{count} > t_{table}$, 14.43 > 2.000. Thus, the initial hypothesis ($H_0$) is rejected. It can be concluded that there is a significant influence on the application of the DMRL model in improving students' CTS on environmental change material.

The DMRL model helps students find their knowledge more as well as improve thinking skills through asking and communicating knowledge. The use of the DMRL model is related to one of the learning theories, namely, the theory of constructivism. According to the constructivism theory, learning is an active activity where students build their knowledge and seek meaning from something they learn. Based on constructivism, learning is a problem-solving process (Karli & Margaretha, 2002). Students in solving a problem must identify and make hypotheses that are then tested through observations that caused the CTS of students while learning using the DMRL model to increase.

## Conclusion and Recommendation

We have successfully investigated how the DMRL model can improve students' CTS. With the rise in the moderate category, the DMRL model's application has a sizable impact on students' CTS. Therefore, before using the DMRL model, students are advised to read and summarize the topics in order to improve CTS. Because the goals are closely related to the conclusion, the teacher should give students clear instructions about the activities and remind them of the initial learning objectives.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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