Improving Middle School Students’ Critical Thinking Skills Through Reading Infusion-Loaded Discovery Learning Model in the Science Instruction

Nuryakin¹² and Riandi²

¹ SMP N 4 Pancatengah, Jl. Cayur Km 12, Neglasari, Pancatengah, Tasikmalaya 46194, Indonesia
² Science Education, Postgraduate Student, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
Email: nuryakin@student.upi.edu

Abstract. A study has been conducted to obtain a depiction of middle school students’ critical thinking skills improvement through the implementation of reading infusion-loaded discovery learning model in science instruction. A quasi-experimental study with the pretest-posttest control group design was used to engage 55 eighth-year middle school students in Tasikmalaya, which was divided into the experimental and control group respectively were 28 and 27 students. Critical thinking skills were measured using a critical thinking skills test in multiple-choice with reason format questions that administered before and after a given instruction. The test was 28 items encompassing three essential concepts, vibration, waves and auditory senses. The critical thinking skills improvement was determined by using the normalized gain score and statistically analyzed by using Mann-Whitney U test. The findings showed that the average of students’ critical thinking skills normalized gain score of both groups were 59 and 43, respectively for experimental and control group in the medium category. There were significant differences between both group’s improvement. Thus, the implementation of reading infusion-loaded discovery learning model could further improve middle school students’ critical thinking skills than conventional learning.

1. Introduction

The developed curriculum in the 21st century learning has been shifted from a trend of merely mastering concept to the higher level [1]. Science instruction in the School-Based Curriculum (known as Kurikulum Tingkat Satuan Pendidikan) should be performed using scientific inquiry to foster thinking skill, process skill and scientific attitude as well as to communicate an important aspect of life skills [2]. Life skills are necessary to address the risen problems of life, such as globalization, the changing of industry demand and work field, rapidly growing innovation and the trend of using technology and information. One of the life skills required to overcome these challenges is thinking skills. A minimum thinking skill that should be developed to face the globalization and progress in science and technology in the 21st century, according to Costa [3] is the critical thinking skills [4-5].

Critical thinking skills are included in the complex thinking process. Complex thinking is a high-order thinking process which consists of critical thinking, creative thinking, problem solving and decision making [3,6]. Critical thinking skills is one of the essential skills that affect the academic and professional students’ success in the future [7]. Based on research in various fields such as social-science said that students who graduate from schools in various countries do not have the ability to
compete on a global scale because they do not have the ability to think critically [8]. Thus, the critical thinking skills necessary to be developed at the school level (namely in middle school) as a provision in preparing for student life in the future, particularly on the Natural Sciences subject.

Science learning process that foster thinking skills, process skills and communicating them as an important aspect of life skills can be accomplished through the investigation (discovery / inquiry learning) [9]. Discovery/inquiry learning is a learning process that involves the students perform various activities such as observing, asking questions, seeking referrals from a variety of sources, planning investigations, conducting experiments, analyzing and interpreting the data, answering, explaining and estimating, and communicating results (NRC, 2000 in Ref. [2]). Discovery learning is a student-centered learning which activates students to seek and find a knowledge of natural phenomena that occur around them [10]. Learning by discovery prioritize the activity of reflecting, thinking, experimenting and exploring [11]. In discovery learning, students perform mental operations such as measurement, prediction, observation, inference and groupings [6]. A mental operation involving those intellectual skills can develop students’ skills in constructing knowledge and enable them to recognize well their environment with the existing concept or knowledge they learned. However, discovery learning does not entirely provide a positive impact on student achievement [12]. Discovery learning that is only used without providing guidance or assistance do not provide meaningful benefit to their students [13]. Therefore, we need a strategy that supports discovery learning in order to improve student achievement such as critical thinking skills. One strategy used is through reading infusion.

Reading infusion is a reading that is integrated with discovery learning. Through reading infusion students can build scientific knowledge widely because students are provideda learning opportunity to obtain scientific knowledge from various sources as well as from various media information related to the subject matter [14]. Students can also build an argument to clarify an investigation result with the information obtained from reading material [14-15]. In line with these opinions, Muttaqin& Sopandi [1] states that there is a strong relationship between reading with critical thinking skills. In reading process, there should be tactics and strategies to understand literature well [14, 16-17]. A strategy that combines reading and writing during the phase-before-during and after reading [16] is the SQ3R method (Survey, Question, Read, Recite and Review). This reading method can be incorporated with discovery learning on verification phase. At this stage, the students perform reading activities after collecting data through experiments and analyzing the experimental data.

Based on the above rationale, this study was conducted to obtain information about middle school students’ critical thinking skills improvement as an effect of the implementation of reading infusion-loaded discovery learning model in science instruction. The learning object in this study is the concept of vibration, waves and auditory senses. Through this study we may provide useful information about an appropriate learning model in teaching science as an effort to improve student learning outcomes, particularly the critical thinking skills.

2. Research methodology
This study used a quasi-experimental method with the pretest-posttest control group design [18]. Fifty five of eighth-year students in the academic year 2015/2016 at Tasikmalaya regency was involved in this study. They were divided into the experimental group (28 students) who had reading infusion-loaded discovery learning model and control group (27 students) who had conventional learning.

The learning phases of reading infusion-loaded discovery learning model includes the following phases: (1) stimulation, (2) problem statement; (3) data collection; (4) data processing; (5) verification; and (6) generalization. Reading infusion with SQ3R reading technique (survey, question, read, recite and review) performed at the verification phase. Conventional learning is a learning process that applies a verification lab-based direct learning model. Laboratory activities based on the laboratory guide books used in the school.

Students’ critical thinking skills are measured using a critical thinking skills test in multiple-choice with reason format questions. The test was 28 items encompassing three essential concepts, vibration, vibration,
waves and auditory senses, which was preceded by construct and statistical validity. Scoring rubric for the critical thinking skills test was adapted from Stiggins [19] with the minimum and maximum score range from 0 to 4. The critical thinking test refers to the five indicators of critical thinking skills proposed by Ennis [3,6]. Critical Thinking Skills (CTS) measured in this study include indicators skills (sub-indicator): (1) elementary clarification (focusing questions, analyzing arguments, asking and answering questions about an explanation or challenge); (2) basic support (considering a source’s credibility); (3) advance clarification (defining the term and considering the definitions); (4) inference (making and considering induction, making and considering deduction, and making decisions and considering the results), and (5) strategy and tactics (deciding an action). The critical thinking skills improvement was measured by using students’ pretest and posttest score that analyzed using normalized gain score formula proposed by Hake [20].

3. Results and discussion

Critical thinking skills test was administered before and after the given instruction in both groups. Recapitulation of the average pre-test, post-test and n-gain score for experimental and control groups are presented in Figure 1.

Figure 1 shows that there is no significant difference on the average of initial critical thinking skills between both groups. The average score of the two groups before the instruction differs only one point, while after instruction differ 11 points. It means that both groups have similar initial critical thinking skill before instruction and there are different changes in critical thinking skills of both groups after instruction. Both groups show medium improvement with the average n-gain score differ 0.11 points, in which n-gain score of the experimental group (59) is higher than n-gain score of the control group (43).

An analysis of the improvement in each critical thinking skills indicators shows that the highest average pre-score for the experimental and control group are respectively 54 and 46 with a difference of 8 points, on the similar advance clarification indicator. While the lowest average prescore is 34 for the experimental group on inference indicator and 35 for the control group on elementary clarification indicator. The highest average post-score is 85 for the experimental group on advance clarification indicator and 73 for the control group on basic support indicator. While the lowest average post-score for experimental and control group are respectively 72 and 58 on the similar inference indicator for both. The highest average n-gain score for the experimental and control groups are respectively 62 on strategy and tactics indicator and 53 on the basic support indicator. Both groups demonstrate a medium improvement. Comparison of the average n-gain score for each critical thinking skills indicators are presented in Figure 2.
Figure 2 shows that the average improvement of each critical thinking skills indicators in the experimental group sequentially from highest to lowest is strategies and tactics, advance clarification, basic support, inferences, and elementary clarification. As for the control groups is basic support, advance clarification, elementary clarification, strategies and tactics, and inference. Overall, the experimental group improvement is higher than the control group.

The difference in critical thinking skill improvement between two groups was analyzed using the mean difference test, which preceded by the normality and homogeneity test. Mean difference test of the students’ prescore showed that there was no significance difference in the initial critical thinking skills between the experimental and control groups (sig = 0.446 > {\alpha} = 0.05). While after instruction, there was a significantly different in their critical thinking skills between the experimental and control group (Z_{count} = -4.767; sig = 0.000 < {\alpha} = 0.05). The average n-gain score of students’ critical thinking skills addressed the significant differences between experimental and control group (Z_{count} = -5.137; sig = 0.000 < {\alpha} = 0.05). These mean that the implementation of reading infusion-loaded discovery learning model could further improve students’ critical thinking skills than the conventional learning.

| Critical Thinking Skills (CTS) Indicators |
|-----------------------------------------|
| Exp. | Ctrl. |
| CT1=elementary clarification; CT2=bas... |

A higher improvement in the experimental group than control group can be explained by the learning process that provides the opportunity for students to activate critical thinking skills during instruction. It also provides facilities for students to practice their critical thinking skills. Various studies previously mentioned that the discovery learning model can improve student’s performance in learning [11, 21-26]. Discovery learning is a process of inquiry-based learning that will practice students’ thinking skills gradually, moving from the basic thinking skills towards the higher-order thinking skills [27]. By activating thinking process during the learning process, it affects students' critical thinking skills improvement. Brasford & Donovan [7] states that by practicing critical thinking skills during learning, students are practiced to "how they think," not just to know "what they think". In contrast to conventional learning, students are likely to receive facts through a direct explanation and proven by an experiment. The weakness of verification laboratory that the student is rarely given the opportunity to experience the real scientific efforts in solving new problems. The learning process with discovery learning model provides an opportunity for students, from evoking the problem until a solution is all done by the students themselves [28].

In addition to the learning process, the differences improvement in both groups cannot be separated from reading infusion strategy. Reading infusion is reading activities using the SQ3R technique (survey, question, read, recite and review) conducted at the verification phase. The SQ3R method will make the students studying readings that involve critical thinking skills. It also provides opportunities to determine the important parts that will be the question in understanding the text. These questions...
then they answer based on the literature they read, so that at the same time the students perform reading and thinking. The SQ3R reading method gives students the opportunity to practice critical thinking skills [29]. This is in line with the opinion of the Syah [30] states that by using SQ3R, student learning outcomes such as critical thinking can be more satisfying, because the students read active and targeted directly at the essence or implicit and explicit contents in the reading text. Reading texts or literature can basically develop critical thinking skills [31]. The previous studies showed that reading can stimulate discussion and inquiry activities [32]. In line with these opinions, reading gave a positive impact on learning outcomes [33]. Hermida [34] and Jones [3] states that the reading activity will stimulate students to use higher order thinking skills. Reading will assist students to fill their own knowledge that will improve their learning outcomes, such as their critical thinking skills [35]. Assigning students to read with SQ3R method that elaborated with innovative learning model will obtain the critical thinking skills improvement. Kalelioglu & Gulbahar [4] states that the innovative learning model, such as reading infusion-loaded discovery learning model, will have an impact on students’ critical thinking skills that last a long time and touches all students.

4. Conclusion
The findings showed that the average improvement of students’ critical thinking skills for the experimental and control group are respectively 59 and 43, in the medium category. There was a significant difference in the improvement of students’ critical thinking skills between the experimental and control group ($Z_{count} = -5.137; \text{sig} = 0.000 < \alpha = 0.05$). Thus, the implementation of reading infusion-loaded discovery learning model could further improve middle school students’ critical thinking skills than conventional learning.

In this study, the designed instruction still requires plenty of time than the usual in the classroom. It need more improvement in designing and planning each learning phase’s efficiency. In addition, a continous efforts are important to develope an appropriate learning model by utilizing the potential of discovery learning and reading infusion in science instruction, particularly in different learning objects or themes.

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