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RESEARCH ARTICLE

PROBLEM BASED LEARNING THROUGH LABORATORY WORK AND AUTHENTIC ASSESSMENT: EMPOWERING CRITICAL THINKING ABILITIES IN INDONESIA STUDENTS

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ABSTRACT

Twenty-first century learning has seen the memorizing concept of learning replaced by a new concept, namely self-finding and self-constructing concept aimed to boost students' high order thinking skill, critical thinking, creative thinking, and problem-solving ability. The present research incorporated a Problem-Based Learning (PBL) model through laboratory work and authentic assessment to enhance the student's critical thinking ability. The design of the study was quasi-experimental with pretest-posttest non-equivalent control group. The participants were 60 students of biology department of School of Teacher's Training and Education of Persada Khatulistiwa Sintang, Indonesia. The students were taking animal physiology course and were randomly allocated into wither a PBL class or a standard instruction control class. Students were pre-tested for their critical thinking ability and then tested again after the 12-week semester. Both classes significantly improved their critical thinking skills over the semester. However, at post-test, the PBL class scores on the final essay test were significantly higher than the control class. These results support the inclusion of PBL with laboratory work and authentic assessment to improve students' critical thinking abilities in biology courses.

INTRODUCTION

In Indonesia, one of the problems with learning is that only learning lecture or direct instruction, discussion, question and answer are emphasised. Rarely does learning involve direct student activity with the result that studentscannot hone their critical thinking skills optimally. According to Susanto (2002), there are 3 problems in science learning: (1) science learning tends to be knowledge-oriented and not process-oriented, (2) science teaching is merely about transferring knowledge, in terms of facts, concepts, and scientific principles that are mostly transferred by lecture, inquiry, or discussion without any practical work outcomes, and (3) science teaching focuses on answering questions, teachers tend to implement inquiry method, and the answers are in form of facts, concepts, and standard principles taught by the teachers or written in the text books. Baskoro (2009) stated that one of the shifts in learning in the twenty-first century has been from memorizing concepts to self-finding and self-constructing concept learning. These can enhance students' higher-order thinking skills, critical thinking, creative thinking, and problem-solving ability.

Snyder (2008) claimed that barriers to critical thinking were the implementation of direct instruction learning, lack of practicing or experimental activities, limited resources, bias thought, limited cooperation time, and less use of a learning environment that enabled critical thinking ability. With respect to Indonesian education, Sanjaya (2006) stated that one of the problems was a learning process that did not stimulate or develop student's thinking abilities. That is, learning activities are mostly concerned with memorizing and augmenting information, so the students are smart theoretically yet poor in action. For example, science education cannot build students' critical thinking and systematic thinking abilities as the learning strategy of thinking is not applied directly during the learning process.

Liliasari (1999) suggested that learners should not only comprehend concepts, but also be able to engage in higher order thinking skills, such as critical thinking. The act of learning how to be critical, analytical, and evaluative is a way to activate mental processes like focussing, categorizing, selecting, and decision-making (Cottrell, 2005). According to Angelo (1995), critical thinking ability is useful in developing students to be a skilful learner in analysing, synthetizing, problem-solving,

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deducing, and evaluating against some particular criteria. As a part of cognitive ability, critical thinking gives students a number of academic, personal, and professional advantages for solving problems (Quitadamo & Kurtz, 2007).

Gordon *et al*. (2001) found that problem-based learning (PBL) helped students develop their interpersonal skills, critical thinking, and information finding abilities. Nowak (2001, cited in Sungur & Tekkaya, 2006) reported that PBL may improve one's critical thinking, problem-solving, and decision-making ability. This is congruent with Ali and Sebai's (2010) argument that PBL was effective in improving the students' independent learning and critical thinking ability. For Tan (2009), PBL is emphasized to improve individual learning styles in order to strengthen the real concept, develop high order thinking skill, develop problem-solving ability, improve students' active learning, develop a decision-making ability, find information, improve self-confidence, responsibility, cooperation, and communication. Akcay (2009) states that PBL facilitates students in developing thinking and problem-solving ability as well as intellectual skill through the involvement of experience or simulation.

Kirschner, Sweller, and Clark (2006) suggested that even though PBL might help students to obtain meaning from a course, cognitive load theory implies that the free exploration of a highly complex environment may generate a heavy working memory that is detrimental to learning. To counter this limitation with PBL, laboratory work can be integrated so the problem solving can be more focussed through practice and does not lead to cognitive overload. To be effective, laboratory work method needs to be related to authentic issues from a particular environment thus making it suitable to be integrated with PBL.

Laboratory Work-Based Learning is an effective learning strategy for students to build their skill and ability of thinking (hands-on and mind-on) since they are required to be active in solving problems, thinking critically and creatively to analyse and apply facts, concepts, and principles(Santyasa, 2004). For example, Ariyati and Munandar (2010) found that practical-based learning in mangrove forests improved their students' critical thinking ability. The research of Beck *et al*. (2014) also showed a positive effect of inquiry-based teaching in biology laboratory towards the students' learning outcomes.

Beside PBL and laboratory work method, authentic assessment in the form of authentic tasks is also beneficial for the development of the model problem-based learning through laboratory work and authentic assessment. According to Hart (1994) authentic assessment is an assessment conducted through presentation or demonstration in the form of doing tasks or other activities which are meaningful to the education. Authentic tasks involve higher-order thinking skills and coordination of various branches of science, by telling them that their works will be assessed by clear criteria (Wiggins, 1990). In addition to the importance of real tasks or representative tasks (such as writing reports and developing portfolios), authentic assessment acts as an instruction and skill forming opportunity and not merely as an evaluation set (Wiggins, 1989, in Frey *et al*., 2012). Therefore, it is expected that the implementation of problem-based learning through laboratory work and authentic assessment in the present study will improve the students' critical thinking ability in an animal physiology course within a study program of biology educationat the School of Teachers' Training and Education of Persada Khatulistiwa Sintang of West Borneo.

METHOD

Participants

The population of the study were the biology department students of School of Teachers' Training and Education of Persada Khatulistiwa Sintang of West Borneo. The study sample consisted of two classes with programmed courses in animal physiology. The experimental class included 30 students (19 females) with the control class also numbering 30 students (18 females). Students generally have the age range 19-22 years. The study samples were students with homogenous initial academic ability based on grouping test.

Design

This research is a quasi-experimental study designed to compare the effect of PBL through laboratory work and authentic assessment (PBL group) to conventional learning (Control group) towards critical thinking ability of biology students. The research used a pretest-posttest non-equivalent control group design (Borg & Gall, 1983).

Measures

The instrument used to measure the ability of critical thinking was an essay test. This essay questions about the physiology of animals that includes material about the structure and function of cells in general, the food, the digestive system, blood, circulatory system, respiratory system, excretory system, coordination of the nervous system, hormones coordinate system, osmoregulation, thermoregulation and the senses, which include: sight, smell, skin, hearing, and balance tool. This essay questions as much as 16 numbers. Long time working on the essay test is 150 minutes either in pretest and posttest for both classes. The essay questions made by the researcher. The essay test questions covered the five indicators of critical thinking skills namely elementary clarification, basic support, making inferences, advanced clarification, and strategy and tactic. The instruments of the study were validated before used. The maximum score on the critical thinking skills essays was 100.

Procedure

For the first phase, both the PBL and control groups (classes) completed initial tests of critical thinking skills. During the second phase, the class experiments of PBL group employed a problem-based learning model through practical and authentic assessment while the control class were provided with direct instruction. Every week learning takes 150 minutes either the experimental class and control classThese learning modes were used for a complete semester of 12 weeks. For the third and final phase, both groups were again tested for their critical thinking skills.

RESULTS

The descriptive data for pre- and post-instruction by Group is presented in Table 1. The data was analysed with a 2 (Group:

PBL vs. Control) x 2 (Time: Pre- vs. Post-instruction) mixed-model ANOVA with Group as a between-subjects factor and Time as a repeated measure. There were significant main effects for Group and Time, *p*s < .001, but these were superseded by a significant Time x Group interaction, $F(1,58) = 167.22$, $p < .001$. Simple effects analyses of this interaction revealed that Group differences were not evident at Pre-instruction, p = .945, but were significant at Post-instruction, $F(1,58) = 102.87$, $p < .001$.

Table 1 Descriptive data (Ms and SDs) for pre- and Post-instruction by Group

Group	Pre-Instruction	Post-instruction
PBL+ laboratory work + authentic assessment	30.17 (2.91)	80.33 (4.38)
Control	30.12 (2.72)	67.98 (5.03)

As can be seen from Table 1, the PBL group ($M = 80.33$, $SD = 4.38$) scored significantly higher at Post-instruction than did the Control group ($M = 67.98$, $SD = 5.05$). There were no differences at Pre-instruction.

DISCUSSION

This research sought to investigate the effects of PBL with laboratory work and authentic assessment on students' critical thinking skills. The problem-based learning model through practical work and authentic assessment emphasized three key components, namely analysing problems, conducting laboratory work, and creating a product. In the present research, there were five indicators of critical thinking ability: elementary clarification, basic support, making inferences, advanced clarification, and strategy and tactic (Ennis, 1985). Students in the PBL class were shown to have significantly higher essay scores at the end of the semester than were students in the standard instruction control class.

The first component that influences critical thinking ability is analysing problems through problem-based learning. According to Arends (2008), problem-based learning is used to stimulate high order thinking skill in problem oriented situation including learn to learn. Our results support Dasna's (2005) idea that problem-based learning model functions as a media to build high order thinking skill (HOTS) such as critical thinking, creative thinking, and problem solving ability. As with Halim (2011), our study indicates that there was an effect of the implementation of problem-based learning to the students' critical thinking ability.

Our findings can be explained by Proulx (2004) who found that critical thinking stages were similar to scientific method stages. Thus by applying scientific method that is the core of problem-based learning in the learning process, critical thinking ability can be activated. Buris and Garton (2007) showed how problem-based learning could contribute to every level of education including retention of knowledge, students' satisfaction, motivation, and critical thinking. For Sungur (2006), students in PBL group tended to participate more actively in doing tasks due to the challenge, curiosity, and mastery compared to students in their control group. They accepted biology as an interesting, important, and beneficial subject. Whilst this was not examined in the present research, there was anecdotal evidence to suggest that students in the PBL class were more engaged.

The second component that aimed to improve critical thinking ability from problem-based learning model was the laboratory work. Hofstein and Lunetta (2003) stated that science laboratory facilitates teachers to improve the students' learning outcomes, and there are many advantages obtained from laboratory learning. For example, practical-based learning of invertebrate concepts improves the students' critical thinking ability with gain index 0.61, categorized as high (Hayat, 2010). This finding is supported by other relevant research findings such as Kaswan (2005) who found that the improvement of critical thinking ability of students enrolling in teaching and learning process by using laboratory learning tools was better than the critical thinking ability of students enrolling in conventional learning. The third component in the present research that influenced the students' critical thinking ability of problem-based learning model was creating product through authentic tasks. Brooks and Broks (1993, cited in Johnson, 2002), stated that authentic scoring was better than memorizing texts, since students were required to apply higher thinking ability to help them solve problems in their daily activities. Authentic scoring, as suggested by Oneil (1992, cited in Pantiwati, 2007), provides complete data of students' ability and based on the learning activity, can lead to an appreciation of products (in terms of meaning, concept, procedure, notion, law, and theory) and process (in terms of scientific method stages).

The research has advantages especially in the learning model used in the experimental class. The advantages of this model is the students can implement or carry out three main components, namely analyzing authentic problems raised from the environment, conduct investigations through the lab and at the end of the lesson made products through authentic tasks. This learning course involves all the senses and the ability of students to participate in learning and thus can sharpen the critical thinking skills of students and students an understanding of the theory and practice balance. Weaknesses in the model developed is requires a lot of time for preparation and implementation of learning and involve more teachers.

CONCLUSION

Based on the present research findings, it can be concluded that there was an effect of the implementation of problem-based learning model through laboratory work and authentic assessment to the students' critical thinking ability. Problem-based learning model through laboratory work and authentic assessment directly involved the students in the learning process by analysing problems and solving problems through laboratory work as well as creating products so that it develops the students' critical thinking ability. Have a sentence here about possible future research.

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