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# DESIGNING LITERACY AND PROBLEM BASED LEARNING TO FOSTER CRITICAL THINKING IN BIOLOGY

**Eko Fery Haryadi S[1], Andreas Priyono BP[2], Amin Retnoningsih[3]**

[1]*Post Graduate Student of Unnes (Semarang State Univerisity), Science Education Departmen*
[2]*University teacher of Unnes, Departmen of Biology*
[3]*University teacher of Unnes, Departmen of Biology*

**ABSTRACT**

A systematic science lesson plan is usually developed by teachers to achieve students' competencies in science, which is strongly related to the implementation of literacy-based teaching. This research was aimed at developing biology lesson plan grounded in literacy and problem-based learning and identifying the effect of the lesson plan on student critical thinking. The lesson plan was developed on the basis of needs analysis and particular literature reviews. Small-scale field test was implemented on ten students who already took environment subjects. Field testing was used to generalize findings, and implemented on MIA 1 and MIA 2 as treated and control groups. Validity of the products was assessed by experts from university teachers at Unnes Semarang. Sylabus, lesson plan, and learning materials were classified as "higly valid" (4.10; 4.20; 4.40) respectively. t test indicated that that average scores of control and treated groups were significantly different one another tvalue (6.621) > ttable (0.312). More than 72.8% of students gave positive responses to the critical thinking skills questionaires. The findings showed that science lesson plan grounded in literacy and problem-based learning was valid and could be used to encourage critical thinking skills in science teaching.

Key Word: critical thinking, problem based learning, science literacy

## INTRODUCTION

Implementation of curriculum 2013 in schools has not fully used science literacy as standards of learning. Science teaching takes more emphasis on academic purposes and content understanding, and scientific literacy are not be accomplished. According to Norris & Philips (2003) scientific literacy was difined as an ability to understand knowledge and to think critically to solve problems using scientific expertise. There are three dimensions of scientific literacy, according to OECD (2009), such as undertanding scientific concepts, scientific processes, and scientific context or areas of application. Science literacy can be achieved through the process of learning that makes the students use critical thinking. Students not only expected to read books, journals and science articles, but have a deep understanding of science (Holbrook & Mia, 2009). Literacy needs to be used by the students to understand environments, health, economic and development of science.

The improvement of science learning at school has been addressed by a variety of approaches. One of them is the implementation of Problem Based Learning (PBL). Saeed & Rousta (2013) mentioned that PBL encouraged teachers to focus on students than themselves. Teachers involve students actively in the process of learning to increase critical thinking skills. Gallow (2012) underlined that PBL asked students to create new knowledge and new things. In this case, students seems to have more knowledge to solve problems, improve crical thinkings, work in groups, and have interpersonal commmunication.

Critical Thinking is needed to face modern world when all the information presented in an instant way. Thinking is an important part of social and intellectual rights (Saeed & Rousta, 2013). According to Fisher (2001) learning process and quality of life depends on quality of thought. Critical Thinking is a process of thinking to address issues and make decisions, and make analysis before action. Paul (1993) interprets critical thinking is a mode of thinking to improve the quality of thoughts by applying standards of

intellectual activities. Critical thinking relates to judgment or decision making measured independently. Components critical thinking skills among other are interpretation, analysis, evaluation, inference, explanation, and self regulation (Duldt, 1997). Teaching in schools should empower students to develop their skills in searching for, manage, and to assess various information critically.

How science teachers do integrate their teaching learning to suport critical thinking skills is one of big challenges for most science teachers in Indonesia. This study is focused on the development of a model of teaching devices for critical thinking through the use of literacy-based and problem based activities. This study was aimed at developing a science lesson devices, grounded in literacy based and PBL, and analyze the influence on student critical thinking skills. Critical Thinking is one of the criteria of science literacy. Implementation of the teaching learning devices is expected to produce students who think critically. Students with critical thinking skills are ones who are cabable of solving their daily life.

## METHODS

Science teaching devices was developed on the basis of research and development (R&D) procedures in education, starting from needs of analysis, setting objectives, developing a product, and conducting field-testing of the product. Needs analysis was conducted at SMA Negeri Pecangaan to collect data of science teaching devices used by biology teachers. This teaching device was analysed whether it already integreated literacy and PBL or not. Since there was no teaching tools of scientific literacy, the next step of research was focused on designing a teaching model grounded in literacy based and PBL approaches. This model was focused on the use of real problem of environment as a starting point of teaching and PBL cycles as the teaching procedures. Both formative and summative learning assessment was used to portray student critical thinking. Student critical thinking was assessed by C4 (high level thinking) problems of Bloom taxonomy of learning. The product was then theoritically validated by experts of biology and biology education. Field testing was carried out to identify the effect of the use of the product on student critical thinking skills. Subjects of this study was a class X MIA-1 as experimental groups and X MIA-2 as control groups at the Senior High School 1 Pecangaan. t-test was used to compare means of the experimental and control groups.

## RESULT AND EXPLANATION

Science teaching tools (syllabus, teaching materials, lesson plans, instruments, student assessment) were successfully developed on the basis of literacy teaching principles and PBL approaches. This teaching devices was declared 'valid enough' by the validator. Validity is a measure of quality of an instrument (Nursalam, 2003). Table 1 summarizes the spesification of the devices developed.

**Table 1.** Specification of Literacy and PBL based Teaching Devices.

| Teaching Tools | Aspects | Note |
|---|---|---|
| Syllabus | Competency | Three dimensional indicators that contains the concept of |
| | Indicators | literacy in science with critical thinking skills |
| | Subject matter | Topics discussed were Environment for exploring critical thinking skills. |
| | Learning activities | The learning process of PBL in line with the literacy of science. |
| | Assessment | High level thingking problems, related to everyday life. |
| Lesson plan | Competency | Three dimensional indicators that contains the concept of |
| | Indicators | literacy in science with critical thinking skills |
| | The purpose of the lesson. | Students with critical thinking skills are able to solve environmental problems and/ or to to give ideas to solve environmental problems. |
| | Learning materials | Environmental problems at urban areas, and clear environemntal issues by students. |
| | Learning activities | PBL syntax and attention was taken to the three dimensional aspects of scientific literacy (concepts, processes, applications) |
| Teaching materials | Books | Teaching materials with environmental problems that have never been experienced by students. supplemented with pictures (photograph) of science literacy. |
| Evaluation tools | Grille & question | Test was used to measure critical thinking skills, related to a high |

| | | |
|---|---|---|
| | | level Bloom cognitive taxonomy. |
| The discussion | Worksheets | Discussion sheets contained environmental problems. Discussion was guided by a number of questions that leads to answer pros and cons, guide students find the truth that can be trusted. |

Table 1 showed that science teaching tools (devices) had put emphasis on some different aspects of learning tools if compared with traditional sylabus, lesson plans and related teaching materials. Literacy was underlined by asking students to address real life problems of environment. How students learn was created by the use of PBL.

Critical Thinking is one of the criteria for a science literacy of the Curriculum 2013. It should be realized. Critical Thinking in this research was assessed by capability/skill tests, to answer problems with the criteria C4 and C6 (see table Bloom). Elder & Paul (2005) stated that critical thinking was the foundation to learn about each disciplines. Critical thinking skills students could be taught through the use of teaching models. PBL. According to Savery (2006) PBL was teaching methods that encouraged students to get to know how to learn and work together in groups to resolve the problem in life. PBL could be used to encourage students develop the thinking process and encourage students to produce a solution to problems. Langrehr (2006) said that critical thinking could be trained, when students were encouraged to answer the questions, namely (1) please indentify consequences of a decision or an incident; (2) identify the assumption that is used in a statement; (3) formulate problems; (4) find a solution based on a different perspective; (5) describe causes an incident; (6) choose factors that support to a decision.

Jonassen & Hung (2008) stated that PBL was elaborated as teaching models with open ended, complex, and authentic. Students are not just to understand the concept with a problem presented by scientific methods, but also to apply a problem solving skills to nurture critical thinking. Through PBL students are able to solve problems in a structured one. PBL trains students to identify, analyze, and to evaluate their problems carefully. When fixing problems, children search information actively, adopt the purpose and orientation coming through thinking analytically, thinking generatively and producing a solution effectively (Tan, 2009). Yaman (2005) in his research showed that PBL was proven to be able to develop ability to think and the ability for reasoning.

Learning devices grounded in scientific literacy and PBL could encourage critical thinking skills. Tinio (2003) said that one of the skills needed to face the challenge in the future was thinking skills, often called critical thinking skills. Critical thinking skills are used by all the people because they can be used to protect themselves and others as well as to take a decision wisely in their daily life (Liliasari, 2010). People fundamentally need thinking skills to address their daily life.

Critical thinking skills in this study was measured by C4 and C6 problems or questions (Bloom taxonomy), and the different score of this thinking skills was compared between the control and experiment groups. Learning teaching devices influenced critical thinking skills of students, that can be read from different average scores of critical thinking between class experiment and control classes as as presented in the table 2.

**Table 2**. Average scores of critical thinking

| Variable | Experiment | Controls |
|---|---|---|
| Post-test | | |
| average | 78.45 | 64.20 |
| The highest | 96 | 82 |
| The lowest | 52 | 50 |

Table 12 shows that a grade experiments have the ability to a higher in answering the questions critical thinking than control classes. Scores critical thinking then tested t, to see the difference significantly in both classes. Analysis of critical thinking t test scores are presented in Table 3.

**Table 3.** Analysis of t test score think critically

| Analysis | Class | Post-test |
|---|---|---|
| Normalitas | Experiment | 4.5842 |
| | Controls | 5.8584 |
| Homogenitas | | 1.18 < 1.7 |
| Signikansi t | t Tabel = 0,312 | 6,621 |

Table 3 showed that critical thinking skills of students in the experimental class was better than one of the control class and was significantly from the treated groups tcount 6.621 ≥ 0.312 ttabel. The difference could be caused by the use of the teaching learning devices. The Learning devices of scientific literacy were seen 'relevant or connected to student interests, since it used environmental problems which are familiar among students. Students were also involved in more active learning such as doing observation, finding information, collecting ideas, engaging in peer discussions. This fenomena was clarified by other research findings. Bonnie & Potts (2003) stated that critical thinking could be translated in classroom when there were (1) improved interaction between students, (2) a lot of raised questions, (3) a time for a reflection and question. Critical thinking skills in this study could be recorded, when students generated ideas to prevent or reduce pollutions. Many of these ideas during the discussion were created by students who tried to implement green school revolution. Students made their environmental slogans, inspiring advertisements in school wall magazine, canteen and a number of places. All of these student activities were supported by Filsaime (2008) who underlined that one of the ways to improve critical thinking was a innovative lesson plan with a problem or questions, and ended with an evaluation. Critical thinking skills students were identified during the study, because students were trained to be more active in asking questions and answers to the question predicted. Critical Thinking could be encouraged when students were faced with the new and problematic cases. and then students constructed thir own thoughts for finding truth and clear reason (Sabandar, 2007). Real problems was used in the study, students became familiar with their surrondings. Addressing real problems from surounding was part of literacy based education. Rustaman (2004) underlined that science was related to major actions of students in identifying, interpreting evidences. In other words, problem based learning and scientific literacy are both sides in one coin, they are both supporting to the translation of scienfic inquiry and literacy, as well as critical thinking.

## CONCLUSION

This research was an attempt to translate scientific literacy, problem based approaches in science teaching to support the improvement of student critical thinking. Sylabus, lesson plan, and other related teaching aids were successfully developed and validated by local experts. When they were implemented, there were significanly different in terms of student effects (knowledge, attitudes, and thinking skills). Teachers of biology or related science could use this design for improving the quality of biology learning.

## BIBLIOGRAPHY

Bonnie & Potts. 2003. S*trategies for Teaching Critical Thinking. Practical Assesment, Research & Evaluation*. Available http://www.edresearch.org/pare/getvn.asp?v=4&n=3

Duldt, B.W. 1997. Coaching Winners: How to teach Critical Thinking in Critical Thinking across the Curricullum Project, Longview Community College. Lee's Summit : Missouri.

Elder, L & Paul, R. 2005. *A Guide for Educators to Critical Thinking Competency Standards*. Foundation for Critical Thinking. http://www.criticalthinking.org.

Filsaime, D.K. 2008. *Menguak Rahasia Berpikir Krits dan Kreatif*. Jakarta : Prestasi Pustaka

Fisher, A. 2001.*Critical thinking: an introduction*. UK: Cambridge University Press. http://www.eyelevelaurora.com/CTdefinition.pdf

Gallow, De. 2012. *What is Problem-based Learning?*. Irvine University: California. http://www.pbl.uci.edu/whatispbl.html

Holbrook, J & Mia R. 2009. The Meaning of Literasi Sains. *International Journal of Environmental & Science Education* Vol. 4, No. 3, July 2009, 275-288. IJESE

Jonassen, D. H & Hung, W. (2008). All Problems are Not Equal: Implications for Problem-Based Learning. *Interdisciplinary Journal of Problem-Based Learning, 2(2)*. http://dx.doi.org/10.7771/1541-5015.1080

Langrehr, John. 2006. *Thinking Skills*. Edisi Pertama. Jakarta: PT.Gramedia.

Liliasari. 2010. Pengembangan berpikir kritis sebagai karakter bangsa Indonesia melalui pendidikan sains berbasis ict. *Potret Profesionalisme Guru dalam Membangun Karakter Bangsa: Pengalaman Indonesia dan Malaysia*. Bandung: UPI

Nursalam. 2003. *Konsep dan Penerapan Metodologi Penelitian Ilmu Keperawatan*. Jakarta: Salemba Medika.

Norris, S.P & Philips, L.M. 2003. *How Literacy in Its Fundamental Sense Is Central to Memiliki literasi sains*. Inc.SciEd87:224–240. Wiley Periodicals. www.interscience.wiley.com

OECD. 2009. *Top of the Class High Performers in Science in PisA 2006*. www.oecd.org/publishing/corrigenda

Rustaman, N., Firman, H. & Kardiawarman. 2004. Ringkasan Eksekutif: *Analisis Hasil PISA Bidang Literasi Sains*. Puspendik.

Sabandar, J. 2007. *Berpikir Reflektif*. Proseding Seminar Nasional Matematika. Bandung: Jurusan Pendidikan Matematika FPMIPA UPI.

Saeed, S. J.G.M & Rousta, S.N. 2013. The Effect of Problem-based Learning on Critical Thinking Ability of Iranian EFL Students. *Journal of Academic and Applied Studies* (Special Issue on Applied Linguistics) Vol. 3(7) July 2013, pp. 1-14. online @ www.academians.org

Savery, J, R. 2006. Over of Problem Based Learning: Definitions and Distintions. *The interdisciplinary Journal of Problem Based Learning*.

Tan, O. 2009. *Problem Based Learning and Creativity*. Singapore: Cengage Learning Asia.

Tinio, V.L. 2003. *ICT in Education*. http://www.apdip.net/publications/iespprimers/ICTinEducation.pdf

Yaman, S. 2005. Effectiveness on Development of Logical Thinking Skill of Problem Based Learning Skills in Science Teaching. *Journal of Turkish Science Education*. 2(1): 32-43