Comparison of Scientific Literacy in Engine Tune-up Competencies through Guided Problem-Based Learning and Non-Integrated Problem-Based Learning in Vocational Education

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Abstract. This research is aimed to describe comparison of scientific literacy improvement of vocational school students in Banten, Indonesia in integrated scientific teaching using Guided model and non-integrated PBL. Research design uses quasi-experiment approach with pretest-posttest sati non randomized group. Research instruments are essay test and performance test. Results reveal that there is no significant difference between students’ scientific literacy achievement improvement using integrated guided PBL and non-integrated PBL. Scientific literacy teaching using guided PBL can increase students achievement by 0.4243 (medium category) while the non-integrated PBL can give 0.3924 (medium category). It can be concluded that both PBL models increase student’s literacy comprehension. Improvement in scientific literacy is in the form of problem identification, problem investigation, and utilization of scientific facts. Efforts to improve scientific literacy must be conducted continually in vocational education, for problem solving in education environment.

1. Introduction
The decline of vocational students learning routines in Serang, such as literacy of reading and writing and even completing school tasks, should be overcome so as not to cause continuous and more complex problems [1]. The role of educational policy, one of which is the School Literacy Movements that is implemented before the learning starts, is one way to restore ideal learning stability. In addition, the educational policy of vocational schools learning using scientific approach is seen as an effective step to increase the role of students in teacher-centered learning activities. Thus the scientific approach, one of them is the problem-based learning method, can be used as solution to improve scientific literacy [2]. Scientific literacy based learning is a process of learning by identifying problems, investigating and showing scientific facts of problems through justified sources of information by reading, listening, and writing during the learning activities [3]. It aims to prepare students to solve problems and even prevent problems that arise in the work environment or
educational workshop environment. Scientific literacy based education is essential to improve sustainable problem-solving skills [4].

The engine tune-up curriculum on four-wheeled vehicles, supports scientific literacy based learning. It is characterized by learning in the form of damage troubleshooting to components and systems to solve and overcome the root-cause. This is a continual condition brought by the vehicle regular use. Moreover, similar problems may occur on other vehicle types. The scientific literacy concepts used to solve the problem also remain the same. The scientific literacy concept in vocational education is measured by achievement. Improved achievement indicates the success of scientific literacy ability obtained by students. Habituation of the need to solve the problem has a positive impact in everyday behavior. Students will respond quickly through valid information and deemed able to solve the problem. Thus the students will be aware of literacy and even media and technological developments. This enhances job-responsibility behavior through knowledge, skills and attitudes toward the growing literacy.

Research on the scientific literacy has been encouraged in various schools, especially vocational schools. Some research results indicate that the quality of learning literacy is decreasing due to the media and the lack of student limitation in using them. [5]. However, this study uses a problem-based learning strategy which stages are as follows: problem identification, problem-solving, investigation, developing and presenting reports, analyzing and evaluating the process [6]. This strategy is considered capable of solving educational problems and increasing literacy during the learning process.

Problem-based learning is a learning innovation with the concept of optimizing students' cognitive skills through systematic learning activities in groups. Learning activities that takes place in the student teamwork can empower, sharpen, test, and develop the ability to think well. Thus, problem-based learning is identical as a student-centered learning in the category of active learning. The concept applied is the solving problems that often arise at work that they will encounter later, the problem is unstructured, the student's expected ability is to identify the problem, to test and perform proofing. The process involves active scientific literacy practices and, inadvertently, curiosity to find solutions will emerge. Although this process requires mentors to direct or identify process that is considered complicated, during the process of problem identification, students themselves look for damage that is accompanied by logical or reasonable reasons.

Problem-based learning is stated as an ego process of obtaining the truth from given solution and developing the applied process. [7], [8]. Problem-based learning is identical with the characteristics of students in ability, based on the level of problem resolution faced, that are between beliefs, doubts and even uncertainties of phenomena at the end of the cycle. The important process is how to find the right solution for the given problem. Working in groups will familiarize students with the tasks distribution and reinforce the statements obtained. Students seek and build their own information with the assistance of the environment, friends and literacy discoveries. All this time, working in groups makes learning more motivating, fun and more active. Research conducted by the Center of Teaching and Learning Stanford University stated that group work can improve learning achievements. Empirical research of problem-based learning shows that students are able to apply their knowledge in solving new problems as well as effective learning strategies away from traditional learning [9]–[11]. In this case, problem-based learning is significantly considered effective for competent and skilled practitioners and also contains the knowledge and skills that can be gained from their learning experience [12]. The use of problem-based learning as an alternative can increase the scientific literacy of vocational students.

2. Experimental Method
The method used in this research is quasi experimental approach with Non-Statized Group Pretest-Posttest Design. This research is intended to determine the improvement effect on the research subject [13]. Research population is students in Serang in the academic year of 2014-2016 and research subjects are 54 students divided into two groups. First group will be given scientific literacy learning using guided PBL model, and the other will be given scientific literacy learning using non-integrated
PBL model. Instruments in this research are closed questions to assess students’ scientific ability in the knowledge and scientific competence aspect. Data are analyzed qualitatively and quantitatively.

Table 1. Research Design: Non Randomized Static Group Pretest-Postest Design

| Group       | Pretest | Treatment | Posttest |
|-------------|---------|-----------|----------|
| Experiment I| Y1      | X1        | Y2       |
| Experiment II| Y2     | X2        | Y2       |

Notes:
Y1: Pretest to determine initial achievement for students’ scientific literacy
X1: Scientific learning with Guided PBL
X2: Scientific learning with un-Guided PBL
Y2: Posttest to determine post-treatment scientific literacy

3. Result and Discussion

The learning of tune-up engine competence by applying the problem-based learning method shows a great impact [14] in all aspects of scientific literacy to improve in-depth learning of the students. [15]. Problem-based learning method is a contextual model that can stimulate students to learn [16]. The ideal team division helps the achievement of learning objectives [17], [18]. Therefore, this study assesses the literacy achievement knowledge, competence and scientific ability aspects.

The treatment in this research is integrated scientific learning using guided problem-based learning model in experimental group I and integrated scientific learning using problem-based learning without guidance for experiment group II. The learning is divided into four meetings. The tests are conducted in the first and final meetings of the treatment. There are 5 essay questions. Overall, the scientific literacy achievements in integrated tune-up engine using guided PBL and non-integrated PBL are good (N = 54, p > 0.026), while the scientific literacy of both groups were increased by 42.43% for guided PBL and 39.24% for non-integrated PBL.

Scientific literacy has been greatly improved in both groups. However, after the average post-test difference between the two groups is examined, it was found that there was no significant difference (figure 1) in the tune up engine skill that is integrated with literacy. The results shows that both groups are able to communicate every problem using scientific literacy approach.

Improved literacy skills of both groups can encourage students to build and establish relationships between knowledge, habituation, and skills for problems encountered in daily life. This is also supported by Holbrook,at.al.,[19] literacy in the student's point of view and also related to human life, interests and aspiration.

Implementation of scientific literacy learning in both groups provides opportunities for students to collaborate with other groups in investigating, developing processes, and social skills. Collaboration done in problem solving goes well, this is where social interaction has been achieved. Thus, the learning outcomes of guided PBL and non-guided PBL indicate a positive impact and students’ comprehension has been well developed. In line with previous researchers [20] - [22] where the learning process provides students the opportunity to be active in gathering knowledge that is analyzed both deductively and inductively to develop their thinking skills and cognitive abilities.
Figure 1. Overall student Scientific Literacy. Test result difference is not significant between Guided PBL group and non-integrated PBL group (***p>0.026)

Analysis of scientific literacy knowledge is conducted to measure the mastery of tune up engine curriculum. The tune-up process is divided into several topics shown in table 2. Overall learning of scientific literacy can imply the mastery of scientific content during the learning process. The highest increase of both groups was on the ignition system improvement (figure 2). Observation result of students activity showed dominant activity is in experiment activity. This indicates that the experiment activities are positively going well. Through various case studies, students learn to apply the concept of powerful spark. The role of the teacher is to provide reinforcements for what is understood to be strongly stressed in the memory of students using scientific media in the form of ignition system video. The scientifically applied steps help students in mastering the concepts. In line with Swaak, et.al., [23] where the process approach in the form of information collection and classification, hypothesis formulation, prediction, experimental results interpretation, and conclusions formulation improves students' ability in solving their problems.

Table 2. Engine Tune-Up Competence Based on KKNI

| KKNI Kode       | Tune-Up Competence                        | Kode |
|-----------------|-------------------------------------------|------|
| OTO.KR-01-001.01| Component Maintenance/service              | (1)  |
| OTO.KR-01-009.01| Technical drawing reading and comprehension| (2)  |
| OTO.KR-01-010.01| Measurement instruments usage and maintenance| (3)  |
| OTO.KR-01-016.01| Work Health and Safety Procedure           | (4)  |
| OTO.KR-01-017.01| Working tool usage and maintenance         | (5)  |
| OTO.KR-01-018.01| Communication contribution at work         | (6)  |
| OTO.KR-01-019.01| Manual operation procedure                 | (7)  |
| OTO.KR-02-010.01| Cooling system maintenance/service and components | (8)  |
| OTO.KR-02-014.01| Fuel system maintenance/service            | (9)  |
| OTO.KR-05-001.01| Battery test, maintenance/service and replacement | (10) |
| OTO.KR-05-011.01| Ignition system repair                     | (11) |
Figure 2. Competence Mastery Improvement Profile for Engine Tune-Up after Learning Process with Guided PBL and non-integrated PBL.

Tune-up engine competence improvement emphasizes on the students independence and ability to think. Basically the PBL model applied to the practice provides an opportunity to develop a scientific process to solve problems systematically. Findings [24], [25] reveal that facilitating students to solve problems will significantly improves the domain competency process.

Implementation of learning using guided PBL and non-integrated PBL can improve the scientific literacy competence in medium category. This is influenced by several factors: (1) the need for an in-depth learning approach to the individuals in the group, (2) the need for students with the mastery of the knowledge to connect several concepts related with the problems encountered, (3) during the learning process, guided PBL and non-integrated PBL require conceptual understanding with experience gained then, some of the group members were frustrated with the problems, (4) the learning objectives were affected by the conventional concept of the previous learning process.

4. Conclusion
Implementation of learning using guided PBL and non-integrated PBL can improve the scientific literacy competence in medium category. Improvement in scientific literacy is in the form of problem identification, problem investigation, and utilization of scientific facts. Efforts to improve scientific literacy must be conducted continually in vocational education, for problem solving in education environment.

References
[1] F. Maulidya, A. Mudzakir, and Y. Sanjaya, “Case Study the Environmental Literacy of Fast Learner Middle School Students in Indonesia,” vol. 3, no. 1, p. 5, 2014.
[2] H.-E. Chu et al., “Korean Year 3 Children’s Environmental Literacy: A prerequisite for a Korean environmental education curriculum,” Int. J. Sci. Educ., vol. 29, no. 6, pp. 731–746, May 2007.
[3] S. M. Glynn and K. D. Muth, “Reading and writing to learn science: Achieving scientific literacy,” J. Res. Sci. Teach., vol. 31, no. 9, pp. 1057–1073.
[4] M. Erdoğan, Z. Kostova, and T. Marcinkowski, “Components of Environmental Literacy in Elementary Science Education Curriculum in Bulgaria and Turkey,” Eurasia J. Math. Sci. Technol. Educ., vol. 5, no. 1, pp. 15–26, Jan. 2009.
[5] S. Masino and M. Niño-Zarazúa, “What works to improve the quality of student learning in developing countries?,” *Int. J. Educ. Dev.*, vol. 48, pp. 53–65, May 2016.

[6] J. E. P. D., “Using Active Learning Instructional Strategies to Create Excitement and Enhance Learning,” 2010.

[7] J. Barell, *Problem-Based Learning: An Inquiry Approach*. Corwin Press, A SAGE Publications Company, 2006.

[8] H. S. Barrows, “Problem-based learning in medicine and beyond: A brief overview,” *New Dir. Teach. Learn.*, vol. 1996, no. 68, pp. 3–12.

[9] Y. Ding and P. Zhang, “Practice and effectiveness of web-based problem-based learning approach in a large class-size system: A comparative study,” *Nurse Educ. Pract.*, vol. 31, pp. 161–164, Jul. 2018.

[10] M. A. B. Promentilla, R. I. G. Lucas, K. B. Aviso, and R. R. Tan, “Problem-based learning of process systems engineering and process integration concepts with metacognitive strategies: The case of P-graphs for polygeneration systems,” *Appl. Therm. Eng.*, vol. 127, pp. 1317–1325, Dec. 2017.

[11] S. Santharooban and P. G. Premadasa, “Development of an information literacy model for problem based learning,” *Ann. Libr. Inf. Stud. ALIS*, vol. 62, no. 3, pp. 308–315, Jul. 2015.

[12] J. Strobel and A. van Barneveld, “When is PBL More Effective? A Meta-analysis Comparing PBL to Conventional Classrooms,” *Interdiscip. J. Probl.-Based Learn.*, vol. 3, no. 1, Mar. 2009.

[13] J. R. Fraenkel, N. E. Wallen, and H. H. Hyun, *How to design and evaluate research in education*. New York: McGraw-Hill Humanities/Social Sciences/Languages, 2012.

[14] T. Erdogan, “Research Trends in Dissertations on PBL: A Content Analysis Study,” *Procedia - Soc. Behav. Sci.*, vol. 197, pp. 308–315, Jul. 2015.

[15] S. M. Loyens, D. Gijbels, L. Coertjens, and D. J. Côté, “Students’ approaches to learning in problem-based learning: Taking into account professional behavior in the tutorial groups, self-study time, and different assessment aspects,” *Stud. Educ. Eval.*, vol. 39, no. 1, pp. 23–32, Mar. 2013.

[16] R. Delisle, *How to Use Problem-Based Learning in the Classroom*. Association for Supervision and Curriculum Development, 1250 North Pitt Street, Alexandria, VA 22314-1453; phone: 800-933-2723; fax: 703-299-8631; www: http://www, 1997.

[17] S. Mennin, P. Gordan, G. Majoor, H. A. S. Osman, and Network: TUFH, “Position paper on problem-based learning,” *Educ. Health Abingdon Engl.*, vol. 16, no. 1, pp. 98–113, Mar. 2003.

[18] D. I. Mansur, S. R. Kayastha, R. Makaju, and M. Dongol, “Problem Based Learning in Medical Education,” *Kathmandu Univ. Med. J.*, vol. 10, no. 4, pp. 78–82, Sep. 2014.

[19] J. Holbrook, A. Laius, and M. Rannikmäe, “THE INFLUENCE OF SOCIAL ISSUE-BASED SCIENCE TEACHING MATERIALS ON STUDENTS’ CREATIVITY,” p. 3.

[20] C. Gormally, P. Brickman, B. Hallar, and N. Armstrong, “Effects of Inquiry-based Learning on Students’ Science Literacy Skills and Confidence,” *Int. J. Scholarsh. Teach. Learn.*, vol. 3, no. 2, Jul. 2009.

[21] A. G. Bal, “The Effects of Discovery Learning on Students’ Success and Inquiry Learning Skills,” p. 2.

[22] V. Alfieri, G. Conte, and C. Pedicini, “Nonlinear Model-Based Multivariable Control for Air & Charging System of Diesel Engine with Short and Long Route EGR Valves,” *Int. J. Automot. Technol.*, vol. 19, no. 3, pp. 405–412, Jun. 2018.

[23] J. Swaak, A. J. M. de Jong, and W. van Joolingen, “The effects of discovery learning and expository instruction on the acquisition of definitional and intuitive knowledge,” *J. Comput. Assist. Learn.*, vol. 20, no. 4, pp. 225–234, 2004.

[24] R. Scherer and J. F. Beckmann, “The acquisition of problem solving competence: evidence from 41 countries that math and science education matters,” *Large-Scale Assess. Educ.*, vol. 2, no. 1, Dec. 2014.
[25] S. Greiff et al., “Domain-general problem solving skills and education in the 21st century,” *Educ. Res. Rev.*, vol. 13, pp. 74–83, Dec. 2014.