Divergent thinking of students teachers’ through problem-based learning in environmental science

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Abstract. Although project-based learning (PBL) has been well documented in the past few decades in diversified higher education: medical education, engineering, and law, there were a few studies touching upon PBL and its effectiveness towards student teachers’ problem-solving skills. The purpose of the present study was to examine the influence of PBL in teacher education on student teachers’ problem-solving skills related to environmental concern. Informed by experimental design, pretest posttest design, the participants of this study were second-year student teachers (treatment= 30, control=30) in one of universities in Indonesia, faculty of teacher education at a primary level, based in West Java. Data were collected through the objective tests, 50 multiple choice items, which aimed to examine student teachers’ comprehension towards the impact of pollution on people’s health. The statistical procedure, ANOVA, was used for repeated measures which played as data analysis. The result of this study was that PBL within the high divergent thinking has effectively influenced their problem-solving skills, compared to the conventional teaching method, lecturing. The Implication of this study was furthered discussed in this article.

1. Introduction
Divergent thinking skills must be acquired and mastered by students. Students are encouraged to find multiple, imaginative, intuitive, as well as common-sense solutions [1]. The application of divergent thinking in the class is very influential on students, so that a student can gain creativity abilities. Divergent thinking is the ability to generate as many solutions as possible to an openended problem for which there is not a single answer or finite set of answers [2]. Applied of divergent thinking is an effective step to improve students’ abilities and apply the pattern of student-centered learning. It can also use various models, especially problem-based learning.

The notion of problem-based learning (hereafter, PBL) has been of great interest in higher education in such a variety of fields as accounting education, civic education, science education, medical education. This empirical evidence indicated that PBL was influential to motivate university students in building and enhancing learning outcomes [3-6]. For instance J. Pagnotti and W. B. Russell showed that by using a PBL-based students are offered a fun, engaging, and challenging tool to learn with [4]. In other words, the enactment of PBL in a classroom might be potential to create a nuanced learning atmosphere compared to a conventional teaching methodology (e.g., lecturing); therefore, PBL make students recognized their development of employability-related skills in problem-solving, collaborative working, conflict resolution, report writing, presentations, and research [6].

Generally speaking, PBL provided a platform for students to learn through problems. This conception has a series of three stages; they are a problem analysis, a self-directed learning, and
reporting phase [3]. To begin with, the problem analysis enables students to discuss with their peers related to a particular problem. This process urges them to interpret this problem based on their funds of knowledge and find solution towards the problem they have discussed previously. The stage is a self-directed learning, engaging students on the learning issues identified. Students in this process will navigate related-issues so as to find out the proper solution. This stage is finally related to the last one, the reporting stage, where students share findings obtained from their collaborative work. Discussion session will help them refine ideas which are not completed. As a result, PBL can be constructed as a result of collaborative learning and self-directed learning, engaging students in an active learning which could support their critical thinking skills.

In addition, as a way to activate students’ learning, PBL also motivates students to learn problem-solving skills basically and get more input, such as knowledge, because of interactive learning with one with another (e.g., group work) which plays an important role. This can be related to how students carry out specific tasks, either real-life or empirically-based. A study by Loyens, Krischner, and Paas indicated that PBL has been mainly developed in educational practice having great impacts in courses and disciplines extensively [7]. Additionally, Etherington reported that PBL has been successfully implemented in primary education, a science course, changing the traditional content driven. In this study, it was also discovered that PBL contributed positively towards pre-service teachers’ motivational component regarding how to teach science within a real-world context [8]. In PBL, students will be engaged in inquiry learning, identifying solutions based on their funds of knowledge through questioning and navigating of locations, objects, people, books, and any other relevant evidences, in particular, to support the appropriate solution. Thus, the seeking solution process from particular problems is a part of learning, especially collaborative learning among classroom members, which was carefully identified by students and lecturers. Although PBL is not a new endeavor in teacher education, little is documented how to examine PBL and divergent thinking in science teaching. For this reason, the present study aims to reveal how problem-based environment within divergent thinking could influence student teachers’ problem-solving skills in an Indonesian teacher education

2. Methodology

2.1. Setting, participants and design

This study was conducted in one of Indonesian universities, teacher education at a primary level. This site was considered due to the fact that students’ problem-solving skills towards environment were still low. In response to this situation, the present study attempted to intervene PBL and divergent thinking as the way out to create changes related to this skill. This study has also been conducted for six months, from February 2017 until July 2017 entailing some different processes: framing the issue, writing a research proposal, conducting research, and writing a research report. The participants of this study were second-year student teachers of teacher education at a primary level, based in West-Java, Indonesia. A number of participants in this study were 60 students whose ages were between 19-21 years old who were randomly recruited; most of them were female, 52 students, and the rest of them were male. These students were divided into two groups, i.e., experimental and control groups with 30 students for each group.

Informed by an experimental design, this study was a pretest-posttest control group design taking a place over the duration of a six-week undergraduate environmental education course. Since it has two independent variables, the experimental group was intervened with PBL with collaborative work while the control one was with the conventional lecture. The attributive variable was high divergent thinking and low divergent thinking. The design was simple factorial design (adapted from Best, 1982) which can be seen in table 1.
2.2. Data collection and analysis

In this study, data were collected through the test consisting of the objective test, multiple choice. Test items were 50 with five options for each question. This test aimed to examine to what extent students could comprehend the impact of pollution towards people’s health. However, before this test was given, it was analyzed its validity, reliability, and level of difficulty to ensure that the test was appropriate. To test the research hypothesis, they were different steps carried out: 1) analyzing normality using Kolmogrov-Smirnov and Liliefors normality test; 2) analyzing homogeneity with Bartlett test; 3) analyzing diversities between variables using ANOVA, which was then analyzed using Tuckey test because of the similar number of members for each group.

3. Result and discussion

The result of this study was that the researcher found PBL with divergent thinking has influenced on student teachers’ problem-solving skills related to environmental concern. Based on the result of analysis, ANOVA, it indicated that $F_{\text{observed}}$ is higher than $F_{\text{table}}$ (5.676 $>$ 4.01). In other words, there is a significant difference between student teachers’ problem-solving skills intervened by PBL and others with the conventional teaching method, lecturing. The diversity has also been shown by the average result of their environmental problem-solving skills with PBL, which is higher than the other one, problem-solving skills with lecturing, 44.85 $>$ 42.37. Additionally, to measure data with a significant average, it was then carried out testing t-Dunnet, and the result was $t_{\text{observed}}$ was higher than $q_{\text{table}}$ (0.05) ($t_{1:56} = 2.38$ $>$ 1.67). It indicated that the average result of a student teachers’ environmental problem-solving skills supported by discussion (see table 1) was much higher than the one with conventional teaching method, lecturing.

Despite the influence of PBL, the ability to solve the environmental problem has been affected by student teachers’ divergent thinking. Based on the result of ANOVA, it showed that $F_{\text{observed}}$ was higher than $F_{\text{table}}$ (6.634 $>$ 4.01). This result depicted that student teachers’ problem-solving skills within the high divergent thinking had significant difference than those with low divergent thinking: the difference from of the average was 44.93 $>$ 42.27. To see the clarity of the interaction result using ANOVA, it has been found that $F_{\text{observed}}$ AB, was higher than $F_{\text{table}}$ ($F_{\text{observed}} = 25.877 > F_{\text{label}}$ (0.05)/(1:56) = 4.01). This implied that there was a significant influence of interaction between teaching methodology and thinking divergent. Since the significance of interaction was high; therefore, it was continued to analyze the simple effect test. It resulted that students who learned environmental problem supported by PBL and high divergent thinking had a better understanding than those with high divergent thinking intervened by conventional teaching method, lecturing.

The aim of this study was to reveal the effect of PBL on student teachers’ problem-solving skills dealing with the environmental concern. Since the result showed the positive attribute of PBL towards student teachers’ problem-solving skills, few empirical studies evidenced integrated problems as the starting point in teaching and learning activities, and it became the foundation of learning, to be discussed collaboratively in a small group, more student-centered learning, bringing teacher as the facilitator not as a sole source of knowledge. This even implied further that PBL played a vital role in higher education curricula across the globe [9-12]. Moreover, other empirical works on PBL also demonstrated its positive attributes in the students’ learning process as well as the learning outcomes which could improve long-term retention of learning content [13] and skill development [14].

| PBL Divergent Thinking | (By Discussion Method) (A.) | (By Lecture Method) (A.) |
|------------------------|----------------------------|-------------------------|
| High (B.)              | A.B.                       | AB.                     |
| Low (B.)               | A.B.                       | AB.                     |
This study also placed emphasized on how PBL with divergent thinking could support student teachers’ problem-solving skills. It resulted that student teachers with high divergent thinking had better learning outcomes than those with low divergent thinking, especially intervened by PBL. Generally speaking, divergent thinking is the ability to proceed and respond particular issues (e.g., environmental problem, floods, pollution) using such different appropriate strategies as navigating through online sources and being brave to take any risk. In line with two studies Bignell et al. and Sun et al. PBL could be potential learning strategies for students so as to aid learning multi-skills context [15,16]. Additionally, in the 21st century era, students had better be prepared for more self-directed learning and development to enhance their skills which will be influential in their future careers. PBL in this case helps students hone these 4Cs skills: critical thinking, communication, collaboration, and creativity. Students find solutions to solve a problem and can solve it in the future [17]. Phungsuk, Viriyavejakul, and Ratanaolarn added that PBL also helps students build and enhance their learning outcomes [13]. The problems provided when teaching and learning process urged them in inquiry learning, bring them to have a high quality of learning. Besides using interactive multimedia is one of the learning media which is widely used by education practitioners in the learning process [18].

In this study, PBL resulted learning outcomes significantly because it allowed student teachers to engage in discussion when learning a problem. For this reason, Loyens, et al. Contended that students were encouraged to activate their background knowledge while discussing the problem in the group [19]. They also share ideas they have so to propose possible way out of the discussed problems. Each of the members also had the opportunities to navigate literatures related to the issues proposed in teaching and learning process. Therefore, this process shaped and reshaped students build and hone their problem-solving skills as well as understand how they learn [20].

4. Conclusion
From the illustration of this study, it can be concluded that implementing PBL with high divergent thinking in the teacher education could enhance student teachers’ environmental problem-solving skills compared to attending lectures and self-study. PBL also provided more learning spaces for them to engage actively in teaching and learning activities which scaffolded them one with each other to achieve the learning outcome. Since this study is a quantitative design, this study calls for more investigation how student teachers’ engagement through qualitative designs, such as classroom ethnographic research, action research, and narrative inquiry, in particular. Besides, the future research agenda can also investigate macro perspectives through a survey study involving more participants, which can get a clear and a big picture towards PBL in teacher education.

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