Improving creative thinking skill through project-based-learning in science for primary school

S U Putri, T Sumiati and I Larasati
Program Studi Pendidikan Guru Sekolah Dasar, University Pendidikan Indonesia
Kampus Purwakarta, Jl. Veteran No.8, Purwakarta 40151, Indonesia

*suciutami@upi.edu

Abstract. The aim of the present study is to examine the improvement of creative thinking skill of primary school students in science through project based learning (PBL). This research used quasi experiment with non-equivalent control group design. The study involved 45 fifth grade students at a public primary school in Karawang, West Java. The students were divided into two groups i.e. experimental group (n=24) and control group (n=21). The students in experimental group were given instruction through PBL; meanwhile, the control group were involved in traditional instruction. Creative thinking test was used as pre-test and post-test to both groups. The data were analyzed by using independent sample t-test to compare the creative thinking score between the experiment and the control group. The result showed that the students in experimental group had better creative thinking skill rather than the students in the control group. It can be concluded that project based learning can effectively improve creative thinking skill of primary school students in science class.

1. Introduction
In the context of 21st century learning, there are four skills that are very important to be mastered by an individual i.e. the Creative, Critical thinking, Collaborative, and Communication skill (4C skills). Those skills are the basic capital for students in facing the rapid development of technology and knowledge that give impact to the social, cultural and economic dynamics with all issues happening in the present era.

Creative thinking as one of the skills receives serious attention from Indonesian government which is written on the “Kurikulum 2013”. On the curriculum, it is clear that creative thinking skills need to be developed in the learning process to help students to be aware of recent problems and to find the solution based on their own knowledge. Creative thinking is a crucial skill which must be owned by individual for facing the complex problem in the future [1]. At the end of the twentieth century, creativity is conceptualized as something that anyone can acquire [2].

Creative thinking has been defined as the forming of associative elements into new combinations which either meet specified requirements or are in some way useful [3]. Creative thinking is about generating ideas that can in some way be applied to the world [4]. Creative thinking involves some activities, for example, formulating idea into a new knowledge to find new and better things [5,6]. The creative thinking process involves a number of scientific activities that begin with the problem definition which leads to information gathering and selection of the concepts to produce new...
knowledge through conceptual combination which then followed by evaluation and monitoring the ideas [7].

There are several indicators that indicate that an individual has creativity in thinking such as fluency, flexibility, originality and elaboration [8]. Other than that, Munandar [9] divided creative thinking into several indicators such as fluency, flexibility, originality, elaboration, evaluation, curiosity, imaginative, feel challenged by plurality, run-a risk, and respect for others. In primary school, not all of the indicators can be measured. This is influenced by the level of cognitive development of primary school students who are still limited in the concrete operational stage.

Based on the description above, it can be concluded that creative thinking is a complex cognitive process which can stimulate the students for developing the thinking skills. This thinking process can form students who are analytical and master good problem solving skill to deal with everyday problem. Science learning is very potential for helping students in developing their creative thinking skills through a set of scientific activities like observing, analyzing, evaluating, and creating some conclusion or product. Therefore, teacher as a facilitator can accommodate this need by integrating the creative process in scientific learning such as by making use project based learning approach.

Project based learning focuses on complex tasks, based on challenging questions or problems, that involve students in designing, problem-solving, decision making, or conducting investigative activities; gives students the opportunity to work relatively autonomously over extended periods of time; culminates in realistic products or presentations [10], and provides opportunities for students to work together and to do reflection [11]. In the PBL, students will be directed by content-related issues, learn concepts and information that can solve problems and apply that knowledge to complete assigned products so as to encourage the development of 21st century skill [12]. The benefit of project based learning is to improve students’ activity so they understand the content more deeply after they complete a project [8].

From the characteristics of project based learning which have been described above, it can be concluded that project based learning provides an opportunity for the students to investigate some problems through a scientific method, and it is relevant with the nature of science subject. Project-based science focuses on student-designed inquiry that is organized by investigations to answer driving questions, collaboration among learners and others, the use of new technology, and the creation of authentic artifacts that represent student’s understanding [13]. Through a series of such activities, the curiosity and active, innovative also interactive learning, it will promote the development of students’ thinking skills.

Many research has been done on project based learning. Project based learning in primary schools can help students to master the concept, to increase the motivation of learning and to develop positive attitude in social interaction [14]. Moreover, the implementation of project based learning can improve the academic achievement of the students on science [15,16]. Another study has shown that the integration of technology in project based learning can improve self-efficacy and build a positive opinion about the use of project based learning [17]. Therefore, to examine the effect of project based learning on thinking process, more specific research need to be conducted. The research question of the present study is to identify the significance different of creative thinking skills between traditional learning instruction and project based learning instruction in science on fifth grade students.

2. Method

Quasy experiment was used in the present research with nonequivalent control group design. The present study involves 45 fifth grade students at a public primary school in Karawang, West Java, Indonesia. The students were divided into two groups i.e. the experimental group (n=24) and the control group (n=21). The students in the experimental group were given instruction through PBL, and the control group were involved in the traditional instruction. Pretest and posttest were given to both groups to identify the creative thinking skills before and after the implementation of the learning by using creative thinking test on science unit regarding the “water cycle”. The test is developed based on four creative thinking indicators that can be measured in primary school students such as fluency,
flexibility, elaboration and evaluation. The process of learning was conducted eight times by face to face meeting consisting of: 1) introduce project based learning; 2) provide an initial description about the water cycle and formulate the problem; 3) find and discuss the information from the internet related to the problem; 4) make a plan to complete the task; 5) report the plan and receive the feedback for improvement; 5) do the task (create water cycle models); 6) report progress and receive the feedback for the next improvement; 7) complete the task; and 8) create a publicity of the water cycle model. The data was analyzed using SPSS v.21 by calculating the statistic inferential using independent sample t-test if the data is normally distributed or using Mann-Whitney test if the data is not normally distributed.

3. Result and discussion

The scores of creative thinking skills of the students were compared between the control and the experimental group both on pretest and posttest using independent samples t-test or Mann-Whitney test. The result of the calculation will be presented in Table 1, 2, 3 and 4 below.

Table 1. Pre-test result of students’ creative thinking scores using independent sample t-test.

| Pre-test | Groups    | N  | Mean | SD  | t    | df | p   |
|----------|-----------|----|------|-----|------|----|-----|
|          | Creative  | 21 | 16.09| 3.81| 4.270| 43 | 0.000|
|          | thinking  |    |      |     |      |    |     |
|          | Control   |    |      |     |      |    |     |
|          | Experimental | 24 | 11.07| 3.20|      |    |     |

Table 2. Pretest result on each indicator of students’ creative thinking using Mann-Whitney test.

| Pre-test | Groups    | N  | Mean | SD  | p   |
|----------|-----------|----|------|-----|-----|
|          | Fluency   |    |      |     |     |
|          | Control   | 21 | 1.09 | 5.83| 0.072|
|          | Experimental | 24 | 0.79 | 3.58|
|          | Flexibility |    |      |     |     |
|          | Control   | 21 | 3.52 | 8.13| 0.000|
|          | Experimental | 24 | 1.79 | 7.21|
|          | Elaboration |    |      |     |     |
|          | Control   | 21 | 1.85 | 7.77| 0.492|
|          | Experimental | 24 | 2.06 | 8.63|
|          | Evaluation |    |      |     |     |
|          | Control   | 21 | 2.30 | 5.36| 0.000|
|          | Experimental | 24 | 1.40 | 5.47|

As seen in Table 1, there is a significance difference between the two groups’ pretest score (p < α, 0.00 < 0.05). The mean scores show that control group has better mean score than the experimental group. It means that creative thinking between control and experimental group is not at the same level.

Table 2 shows that there is no significant difference between control and experimental group on fluency and elaboration (p (fluency) > α, 0.072 > 0.05; p (elaboration) > α, 0.492 > 0.05), it suggests that the two groups were equal in terms of both indicators. Different condition can be observed on the flexibility and evaluation indicators. The data shows that there is a significant difference between two groups (p (flexibility) > α, 0.072 < 0.05; p (evaluation) > α, 0.492 < 0.05). The mean scores on flexibility and evaluation show that the control group has better scores than the experimental group.

Table 3. Post-test result of students’ creative thinking scores using independent sample t-test.

| Post-test | Groups    | n  | Mean | SD  | t    | df | p   |
|-----------|-----------|----|------|-----|------|----|-----|
| Creative  | Control   | 21 | 16.28| 5.37| -4.782| 43 | 0.000|
| thinking  | Experimental | 24 | 22.29| 4.41|

As seen in Table 1, there is a significance difference between the two groups’ pretest score (p < α, 0.00 < 0.05). The mean scores show that control group has better mean score than the experimental group. It means that creative thinking between control and experimental group is not at the same level.

Table 2 shows that there is no significant difference between control and experimental group on fluency and elaboration (p (fluency) > α, 0.072 > 0.05; p (elaboration) > α, 0.492 > 0.05), it suggests that the two groups were equal in terms of both indicators. Different condition can be observed on the flexibility and evaluation indicators. The data shows that there is a significant difference between two groups (p (flexibility) > α, 0.072 < 0.05; p (evaluation) > α, 0.492 < 0.05). The mean scores on flexibility and evaluation show that the control group has better scores than the experimental group.
Table 4. Post-test result on each indicator of students’ creative thinking using Mann-Whitney or t-test.

| Pre-test | Groups     | n  | Mean | SD  | Mann-Whitney | t-test |
|----------|------------|----|------|-----|--------------|--------|
|          |            |    |      |     | p            | p      |
| Fluency  | Control    | 21 | 1.09 | 5.83| 0.012        | -      |
|          | Experimental| 24 | 0.79 | 3.58| -            | -      |
| Flexibility | Control    | 21 | 3.52 | 8.13| 0.033        | -      |
|          | Experimental| 24 | 1.79 | 7.21| -            | -      |
| Elaboration | Control    | 21 | 1.85 | 7.77| 0.000        | -      |
|          | Experimental| 24 | 2.06 | 8.63| -            | -      |
| Evaluation | Control    | 21 | 2.30 | 5.36| -            | 0.000  |
|          | Experimental| 24 | 1.40 | 5.47| -            | -      |

According to Table 3, it can be observed that there is a significant difference between creative thinking scores of the control and the experimental group (p < α, 0.00 < 0.05). From the post-test scores, the experimental group shows a better creative thinking than the control group. Moreover, in Table 4, it can be observed that there is a significant difference almost in all indicators of creative thinking (p(fluency) < α, 0.012 < 0.05; p(flexibility) < α, 0.03 < 0.05; p(elaboration) < α, 0.00 < 0.05; p(evaluation) < α, 0.00 < 0.05).

Given that the pretest result indicates that there is a significant difference between the control and experimental group which means that one group is at a better level, the effectiveness of the implementation of project based learning in the present study can not only be deduced based on the result of the statistical test of the posttest score. A statistical test of individual n-gain scores is needed. The result of the statistical test of students’ n-gain scores are presented in Table 5 and 6 below.

Table 5. N-gain scores using independent sample t-test.

| Pre-test | Groups     | n  | Mean | SD  | t       | df  | p     |
|----------|------------|----|------|-----|---------|-----|-------|
| Creative thinking | Control    | 21 | 0.02 | 2.03| -8.849  | 43  | 0.000 |
|          | Experimental| 24 | 0.54 | 1.91|         |     |       |

Table 6. N-gain scores on each indicator using Mann-Whitney test.

| Pre-test | Groups     | N  | Mean | SD  | p     |
|----------|------------|----|------|-----|-------|
| Fluency  | Control    | 21 | 0.03 | 2.26| 0.000 |
|          | Experimental| 24 | 0.27 | 1.68|       |
| Flexibility | Control    | 21 | 0.42 | 5.07| 0.464 |
|          | Experimental| 24 | 0.52 | 4.09|       |
| Elaboration | Control    | 21 | 0.02 | 4.74| 0.000 |
|          | Experimental| 24 | 0.58 | 5.60|       |
| Evaluation | Control    | 21 | 0.20 | 5.13| 0.000 |
|          | Experimental| 24 | 0.67 | 3.41|       |

In Table 5, based on the n-gain scores of all indicators of creative thinking skills, it can be observed that there is a significant difference between the n-gain scores of the experimental and the control group (p < α, 0.00 < 0.05). However, Table 6 shows that there is no significant difference in flexibility (p > α, 0.464 > 0.05). The contradicting condition can be observed in fluency, elaboration, and evaluation indicator (p(fluency) < α, 0.00 < 0.05). The improvement of creative thinking skill in the experiment group is influenced by the opportunity for the students to explore materials from many sources, printed and online, which facilitates the success in investigating a problem individually. Project based learning is an innovative
learning model which facilitates students’ learning with meaningful activities. As explained by Berger [18] that PBL combines different learning elements so that students’ learning experience is complete and whole.

In PBL, students are guided by a problem which leads them in completing a certain project through investigating facts derived from many sources, organizing and analyzing plan to complete the project, getting feedback both from their peer and teacher in evaluating and revising the project and doing publicity. This kind of learning will improve students’ critical and creative thinking.

Based on the analysis of the students’ posttest, it can be observed that there is a significant difference in all students’ creative thinking skill indicators. However, since the pretest shows a difference between students’ creative thinking initial skill in two measured indicators i.e. in the fluency and elaboration, the analysis is continued by conducting statistical examination on the students’ n-gain score of each indicator which shows a significant difference in almost all indicators except on flexibility.

The absence of significant difference on the indicator of flexibility is influenced by the similar learning activity in the control and experiment group on giving a temporary answer on the problem in water cycle concept that the students’ proposed. Dominant material emphasis in the control class and guided-individual exploration in the experiment class cause both groups to have certain strength in finding temporary solution regarding the proposed problem.

The improvement of students’ creative thinking in the indicator of fluency is supported by some science learning activities on water cycle unit through PBL, they are: 1) explaining the water cycle in detail, 2) determining the design project of water cycle unit, 3) preparing tools and materials. The varied activity in fluency in the experiment class gives students varied opportunity to develop better fluency thinking skill.

The process of problem solving and a detail product, designing and creating the project, and organizing the project based on the design are some activities which facilitate the students’ elaboration skill. In addition, feedback from their peer and teacher during the presentation of project planning, design and improvement can give the students stimulus to analyze in more detail in the revising activity so a perfect project is obtained.

In the evaluation indicator, students in experiment class are better than the students in the control group class because they are given opportunity in expressing their opinion on the plan, design, and development of the project made by their friends from different group. In addition, making consideration of their friends’ feedback and suggestion on the project they have made also gives effect on their ability in evaluating a statement.

The explanation above shows that project based learning can facilitate the students to develop themselves particularly on creative thinking skills. The stimulus of creative thinking in the phase of collecting ideas, designing, developing the project, making publicity for their product trigger them to continuously exploring, imagining, and innovating the project they are making. This argument is supported by Al-Tabany [19] who says that learning with project based is an effective learning approach focusing on thinking creatively.

4. Conclusion
Science learning is not only about comprehending science concepts but also on how students can learn through science. Therefore, obtaining products of facts, theories, laws, and principles is not the main target of the learning. Science is seen as a learning process based on constructivism and inquiry which can facilitate students’ potentials. Creative thinking is one of the skills which should be mastered by the students in facing 21st century challenges. Project based learning is an appropriate and innovative model in developing 4Cs skill in 21st century education.

Acknowledgments
I am very grateful to the following individuals that provided invaluable perspective, general suggestion, and support during the planning and development of this research work: Prof. Dr.
Turmudi, M.Ed., M.Sc., Ph.D, Director of UPI Kampus Purwakarta, Dadang, Sumpena, S.Pd, Head Officer of SDN Cikampek Barat III, Karawang, West Java, Indonesia and Koswara, S.Pd, Teacher of SDN Cikampek Barat III, Karawang, West Java, Indonesia.

References
[1] Gardner H 2010 Five minds for the future (Cambridge, MA: Harvard Business School Press)
[2] Alghafri R S A and Ismail B N H 2014 The Effects of Integrating Creative and Critical Thinking on Schools Students’ Thinking International Journal of Social Science and Humanity 4 6 p 519-525
[3] Mednick A S 1962 The associative basis of the creative process Psychological Review 69 3 p 220-232
[4] Anwar N M, Aness M., Khizar A, Naseer M and Muhammad G 2012 Relationship of Creative Thinking with the Academic Achievements of Secondary School Students International Interdisciplinary Journal of Education 1 3 p 44-47
[5] Lee K H 2005 The relationship between creative thinking ability and creative personality of preschoolers International Education Journal 6 2 p 194-199
[6] Crumpler W 2014 Higher-Order Skills in Critical and Creative Thinking [online] Available at: https://2014.accreditation.ncsu.edu/pdf/FINAL%20QEP%20DOCUMENT.pdf [Accessed 11 Feb. 2018]
[7] Mumford D M, Medeiros K and Partlow J P 2012 Creative Thinking: Processes, Strategies, and Knowledge The Journal of Creative Behavior 46 1 p 30–47
[8] Thomas J 2000 A Review of Research On Project-Based Learning [online] Available at: http://www.bie.org/index.php/site/RE/pbl_research/29 [Accessed 4 Jan. 2018].
[9] Munandar U 1999 Mengembangkan Bakat dan Kreativitas anak Sekolah (Jakarta: Rineka Cipta)
[10] Thomas J, Mergendoller J and Michaelson A 1999 Project-based learning: A handbook for middle and high school teachers (Novato, CA: The Buck Institute for Education)
[11] Diehl W, Grobe T, Lopez H and Cabral C 1999 Project-based learning: A strategy for teaching and learning (Boston, MA: Center for Youth Development and Education, Corporation for Business, Work, and Learning)
[12] Bradley Levine J and Mosier G 2014 Literature Review on Project-Based Learning [online] http://cell.uindy.edu/wp-content/uploads/2014/07/PBL-Lit-Review_Jan14.2014.pdf
[13] W R, Phyllis C M, Joseph S B and Soloway E 1997 Enacting Project-Based Science The Elementary School Journal 97 4 p 341-358
[14] Kaldı S, Filippatou D and Govaris C 2011 Project-based learning in primary schools: effects on pupils learning and attitude Education 39 1 p 35-47
[15] Cakici Y and Turkmen N 2013 An investigation of the effect of project-based learning approach on children’s achievement and attitude in science The online journal of science and technology 3 2 p 9-17
[16] Kizkapan O and Bektas O 2017 The effect of project based learning on seventh grade students’ academic achievement International Journal of Instruction 10 1 p 37-54
[17] Bilgin I, Karakuş Y and Ay Y 2015 The effects of project based learning on undergraduate student’s achievement and self-efficacy beliefs towards science teaching Eurasia Journal of Mathematics 11 3 p 469-477
[18] Berger R 2012 Work that matters: The teacher’s guide project-based learning (London: Paul Hamlyn Foundation)
[19] Al-Tabany T I B 2014 Mendesain model pembelajaran inovatif progresif dan kontekstual (Jakarta: Prenadamedia)