The effectiveness of project-based learning on students’ communication skills in science

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Abstract. This study aims at analyzing the effectiveness of project-based learning on elementary school students’ communication skills. This study involved 45 5th grade students who were divided into experimental groups (n=24) and control groups (n=21). Both classes were given a pre-test to identify students’ communication skills before learning. The experimental group were given instruction by using project-based learning while the control groups using cooperative learning. At the end of the learning process, the two groups were given post-test. The research instrument used a communication skills test developed in accordance with the water cycle science materials. Data were analyze using n-gain and non-parametric test (mann whitney). Based on the results of the study, it can be identified that there is an increasing number of most of the communication skills indicators except for the drawing the water cycle process and how to save water indicators. The implication of this research is that project-based learning can be an alternative to build the 21st century skills for elementary students in science subject.

1. Introduction
Communication skills are one of the skills that are very important to be achieved by students as a provision for dealing with a complex work and life environment in the 21st century and can lead into more sophisticated, complicated soft skills of critical thinking, problem solving, stress management, and risk taking [1,2]. Regarding the dynamic life in the 21st century which comprise the developments in all sectors, including economic, social, cultural and education, it requires the generation who are able to survive and adapt with all changes. This requirement can be manifested in the form of communication.

Communication skills are the ability to convey the idea effectively verbally and nonverbal in various forms and contexts [3]. In addition, communication has been playing as an assessment in the form of reading, writing and alternative representations such as graphing in mathematics and science, listening and speaking, the assessments have not taken into account the full range of possibilities [4].

The development of communication skills in science can be carried out in interactive and innovative learning situations such as in project-based learning. Project based learning can be viewed as a critical strategy that involves students in investigative activities that are carried out collaboratively and lead to the creation of a project that reflects the knowledge they have [5]. Project based learning can be seen as a learning system that provides independent learning to students, constructive investigations, goal orientation, negotiation, collaboration, communication and reflection in learning situations related to the real world [5,6]. A number of stages that are needed to be passed in the project-based learning is to raise contextual problems that allow students to find solutions, conduct investigations to gather information
and data, analyze and interpret data - which consists of drawing conclusions and report findings [7]. These characteristics allow for the development of various skills such as critical, creative, communication and collaborative thinking as outlined in 21st century learning [8].

Based on the research, project-based learning relatively gives a major contribution especially to the characteristics of teacher-student interaction such as giving praise and encouragement continuously and using asking and answering questions technique for imparting knowledge [9]. Project based learning enabled students to improve in academic achievement as well as developing positive attitude, motivation, problem solving ability, and high order thinking [10-12]. Based on the results of these studies, it can be concluded that project-based learning has the potential to develop various abilities in students. However, the results of research related to the effectiveness of project-based learning in elementary schools have not been widely implemented. Therefore, research on the effectiveness of implementation project-based learning at the elementary school level is very necessary especially related to communication skills students.

Implementation of project-based learning in science for elementary can be conducted in water cycle material. Water cycle as one of the science concepts that needs to be learned requires communication skills because students must be able to understand the process through pictures or schemes. In the textbook, the water cycle process is described as follows.

![Figure 1. Water cycle process.](image)

Based on the figure 1, students must describe the process of the water cycle, which includes evaporation and transpiration, condensation, precipitation and surface runoff using their own sentences. In addition, in this concept, students must classify natural and artificial water sources in tables, explain images that can disrupt the water cycle, sort images of the impact of natural disasters due to imbalance in the water cycle, and explain ways to save water through images. To achieve these learning objectives, the concept of the water cycle will be studied through the implementation of project-based learning.

2. Research method
This study involved two groups of 5th grade students consisting of control groups (n = 21) and experiments (n = 24). The control group are involved in science learning by using cooperative learning, while the experimental group using project-based learning. Both groups were given a pretest to identify the initial communication skills as a basis for analyzing the improvement compared with the posttest. Furthermore, the data was taken by communication skills test that can measure the indicators of communication skills such as: 1) drawing the water cycle process and how to save water, 2) explaining the picture about the causes of water cycle disruption, 3) making a table about water sources that can be used by humans, and 4) sorting images of environmental destruction that can affect the water cycle. Data were analyzed by calculating the n-gain score and non-parametric test (Mann-Whitney). The statistical calculations performed with the assist of SPSS version 23 while the calculation of n-gain scores used the formula below.
Note:
\[ g = \frac{T_2 - T_1}{T_{maks} - T_1} \]

The n-gain score is then translated into the following criteria.

| N-Gain   | Criteria   |
|----------|------------|
| \( g \geq 0.7 \) | High       |
| \( 0.3 \leq g \leq 0.7 \) | Middle     |
| \( g < 0.3 \) | Low        |

3. Result and discussion

The initial stage of learning the water cycle using project-based learning was asking about where water comes from, how the water cycle process occurs, what things can disrupt the water cycle, what events will occur due to imbalances in the water cycle, and how to save water. To answer these questions, students were asked to find information from the internet or books and discussed the answers in the group. To make things easier, activities in groups were assisted by using student worksheets. At the final lesson, students were asked to make a product that describes the process of the water cycle and explained the process using the product that has been made. It took three weeks for entire learning activities using project-based learning.

Based on the analysis of communication skills tests, most students could answer questions related to the water cycle by properly using various forms of non-verbal communication. Various forms of student answers can be seen in Figure 2.
Figure 2. Various form of non-verbal communication skills students.

To identify the improvement of students' communication skills, the n-gain test was conducted on pretest and posttest in the experimental and control group. The results of n-gain analysis can be seen in Table 2.

Table 2. Analysis of n-gain scores in the control and experiment group.

| Communication skill indicator | Control group | | | Experiment group | | |
|-------------------------------|---------------|---|---|------------------|---|---|
|                               | Mean | N-gain | Criteria | Mean | N-gain | Criteria |
| Pre | Post | Score | Criteria | Pre | Post | Score | Criteria |
| Drawing the water cycle process and how to save water | 48,7 | 58,2 | 0.23 | Low | 49,5 | 74,0 | 0.34 | Middle |
| Explaining the picture about the causes of water cycle disruption | 52,5 | 52,5 | -0.03 | Low | 42,7 | 62,5 | 0.31 | Middle |
| Making a table about water sources that can be used by humans | 35,7 | 42,7 | -0.02 | Low | 53,2 | 80,2 | 0.64 | Middle |
| Sorting images of environmental destruction that can affect the water cycle | 42,7 | 46,5 | 0.03 | Low | 47,0 | 62,2 | 0.22 | Low |

In Table 2, the improvement of students' communication skills in the experimental group is generally higher than the control group. It can be concluded that the application of project-based learning contributes to students' communication skills. Whether, the indicator sort images of environmental destruction that can affect the water cycle shows that the communication skills are at the same level. However, based on n-gain score, the experimental group has a greater score than the control group. Then, identifying the significance difference of the communication skills between control and experimental group, parametric (t-test) and nonparametric tests (Mann-Whitney) were carried out.

Table 3. Statistical test results of N-gain scores of each student communication skill indicator.

| Communication skill indicator | Component | Control group | | | Experimental group | | |
|-------------------------------|-----------|---------------|---|---|--------------------|---|---|
|                               |           | Normality test (α = 0.05) | | | Homogeneity test (α = 0.05) | | |
|                               |           | Pvalue | 0.004 | abnormal | abnormal |
|                               |           | Note   |       |            |           | |
|                               |           | F      | 0.576 | Homogen |            | |
|                               |           | Note   |       |           |           | |
|                               |           | Mann-whitney (α = 0.05) | | |                         | |
|                               |           | Pvalue | 0.889 |           |            | |
|                               |           | Note   |       | No significance different | | |

Figure 2. cont.

explain how to save water with pictures and text
Table 3. cont.

| Explain the picture about the causes of water cycle disruption | Normality test (α = 0,05) |
|---------------------------------------------------------------|--------------------------|
| Pvalue                                                       | 0,026 0,000              |
| Note                                                         | abnormal abnormal        |
| Homogeneity test (α = 0,05)                                  |                          |
| F                                                           | 0,012                    |
| Note                                                         | Heterogenous              |
| Mann-whitney (α = 0,05)                                      |                          |
| Pvalue                                                       | 0,004                    |
| Note                                                         | Significance Different    |

Making a table about water sources that can be used by humans

| Normality test (α = 0,05) |
|----------------------------|
| Pvalue                     |
| Note                       |
| Homogeneity test (α = 0,05) |
| F                          |
| Note                       |
| Mann-whitney (α = 0,05)    |
| Pvalue                     |
| Note                       |
| Homogeneity test (α = 0,05) |
| F                          |
| Note                       |
| Mann-Whitney (α = 0,05)    |
| Pvalue                     |
| Note                       |

Sorting images of environmental destruction that can affect the water cycle

Based on the Table 3, the n-gain scores in the experimental and control group showed that there were significant differences in almost every indicator of student communication skill. It means that the Project Based Learning model contributes significantly to students' communication skills in the experimental group. Besides that, there is one indicator of students' communication skills. It indicates that there is no significant difference on the indicator of Drawing the water cycle process and how to save water. It means that the students' communication skills on the indicators in both of the control and the experimental group are at the same level.

Based on the results, it can be identified that the implementation of project-based learning has proven effectively increasing most of the indicators of communication skills except in the skill of drawing the water cycle process and how to save water. Nevertheless, the results of this study indicate that overall implementation of project-based learning has a significant effect on student communication skills.

The improvement of communication skills can be influenced by collaborative learning situations oriented to contextual problems in accordance with the concepts learned and provide flexibility for students to determine ways to solve problems and apply their knowledge into different forms through project creation. Teamwork activity allows students to exchange ideas about problems or project completion. Such characters can affect the way of thinking which is able to be manifested in the form of communication skill. Student’s activity revolves around a complex series of interactions between teams’ members over time and draws on a range of key transferable skills such as communication, planning and team working [8].

The investigation activities in project-based learning are able to help students to build their own concepts that need to be understood. In the context of this research, the concept that needs to be understood by students is related to water cycle material. Based on the test results, it is known that students' understanding of water cycle material in the form of written communication has increased. It means that the learning experience in the project-based learning is able to help students understand about
the concept and applying the concept into different form. Project-Based Learning (PBL) are effectively increasing academic achievement of student in science learning for elementary [13]. Furthermore, the involvement of students in their playhouse design project could influence their understanding and communication of basic math’s and geometry [14].

4. Conclusion
Project based learning based on constructivism theory by adapting the steps of the scientific method. This is in accordance with the nature of science especially in the aspect of the process. The formulation of problems that lead to the completion of the project through collaborative activities allows students to have many opportunities to interact and communicate with each other. In addition, the investigation activities carried out independently with the guidance of the teacher make it possible for students to obtain appropriate information. The obligation to make a project and to publish it can train students' ability to convey the knowledge they have in the form of written and oral communication. Project based learning not only able to recall what they have learned for long periods of time, they are also able to transfer their learning across different contexts [15]. Improving student communication in this study reflects the science knowledge that has been built through the learning process with project-based learning. This shows that project-based learning that is applied in learning in elementary schools also impacts other academic achievements, such as collaboration skills (social skills), the 21st century skills are related to higher orders thinking such as critical and creative thinking, deep content knowledge and also self-directed learning [15,16]. The various advantages of implementing project-based learning have certain implications for the application of curriculum in the schools, especially in Indonesia. Adjusting the curriculum based on the development of students' skills in facing the challenges of the 21st century needs to be a major concern. This can be preceded by increasing primary teacher professionalism which related to technology literate, scientific development, and innovative and up-to-date pedagogical knowledge, so that the characteristics of the 21st century teachers can be realized. The efforts to increase professionalism are carried out with the aim that Indonesia has competitive and progressive human resources in accordance with the progress of the times.

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