The effectiveness of Project-based Learning on students' science process skills: a literature review

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Abstract. The aim of this literature review is to analyse the effectiveness of project-based learning on students’ science process skills (SPS). Project-based learning as the learning method, which is recommended by the Indonesian curriculum, supposed to improve students’ skills. Indonesian curriculum emphasizes the achievement of students’ competencies, namely spiritual, social, knowledge and skills. SPS are the part of skills competency that will improve in science learning process. The method used in this study is a literature review. First, the researcher provides the definition of project-based learning. Next step is to find information about how to conduct project-based learning and the important things to do in project-based learning. Then, the researcher synthesizes some information about work had been done to improve SPS in the previous study and make a connection with project-based learning. Based on the literature review, students’ SPS will improve through clear instructions which involve students to design the science learning activities. The finding indicated that project-based learning activities effective to improve students’ SPS.

1. Introduction

The curriculum implemented in Indonesia emphasizing on reforming the human resources which are knowledgeable and skilled through developing the cognitive, affective and psychomotor aspects to the students [1]. Those aspects implemented in the educational practice aims to make students having competencies needed in the social life nowadays and for future. There are four main competencies in this curriculum, namely spiritual, social, knowledge and skills. Students’ skills competency based on the curriculum is having ability to implement their knowledge in order to make scientific inquiry, problem-solving and creating a creative product related to the daily life [1]. The ability to implement the knowledge in skills competency can be reached through activities such as observing, questioning, exploring, processing, analyzing, presenting, and creating [1]. Those activities represent SPS that is the skills needed by the students in the science learning [2]. SPS are one of the parts of skills that will be improved in science learning process. SPS are important for students to enhance students’ thinking skills and mastering science concept [3].

SPS are the skills that we use when doing science. Teaching SPS is important to reach students’ understanding on the knowledge [2]. SPS are one of competencies measured in the PISA test, and Indonesian students got low rank on PISA test in the year 2015. Indonesian students’ SPS level are low
The facts indicated that Indonesian students’ SPS need to improve since those skills are important for students to achieve the skills competency demanded by curriculum and will help students to fulfill the knowledge competency by mastering the concept of science.

The needs of using SPS in science learning by students lead the government developing the learning process in the curriculum which aims to improve knowledge, thinking skills and psychomotor. The learning process designed into activities-based learning. The activities in science learning process using scientific method which includes activities, namely observing, formulating the problem, formulating a hypothesis, designing experiments, collecting data, analyzing, concluding and making recommendations, and communicating the results. Then the science learning process simplifies the scientific method into 5M activities (in Bahasa Indonesia) they are: mengamati (observing), menanya (questioning), mengumpulkan data (collecting data), menganalisis (analyzing) and mengomunikasikan (communicating).

The learning process provided activities which help students to involve them using the SPS. The curriculum highly recommended the using of project-based learning method to achieve the skills competency. Project-based learning method provides the opportunity for the students to create a product in order to solve the problem in the daily life [1]. The activities in project-based learning involved students to use their skills and improve students’ skills. The involvement of students in the project-based learning may develop their thinking skills, critical thinking and creativity [7].

The purpose of discussing project-based learning to improve students’ SPS through literature review was to investigate the effectiveness of project-based learning on students’ SPS. The previous studies on project-based learning and SPS are varied, and each researcher has different perspective on interpreting and conducting project-based learning and SPS. The question guides this study is how is the effectiveness of project-based learning on students’ SPS?

2. Method

This study is a literature review from previous research which related to project-based learning method in science learning. This literature review includes research on SPS in science learning. To investigate this study, we refer to the previous articles related to the effectiveness of project-based learning on students’ SPS.

The following steps were taken to investigate the effectiveness of project-based learning method on students’ SPS: (1) identified science education articles related to project-based learning method and SPS, (2) analyzed the definition of project-based learning, (3) investigate information about how to conduct project-based learning and the important thing to do in project-based learning, (4) synthesizes some information about work had been done to improve SPS in the previous study, (5) analyzed the reason why project-based learning is effective on students’ SPS, and (6) create the conclusions for this study.

3. Results and Discussion

3.1. What is “Project-based Learning”?

Project-based learning is a learning method that is design the learning process with a project. It is a set of activities begin with posing an essential questions, students are take responsibility to design the activities and supported to produce product [7]. The definitions of project-based learning from previous study are shown in the Table 1.

The basic of project-based learning is the existence of contextual problem. The characteristics of project-based learning method that distinguish it to the others method is problem orientation and support students to design their own learning [8]. In the project-based learning method, the students pursue knowledge through their curiosity into a phenomenon that they face in cooperation in life by developing and asking a question [7, 9]. The learning process considered as an inquiry since the context of learning provided through problem or question stated within real-world practices [10]. The previous studies above emphasize on the essential of requiring questions or problem in project-based learning.
Table 1. Definition of project-based learning from previous study

| Author(s)                      | Poses Problem | Explore Real World | Self-Regulation | Involve Skills | Produce Product |
|--------------------------------|---------------|--------------------|-----------------|---------------|-----------------|
| Bell (2010)                    | ✓             | ✓                  | ✓               | ✓             | ✓               |
| Ergül & Kargın (2014)          | ✓             | ✓                  | ✓               | ✓             | ✓               |
| Al-Balushi & Al-aamri (2014)   | ✓             | ✓                  | ✓               | ✓             | ✓               |
| Corvers R et al. (2014)        | ✓             | ✓                  | ✓               | ✓             | ✓               |
| Chiang & Lee (2016)            | ✓             | ✓                  | ✓               | ✓             | ✓               |
| Anazifa & Djukri (2017)        | ✓             | ✓                  | ✓               | ✓             | ✓               |

In project-based learning, students solve the problem in real world context in order to engage students in real-world tasks [9]. Students are being placed in the realistic and contextual problem solving environment. In so doing, project can encourage students to access information on their own [11]. Students not only design but also direct the activities in project-based learning using their creativity, prefer to solve the surrounding environment problems brought to the classroom [12]. Bringing the problem to solve by the students from the daily life experience will engage students more in the learning process. Their experience and understanding will motivate them to take a role on designing the activity; students will think that the stated problem is their problem which needs their contribution to solve. For example, when students are learning in the topic of energy and they stated a problem based on their observation and experience about the over usage of fossil fuel in motor vehicle.

The stated problem itself determines the activities will be conducted in the learning process. The learning activities involve students or group of students to be initiative solving the stated problem and necessitate a variety of educational activities [11]. Students take their responsibility on control the learning process and utilize their prior knowledge and experience [13]. Project-based learning method build up learning environment which is provides students with the chances to involve and take responsibility of their own learning, developing students, and having them comprehend and structure information [12]. The learning process emphasize in students centered learning, so project-based learning gives the opportunity for the students to work on their activities while trying to solve the stated problem. Project-based learning teaches students become a responsible, independence, and discipline learner through creating independent thinkers and learner [9]. The activities in project-based learning are designed by the students through teachers’ guide. Teacher act as a facilitator whose keep the students work on the track of the project.

Students have their responsibility on designing the activities to solve the problem. The activities must provide a chance to collect data or information which are necessary for their projects’ goal. In project-based learning process students learn the fundamental skills which are needed in science learning such as productive communication, respect for others, and teamwork while generating ideas together [9]. Students were motivated to do discussion to sum up the information based on the stated problem [11]. The statement above explained that during project-based learning activities students have to involve their skills. The use of those skills continuously can help students improving their ability to use more skills needed in the learning process. If students have fossil fuel over usage as the problem, and want to make a report of the society point of view about the usage of fossil fuel, students can start the activities through investigating, collecting data, analyzing, etc.

Doing project is the base of project-based learning. The project conducting in project-based learning can be interpreted in some product result. The stated problem or question which is driving the learning activities results the product which addresses to the question. Students give effort to produce product through steps of constructing process [12, 14]. Project-based learning is a learning method with the product and task oriented, after students conducting the learning activities and discovering new finding they have to produce product related to stated question [9, 12]. The final product in project-based learning is commonly results in various forms such as thesis, report, design plans, computer program and model.
In conclusion, project-based learning can be defined as a learning method which is provide a real-world problem to solve by the students through their own activities by involving their prior knowledge and skills then ended by a final product as the result of the project.

3.2. Project-based Learning on Science Process Skills

Project-based learning is skills-based learning which is in the process of project-based learning activities involved some skills. Project-based learning teaches important skills. The skills involve in project-based learning shown in the Table 2.

| Author                | Teamwork | Problem Solving | Critical Thinking | Communicating | Researching | Creativity |
|-----------------------|----------|-----------------|-------------------|---------------|-------------|------------|
| Arce et al., (2013)   | ✓        |                 |                   |               |             | ✓          |
| Ergül & Kargın (2014) |          | ✓               |                   | ✓             | ✓           |            |
| Ilter (2014)          | ✓        | ✓               |                   | ✓             | ✓           |            |
| Bradley & Mosier (2014)| ✓        | ✓               |                   | ✓             | ✓           |            |
| Anazifa & Djukri (2017)| ✓        |                 |                   |               |             | ✓          |

Project-based learning provides a problem to solve by the student individually or students in small group. Working in a group needs collaboration skills to build a good team. Project-based learning provides collaborative learning environment which can improve teamwork skills among students [15,16]. In a group, students learn how to work on collaboration with the other team member. Students discussing in a group to design the learning activities based on the stated problem or question. Further, the research on project-based learning has been shown to foster collaboration skills in a variety of students [17]. Problem poses in the project-based learning will pursue students to think the solution overcoming the problem. Students will be empowered to use effective work habits and apply problem solving skills by finding or creating solutions in relevant projects. The learning process was organized to encourage the students developing their problem solving, skills by carrying out projects [16]. Result in previous studies indicated that project-based learning improving problem solving skills [12,17].

The activities carried out by the students to solve the problem support them to improve their critical thinking skills [16]. Students learn through collaboration and employ critical thinking skills as they engage in projects [9]. Studies have revealed the project-based learning let the students implementing critical thinking skills to solve problem through various project [16,17]. Project-based learning can be defined as an investigative activities which culminating the product through project which is involves communication skills [16]. The core of communication is to share both prior and new finding knowledge after doing project. Students can communicate to others through variety method such as presentation, demonstration and discussion. Studying science means doing research. Students conducted research to answer the stated question or problem.

The researching activities engage students to participate in real-work activities. Once students work in activities to pursue the new knowledge can improve students researching skill [15,16]. Students demanded to be creative while designing the activities and final product. Project-based learning is an effective way to developing creativity. In the learning process provided supported environment for the students to build up their creativity [9,12,16,17].

There is no limitation to what skills involve and can be improved through project-based learning. The poses problem and student’s ability will be determining the learning activities. Students who improving certain skills can influence to their other skills. For example, when students try to solve problem using problem solving skills, they will involve other skills such as creativity on solving the problem, do investigation to find the information and the other skills needed in each activity. The skills requiring in project-based learning are integrated in the SPS.
3.3. Why is project-based learning effective on Science Process Skills?

SPS are the skills that we use to do inquiry [10]. SPS are important for students to enhance students’ thinking skills and mastering science concept [2]. The skills on project-based learning activities represent SPS in various ways.

![Diagram](image)

**Figure 1.** The relationship of project-based learning skills and SPS

Figure 1 shows the Ostlund theory which is explaining about the SPS. Problem solving skills involves observation skills which will lead to the asking question and think creatively. While students doing research, they are testing the hypothesis, formulating data, tabulating, interpreting data and more. Those skills are included in the integrated SPS. Communicating skills, it is the part of SPS. Doing science means think critically to the object observed, to the decision made. Learning in teamwork will help students on improving SPS.

Previous studies on SPS have been conducted. Many researches are focused on the teaching strategies on SPS. The Learning process which let students actively participating in the activities and having experience directly will give a meaningful learning and make students used to use their SPS. Teachers can teach SPS to the students by involving students in the learning activities which are needed to use the skills. SPS are not only important in science learning but also important in the students’ daily life. Learning in daily context gives strong influence on increasing SPS. Provide a contextual problem which is familiar to students’ daily life help students to understand the concept. Those previous studies indicate that students’ SPS can be improved through learning method which allows students to experience by themselves, and to do the activities with a contextual problem.

The first reason of why project-based learning is effective on improving students’ SPS is the learning activities. Project-based learning activities stimulate students to use their prior knowledge and skills. The learning activities provides supportive environment for students to explore and use their acquired skills. The activities conducted in science learning determine the SPS achievement. Project-based learning provided learning steps that guide students to do activities which involve students to do investigations and direct experience with the objects. Project-based learning activities support students to have a better understanding of a topic, deeper learning, higher level reading, and increased motivation to learn [9].

The second reason why project-based learning is effective on improving students’ SPS is the skills of project-based learning. Students do observation and infer to stimulate questioning. They do investigation and research while solving the problem and built teamwork for achieving the project through various activities which need science process skills. The skills requiring in project-based learning activities are integrated in SPS.
4. Conclusion
The literature review stated that the learning process which is involving students in the designing activities and give direct experience can help students to improve their SPS. The finding indicated that instruction in project-based learning is effective to improve students’ SPS.

Acknowledgment
The authors thank to Indonesian Endowment Fund for Education (LPDP), Ministry of Finance, Republic of Indonesia, for the financial support.

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