The Analysis of *High Order Thinking Skill* (HOTs) on Science Learning Using Project Based Learning Model

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Abstract: This research aims to analyze the High Order Thinking skills (HOTs) on science learning toward preservice teacher in primary teacher education program by using project based learning (PjBL) model. Thinking skill consists of three aspects; Problem-solving, critical thinking, and creative thinking. This research works as an action research with a qualitative method. It involves 70 students. The techniques for data collection are the test, observation, and interview. Qualitative descriptive analysis with triangulation validity technique is utilized for data analysis. The result indicates that HOTs of the student on critical thinking aspect of creative thinking and problem solving still need improvement. It recommends practitioners, researchers, and stakeholders to empower HOTs with PjBL model.

1 INTRODUCTION

High-level thinking is a thought process consisting of complex procedures based on analytical skills, synthesis, comparison, conclusions, interpretations, and judgments (Collin, 2014; Facione, P. A, 1990). High-level thinking skills (HOTs) are deductive inductive reasoning to solve unusual problems (Budsankom, 2015, Masek, 2012). King (1998) explains that high-order thinking includes critical thinking, logical, reflective, metacognitive, and creative. This skill is enabled when students of different ages. Students are involved to deal with unusual problems, uncertainties, questions, or dilemmas. HOTs are based on the assumption that the biggest problem for students is their inability to build the kind of understanding needed to solve difficult concepts (Broek, 2012). Students trained with HOTS are able to create new knowledge and make informed and logical decisions. One of the main rationales for empowering HOTS is developing metacognitive skills. Most students are far backward cognitively not because they are not smart enough, but because they have no socio-cultural experience that develops metacognitive skills (Caitriona, 2012). Metacognition ability is related to awareness and control over how to acquire and process an information and store that information into memory (Broke, 2012). This thinking skill became the focus of learning in the 21st century. This is based on data from research conducted by more than 250 researchers from 60 institutions of the world incorporated in the ATC 21S (Assessment and Teaching of 21st Century Skills) grouped 21st-century skills in 4 categories One of which is the way of thinking. The four categories / characteristics of the 21st-century learning are communication, collaboration, critical thinking and problem solving, creativity and innovation (ATC21S, 2013).

To build a high-level thinking process (HOTs), innovation is needed in the learning either in the form of methods, assessment or learning media. Sulaiman, (2017) analyzed HOTs in science learning that resulted in respondents believing that through question and answer between teachers and students by asking high-level questions about the concept of science and linking to real effective situations can be used to develop HOTs. Respondent also believes that planning an investigation or practicum is able to help students develop HOTs. In addition to investigative planning, the problem-solving analysis is able to help students develop their creative thinking skills. Furthermore, making mind mapping can help students in analyzing the concepts of science and

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make learning easier. Budsankom (2015) shows the factors that directly affect the HOTs are the characteristics of psychological, classroom environment, and intellectual characteristics. Based on this, project based learning model (PjBL) can be used as one of innovative science learning model to develop HOTs.

PjBL is a systematic learning method involving students in learning knowledge and skills through research assignments, authentic questions, and well-designed products. Project-based learning is based on challenging questions and makes students have a central role in the process of designing, problem-solving, and decision making so as to give students the opportunity to work independently (Sumarni, 2015). It is continued that through the project, students do not have to memorize any theory or equation (formula), but rather to analysis and critical thinking by analyzing the information gathered to solve problems through the project. This pragmatic approach concentrates more on process than content.

Hsu (2015) explains that project-based learning has three main aspects, namely active construction, situated learning, and social interaction. Project-based learning involves engaging students in the real world and meaningful issues similar to those conducted by scientists. Furthermore, project-based learning allows students to gain a deeper understanding of the material as they actively build their understanding by working together and using their ideas (active construction). Social interaction allows students to work with others to build shared knowledge. Therefore, project-based learning has been widely applied in science classes to support the development of a deeper understanding of the concept of science.

Bedard (2012) explains that PjBL is able to develop students' thinking skills, develop student creativity, and encourage students to work together in a team. PjBL is able to create an environment that helps students build meaningful, active, and student-centered learning and building students to collaborate. Chiang and Lee (2016) mentioned that a very important point on project-based learning is problem-solving. To complete a project, students need to overcome all the difficulties. It is able to make students have problem-solving ability to be better and meaningful. Williams (2017) explains that project-based learning provides opportunities for students to engage in active learning as well as opportunities to learn new soft skills such as collaboration, communication, and negotiation. The See See (2015) mentions five skills trained during the PjBL process namely, an understanding of the basic design of the project; Problem-solving skills; Using sources/references effectively for information; Ability to communicate; And teamwork.

Harper (2014) mentions important elements in PjBL are, the project method focuses on teaching knowledge and skills; 21st century competencies such as problem solving, critical thinking, collaboration, communication, and creativity / innovation that are explicitly taught and assessed; A deep investigative process involving a long and rigorous questioning process, using resources and developing answers; Focused on open questions to understand and attract students' attention in capturing project tasks; Emphasizes the interest and curiosity of students so that students gain knowledge, understand concepts, and can apply skills; Students are allowed to make several ways to complete the product to be made, how it works, and how they manage project completion time; Project learning involves a process for students to give and receive feedback on the quality of their work to be evaluated for further investigation; The last student presented the project result in front of the class. Based on this, project-based learning can provide students with an opportunity to gain deep content knowledge with "21st-century skills".

Several types of research on the use of PjBL to develop thinking skills such as Saripudin research (2015) resulted in the finding that the PjBL model can improve students' critical thinking skills on the theme of environmental management. Chiang and Lee (2016) conducted research on vocational students in Taiwan resulted that PjBL not only can improve students' learning motivation but also train students to solve the problem (problem-solving skill). Followed by the findings of Margarida (2014) conducted by the civil engineering student of Aveiro University, Portugal resulted in PjBL being able to develop problem-solving skills and students' high-level thinking skills (HOTs). The Hava Research (2015) produced findings that Problem Based Learning (PBL) and Project Based Learning (PjBL) can facilitate meaningful learning and develop complex skills and self-study skills. Complex skills such as problem-solving skills and HOTs require handling with a lot of knowledge.

2 METHOD

2.1 Research Design

This research is a type of classroom action research with the qualitative approach. The researcher as a lecturer also acts as a practitioner. The research design uses the protocol/action paradigm The ARPP consists of 10 steps: 1) diagnose the problem; 2) generate alternatives; 3) design action plan; 4) implementation of the action plan; 5) collect and analyze data; 6) dialogue about process and findings; 7) evaluates outcomes; 8) reflect or dialogue on results; 9) recommend or decide on next steps; 10) communicate results (Capella Univesity, 2012).

2.2 Participants

Participants in this action research are students of 2nd semester of academic year 2017/2018 conducted in PGSD Campus VI Kebumen UNS who follow the basic science concept course 1. Participants of 70 people consist 21 men and 49 women with age between 18-20 years old. High school background in various science, social, language and vocational disciplines. The study was conducted for 2 months, from March to May 2017.

2.3 Instruments

The instrument used in this research is the observation sheet of the syntax of the model of Project Based Learning, the observation sheet of student's impairment for critical and creative thinking. The tests for measuring high-level thinking skills include critical thinking and creative thinking with pre-test and post-test (Joyce and Well, 2001). Critical thinking skill consists of 6 aspects namely analysis, explanation, evaluation, interpretation, conclusion and self-regulation (Facione, 2011). Creative thinking skills include fluency, originality, elaboration, and flexibility (Fieldmann, 2001).

2.4 Data Collection Strategies

Data search process utilizes test and nontest techniques include observation, interview, and documentation. Interviews were conducted to find the issues to be researched and to know the problems in more depth. According to (Atkins and Wallace, 2012) data from the observation results of teacher activities and student activities in the process of teaching and learning activities. In this study, researchers used the observation tool in the form of rating scale (research scale) to obtain data on improving critical and creative thinking skills. Data were obtained holistically and analyzed by qualitative descriptive (Hopkins, 1985: 56). Data analysis using the qualitative method with triangulation technique.

3 RESULTS AND DISCUSSION

High student's thinking ability was conducted by using PjBL model in science learning. The high-level thinking skills studied are divided into two aspects: critical thinking and creative thinking.

Table 1: Results of HOTs analysis of each aspect.

No	Aspects of HOTs	Percent of Success (%)
1	Critical thinking skills	58
2	Creative thinking skills	42
	Total	100

Table 1 shows that respondents have HOTs on aspects of critical thinking skills that are better than creative thinking skills. Critical thinking skills have a better percentage average than creative thinking skills using the PjBL model in science learning. Sulaiman (2017) mentions several approaches in developing HOTs is to provide questions, problem-solving activities, project-based learning, simulation, discussion, role playing, and assigning tasks that have different levels to the most difficult levels. Based on the explanation, PjBL model can be one of the strategies in developing student HOTs. Amanda (2014) continued that one of the key elements in PjBL is project-based learning explicitly teaching and assessing skills such as problem-solving, critical thinking, collaboration, communication, and creativity/innovation. Sumarni (2015) explains one of PjBL's principles is to investigate real-world problems so as to assist students in practicing problem-solving skills and intellectual skills. Figure 1 is the average percentage of students' critical thinking skill in every aspect.

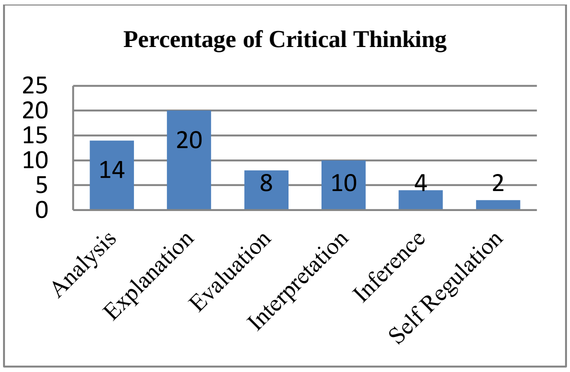

Figure 1: Percentage of critical thinking skills of each aspect.

Based on Figure 1 it can be observed that the value of critical thinking skills on aspects of explanation becomes the greatest value than any other aspect. The results of critical thinking skills test analysis indicates that students are able to explain a concept appropriately through a form of analysis. Based on the observation result during the learning, the development of critical thinking skills on explanation and analysis aspects always looks good enough to every meeting. The aspect of self-regulation becomes the lowest aspect of critical thinking skills. Students tend to provide more and less supportive assessments for further learning improvements. The average student only gives an explanation of the shortcomings during learning without providing solutions or ideas for further learning.

Science learning with the PjBL model begins with brainstorming activities through interesting and challenging questions tailored to real life as when an educator asks students, "why do squid or jellyfish animals move up and down?". The question aims to explore students' early knowledge of a concept. Initial information's obtained from students are continued by giving the questions to a higher level so as to train students to analyze the answers to these questions. Brainstorming activities have a strategic role in training HOTs of students. Ganapathy (2017) suggests that to train student HOTs, the average lecturer conducts brainstorming and problem-solving activities. This is also supported by several other lecturers who stated that brainstorming, problem-solving, interactive lectures are the most widely used activities to train student HOTs. Alias Masek and Yamin (2011) explains that brainstorming sessions can help students to critically consider the best possible solution for the problems at hand. It continues that developing questions can engage students systematically cognitively that encourages the development of students' reasoning abilities. In addition, the process of debate and sharing during brainstorming is able to create a conductive environment to cultivate critical thinking.

The brainstorming activity becomes the initial point on order to make project planning. In planning the project, educators help students by directing them to create a product. In this study, students directed by educators to create water rockets (see Figure 2 and Figure 3). Water rockets are often found in children's games and are often used as a race arena. Therefore, making a project with a water rocket theme is expected to motivate students in learning the existing concepts in the water rocket game. Based on the observations, the majority of students are satisfied with the experiment of making water rockets because they can directly perform the process of making the water rocket game up to analyze the existing concepts. Sumarni (2014) explains one of the advantages of using PjBL in learning is to improve student motivation. When teachers are able to apply PjBL, students can improve their motivation well and produce complex and high-value work. Followed by Chiang and Lee (2016) explains that the PjBL method is able to improve students' learning motivation rather than traditional learning methods.

Figure 2: Water rocket project development process.

Figure 3: Water rocket project development process.

In making water rocket, the lecturer uses free inquiry method which means students are directed to make the hypothesis and problem formulation, designing tools and materials, assembling tools and materials, taking data, analyzing data, and taking conclusions independently with each group. It aims to train students' creative thinking skills and encourage them to collaborate. In addition, giving freedom in making water rockets will motivate students to search the literature and find out the ideal design of props independently.

The literature search will give students the opportunity to gain broad insights. This is because students should look for credible/reliable literature to get the water rocket design that produces the farthest throw distance (Xmax). The literature search is one of the efforts for students to solve a problem (problem-solving) and to answer the hypothesis that they have made at the beginning. This is corroborated by Sumarni (2015) which explains that PjBL will improve students' ability to seek and obtain information. Morgil (2008) states that in finding solutions for project tasks, students can search from various sources such as online, libraries, field visits, observations, and so on where the literature search process is used by students to gain knowledge and process of finding solutions from the project task. See (2015) mentions the five skills trained during the PjBL process is an understanding of the basic design of the project; Problem-solving skills; Using sources/references effectively for information; Ability to communicate, And teamwork. Table 2 is a type of student literature search.

Table 2: Type of student literature search.

No.	Type of Literature	Percentage (%)
1	Book	25
2	Proceedings / journals	13
3	Internet	40
4	Video	5
5	Direct Observation	10
6	Final Project (Thesis, thesis, dissertation)	0
7	Dictate / module	7
	Total	100

Based on table 2, as much as 40% of students use more internet facilities in the literature search. This is because through the internet, able to find the material faster and more alternative/solution answers. In the 21st century, the use of ICT in learning to be one that needs attention. Bell (2010) explains that in the 21st-century students use computers in more advanced ways. Particularly on project-based learning, in the problem-solving process segments, students can use a lot of knowledge by using internet facilities. Therefore, learning by using ICT and visual aids is also an important factor in learning. The props can be utilized to explain the concept of science to be more real, whereas the use of ICT can be used to explain abstract concept of science in order to be visualized in the form of picture/video/ animation.

Table 3: Types of media usage in PjBL learning.

Use of media in science learning	Percentage	
	Yes (%)	No (%)
ICT		
a. Video	100	0
b. Presentation software (power point)	100	0
c. Internet (google)	100	0
d. Web 2.0 (blog, youtube)	75	25
e. Multimedia simulation (PHET simulation, Adobe media flash)	25	75
Tool Display	50	50

Table 3 shows that in science learning with RBL approach, the most used ICT media type are video, power point, and the internet. The use of multimedia simulation is the least used in learning activity because the concept of motion can be discovered in daily life. Hence, the educators prefer to direct students to make a direct observation and project creation. For example, students observe the movement of worm animals. If they know the distance and time value of its movement, the speed of the worm can be calculated. The other example is educators use video basketball players who are throwing the ball into the ring will form a parabolic motion.

The use of ICT in learning can be used as a support in developing students HOTs. Ganapathy (2017) describes his findings that most educators surveyed have mentioned that various ICT tools used in learning can help develop students HOTs. They assume that the use of ICT collecting and presenting material-related information allows easy access to online information and helps to plan lessons and seek new information. In addition, the use of ICT can make learning more interesting and interactive for students in the digital age today. Students will be able to study in a more productive environment especially if the lecturer knows the importance of HOTs and has a good understanding of the use of ICT. However, not all concepts can be explained through ICT. Therefore, educators need other media such as props and the creation of water rocket projects.

Based on the results interview the students, they still find it difficult to design water rocket design if there is no direct instruction from the educator. In addition, the making of hypotheses and problem formulation is still considered difficult for students. Furthermore, the most difficult for students to find the data and analyze the data obtained. The reason is that students are not used to doing project activities independently. Hence, it is very possible if students' creative thinking skills are still not good. This is corroborated by HOTs test score data on aspects of creative thinking skills have a lower value than the aspect of critical thinking skills. In addition, time management in project completion became one of the obstacles in this study. Grant (2002) explains that one of the weaknesses of PjBL is that it takes a long time to solve a complex problem. The impact is on the lack of time to explain some material/content for conceptualization. Figure 4 is the average percentage of students' creative thinking skill in every aspect.

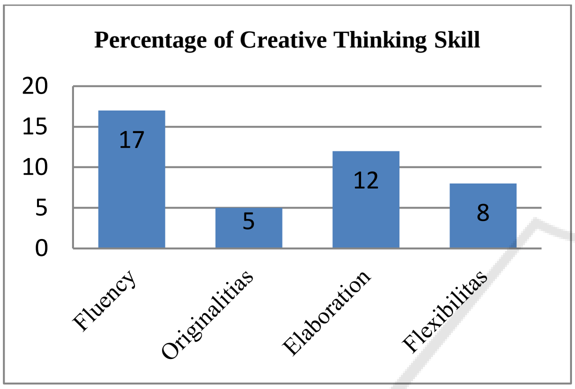

Figure 4: Percentage of creative thinking skills of each aspect.

Based on Figure 4, the percentage of creative thinking skills on the aspect of fluency is the greatest among all aspects. Based on observations during the learning process, students have many ideas to produce the ideal water rocket. In designing water rocket students use various materials in the manufacture of rocket bodies and propellers/rocket wings. For example students utilize plastic bottles of different types and sizes, as well as cardboard and mica plastics to make propellers/rocket wings. Furthermore, the shape of propeller/wing of student rocket is triangular and trapezoidal. Then, the nose cone rocket is cone-shaped, half-circle, and devoid. The goal of this process discover a water rocket design that will produce the farthest throw distance (xmax). The last process of the student demonstrate and present the work. The inputs from lecturers and other groups are used as a reference for improving their water rockets design. Basically, a water rocket project undertaken by a student can be completed properly and the entire water rocket can glide in line with expectations.

Table 4: Student perceptions of PjBL activities.

Level	Activity								
	1	2	3	4	5	6	7	8	9
Easy (%)	90	5	10	15	20	3	58	5	23
Medium (%)	10	43	30	27	62	20	32	7	40
Difficult (%)	0	52	60	58	18	78	10	88	37
Total	100	100	100	100	100	100	100	100	100

Description: 1: literature search, 2: formulate problems and hypotheses, 3: design water rockets / design tools and materials, 4: create water rockets, 5: create observation tables, 6: determine independent and dependent variables, 7: discussions, 8: Create project report, 9: presentation.

Based on table 4, student perceptions in literature search is the easiest activity to do whereas making a practicum report is the most difficult. The outcome of interviewing the students indicates that it is difficult for students to complete the report of practicum within one week. The reason is that students are not yet accustomed to making reports in accordance with the format of scientific papers. Furthermore, making the independent and dependent variables still become difficult for the students. The impact is conducting the experiment obtains some difficulties. Since it is necessary habituation for students to always write the observations into scientific reports form so that they will be accustomed to writing a scientific paper. In addition, when students frequently perform an investigation, students will be used to analyze the independent variables and dependent variables or other variables.

4 CONCLUSIONS

The results present that students 'HOTs on aspects of critical thinking skills is better than aspects of students' creative thinking skills through the PjBL model on science learning. The process of literature searching and evaluation and reflection are expected to be emphasized in the lesson. Furthermore, time management of project creation needs to be considered in order to properly convey the material and concatenation of the concept.

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