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Exploring the impact of project-based learning and discovery learning to the students' learning outcomes: Reviewed from the analytical skills

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ABSTRACT

The purposes of the research were to know the difference between the student cognitive achievement who learned using PjBL and Discovery Learning models, between the student who had the high and low analyzing ability, and their interaction. The research population included the seventh-grade students in one of the Islamic state schools in Surakarta. The research subjects were students with different knowledge capabilities from low to high levels. The method has been implemented was experimental research. A two-way Anava test was chosen for the technique of analyzing data in this research. In collecting data, the multiple-choice test was used based on aspects of analytical abilities, namely mental flexibility, verbal reasoning and reading comprehension, scientific and mechanical reasoning. The result showed that there is the effect of the application of PjBL and Discovery learning model on cognitive achievement with the significance value <0,05, there is the effect between high and low analyzing ability on cognitive achievement with the significance value <0,05 and there was no interaction between learning model and analyzing ability on cognitive achievement with the significance value >0,05. This study implies that the PjBL model and discovery have a significant impact on student learning outcomes so that they can be used for other science subjects by paying attention to the internal factors of students that will be used as a review.

INTRODUCTION

Learning outcomes are one indicator of the learning process. Learning outcomes are not always in line with problem-solving skills. It is assumed that people with good problem - solving skills will tend to display higher levels of learning achievement and produce more original solutions (Yaw et al., 2016; Sung, 2017; Ismail et al., 2018). The results of the science subject in Indonesia do not show positive development. This can be seen from the results of the National Examination (NE) in the science subject in the last 3 years. In the 2014/2015 academic year, the average NE score reached 59.88, while in 2015/2016, it decreased with a national average of 56.26, and in 2016/ 2017, it was 52.19.

Based on the data from the homeroom teacher, the final test scores of the seventh-grade students in the first semester of the 2017/2018 academic year were not satisfactory. This is evident in the students' scores that did not pass the target threshold in science subjects, reaching 60% of the total number of seventh-grade students. This situation indicates that there are still major problems that need to be overcome from learning carried out in school, especially in science subjects. The basic problem faced is that students have not been fully and actively involved in the learning process carried out. Students are still as purer

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listeners of what is conveyed by the teacher without doing exploration by themselves so that the learning process is only seen as a process of transferring information from the teacher to the student alone. This is what causes students to be less able to develop their potential if the learning process is focused on them so that the potential in them can be optimized.

The alternative learning model that can be used as a solution to overcome problems is the one that can help students to build their knowledge. By the opinion of Dwyer et al. (2014) constructivist learning emphasizes the students' needs in learning through experience to develop concepts. Two learning models following the constructivism theory are Discovery Learning and Project-Based Learning (Cruickshank et al., 2014).

One of the science learning that can exploit students' abilities in the aspects of analytical skills can be done with the Discovery Learning model. Discovery learning requires students to build their knowledge and is a learning model based on inquiry (Ott et al., 2018; Astuti, 2015; Oktaviani et al., 2018). Learning becomes more developed, more in-depth, and more memorable with the discussion among students (Dwyer et al., 2014). Without feedback, learning becomes imperfect (Weng et al., 2018).

Project-Based Learning (PjBL) is one of the learning models that try to link problems in everyday life that are familiar with students with technology or school projects (Titu, 2015; Chen & Yang, 2019). PjBL becomes one of the comprehensive learning activities involving students in conducting collaborative investigations (Yulianto et al., 2017). Students can practice 21st-century skills with project-based learning because in the process, students will carry out a lengthy stage of an investigation, answering questions from complex problems or challenges (Malawati & Sahyar, 2016).

The success of learning cannot be separated from various factors that affect both internal and external factors (Mayasari et al., 2016). One of the internal factors that influence the success of learning is analytical skills. Analytical skills are one of the important components for students in the stages of 21st-century skills (Rosdiana et al., 2017; Griffin & Care, 2015). The analytical skill is the provision for students to identify intentions and relationships - the right conclusion relationships among statements, questions, concepts, images, or other forms of representation that are intended to express beliefs, opinions, experiences, reasons, information, or opinions (Setiawan, 2017). The analytical skill needs to be possessed by students like the ability to see possibilities to solve a problem and is a form of thinking that gets less attention in formal education (Mourgues et al., 2016; Aysan, 2015; Timostsuk & Jaanila, 2015).

Previous research conducted by Chen & Yang (2019) about reviewing the impact of project-based learning on students' academic achievement with a moderator investigating meta-analysis. In this study, Chen and Yang compared the impact of project-based learning with conventional learning on student academic achievement. From the research results obtained that project-based learning has a better impact on student academic achievement than conventional learning. Another study was conducted by Malawati and Sahyar (2016) regarding improving student science process skills with a project-based learning model based on physical learning training. The results of data analysis showed that there was an increase in the students' thinking ability in the cognitive domain and the Science Process Skills in the psychomotor domain.

Another study was conducted by Rosdiana et al., (2017) about the effect of the Discovery Learning model on the effectiveness and learning outcomes of students of Class XI Samarinda State Vocational Schools and student responses to the learning process using discovery learning models. The results of his research show that there is an effect of learning

effectiveness on groups that use the discovery learning model, which is higher than other groups that do not use it.

Based on the description above, the authors see that no research compares the effect of Project-Based Learning and Discovery Learning on student learning outcomes in terms of students' analytical skills. Therefore the author researched the effect of the PjBL and DL model in terms of the students' analytical skills to the learning outcomes of junior high school students.

This study is a differentiator with existing research because it compares two innovative models that have not been widely used by teachers to determine the difference in the influence of the use of these models on student learning outcomes. The existence of this research is expected to be a consideration for educators applying innovative learning models that involve direct student participation in the learning process.

This study aims to determine the effect of learning models on students' learning outcomes, the effect of analytical skills on students' learning outcomes, and the interaction between learning models and analytical skills on the students' learning outcomes. Students' learning outcomes in this research focus on the Structure and Layer of the Earth material, which is one of the material contained in science learning. The learning models used in this research are the PjBL and Discovery Learning models, while the analytical skills are categorized into two, namely students who have high analytical skills and those who have low analytical skills.

METHODS

This research was conducted at one of the Islamic state schools in Surakarta in the second semester of the academic year 2017/2018. The type of research used was experimental research. The research population included the seventh-grade students in the 2017/2018 academic year. Students that become research subjects were students with different knowledge capabilities from low to high levels. The research sample was taken by a cluster random sampling technique from two classes, with 58 students consisted of 23 male and 35 female students. Class VII A1 became the experimental class 1, and class VII A3 became the control class 2. Class VII A1 was taught using the Project-Based Learning model, while Class VII A3 was taught using the Discovery Learning model,

Table 1. Learning activity

Syntax	
Project-Based Learning	Discovery Learning
Start with an essential question	Stimulation
Design project	Problem Statement
Create a schedule	Data Collection
Monitoring the students and progress of the project	Data Processing
Assess the outcome	Verification
Evaluation of the experience	Generalization

The instruments used in this research consisted of the students' analytical skill test and achievement test of the Earth Structure and Layer material. The analytical skill test instrument was developed by the researcher, referring to the aspects and indicators of analytical skills proposed by (Mourgues et al., 2016). It was given to students before learning took place. The data obtained were then processed to determine students' analytical skills in high and low categories. The learning achievement test was in the form of objective or multiple-choice tests made based on the material indicators of Earth Structure and Layer with 25 items. The data were obtained through the objective test given after the students got the learning material about Earth Structure and Layer. The researcher could find out student learning outcomes by looking at the results of the objective test. The first thing to do after making an instrument was to conduct an instrument test by an expert or refer to like the content validity test or content test.

The content validation coefficient can be done qualitatively and quantitatively by several experts. After testing its content validity, the achievement test instruments used in the research were tested first using the tests of validity, reliability, level of difficulty, and discriminating power.

The trial of the research instrument was conducted at a different school from the research location. This was done to keep the research instruments confidential. The selection of schools used for the trial of the research instruments took into account the school level so that both the research population and the subjects used in trials are at the same level or homogeneous. Thus, the research instrument becomes more relevant for use in data collection.

The data analysis technique used two-way Anava statistical analysis with factorial design 2 X 2. Before using the statistical test, prerequisite tests were carried out at first. The prerequisite tests used consisted of a normality test and a homogeneity test. For the normality test, the Normality of Test was used, and for the homogeneity test, the Levene test in SPSS version 23 software was used. The research design is explained in Table 2,

Table 2. Research design

		Models	
		PjBL (A1)	DL(A2)
Analytical skills	High (B1)	A1B1	A2B1
	Low (B2)	A1B2	A2B2

RESULTS AND DISCUSSION

The research was conducted by collecting two kinds of data, namely the analytical skills data and learning outcome data. The analytical skill data were obtained by giving an assessment test of students' analytical skills before the learning process took place. The data obtained were processed and averaged to become the basis of high and low groupings. Thus, the data in the form of intervals were converted into ordinal data. The students who got the analytical skill scores above the average score were grouped into the high category. Meanwhile, the students who got the analytical skill scores below the average score were grouped into the low category.

Other data used were student learning outcomes. Learning outcome data were obtained from the results of the cognitive test about the Earth Structure and Layer material. Tests were given to the students after learning about the Earth Structure and Layer. The test scores were then analyzed according to the answer rubric to obtain the students' scores. The test scores were used as the learning outcome data. The learning outcomes data were obtained in the form of interval data. The results can be seen in figure 1 and figure 2,

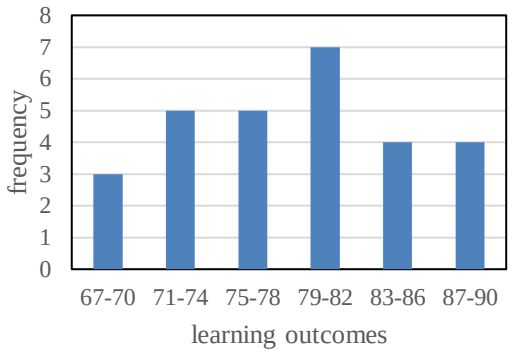

Figure 1. Students' learning outcomes of PJBL class

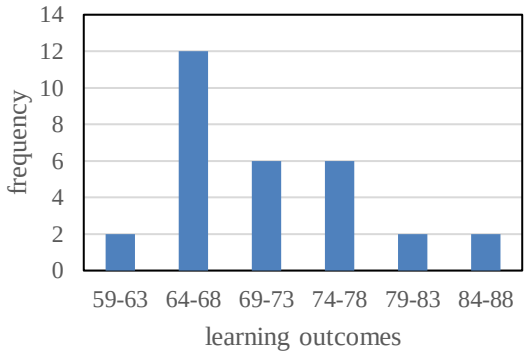

Figure 2. Students' Learning Outcomes of Dl Class

From the fig. 1 and fig. 2, it can be seen that in the PjBL class, the average value is 78.40, with the highest frequency of the PjBL class in the 79-82 interval. While in the DL class, the average value is 70.93,

with the highest frequency of Discovery-class in the interval 64-68.

After the students' learning outcomes were obtained, the results were included in each of the students' scores, which have been grouped based on high and low analytical skills. The results can be seen in Table 3.

Table 3. Average scores of learning outcomes on high and low analytical skills

Analytical Skill	Student (N)	Average Learning Outcome
High	28	76.71
Low	30	72.40

Based on Table 3, analytical skills are categorized as high and low. At high analytical skills, there are 28 students, while at the low analytical skills, there are 30 students. The average learning outcome of high analytical skills is 76.71 and of low analytical skills 72.4. The average score of the students in both categories has a difference of 4.31.

The prerequisite tests were performed on the data obtained in Table 2 to determine the statistical test to be used. There were prerequisite tests performed, namely normality and homogeneity tests. The data normal and homogeneous if the significance value is > 0.05. The results of the normality test are shown in Table 4,

Table 4. Normality-test results

	Analytical skills	Sig.
Learning Outcomes	High	0.138
	Low	0.145

Based on Table 4, the high category has a sig. value of 0.138. Because 0.138 > 0.05, the sample of the high analytical skills comes from a normally distributed population. For the low category, it has a sig. value of 0.145. Because 0.145 > 0.05, the sample of the low analytical skills comes from a normally distributed population.

The homogeneity test used in this research was the Levene test. The homogeneity test results are shown in Table 5,

Table 5. Homogeneity-test results

	Levene Statistic	Sig
Learning Outcomes (based on mean)	0.155	0.503

Based on Table 5, the significance value is 0.503. Because 0.503 > 0.05, the two-sample groups come from the homogeneously distributed population. The prerequisite test done shows that all data were normally distributed. Therefore, the statistical test used was the parametric statistical test.

Two-way variance analysis was used because this research aimed to determine the difference in the effect of two independent variables on one dependent variable. The two-way Anava applied was the two-way Anava with different cells, meaning that the frequency of each cell of the variable under the research has an unequal number. The results of the two-way Anava test using SPSS 23 are presented in Table 6,

Table 6. Statistical Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1112.349[a]	3	370.783	10.081	.000
Intercept	322117.531	1	322117.531	8757.895	.000
Model	805.294	1	805.294	21.895	.000
Analytic	296.849	1	296.849	8.071	.000
Model * Analytic	25.679	1	25.679	.698	.407

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Error	1986.133	54	36.780		
Total	324864.000	58			
Corrected Total	3098.483	57			

Table 7. Mean of Learning Outcomes in PjBL and DL Models

Model	Mean
PjBL	78.400
Discovery	70.933

Table 8. Mean of Learning Outcomes

Analytical skills	Mean
High	76.933
Low	72.400

In the source model, the F value is 21.895, and the significance is 0.000. The value of F is 21.895 > F_{table} 4.08 and sig. 0.000 < α 0.05, which indicates that H_0 is rejected. This means that there are differences in the effect of Project-Based Learning and Discovery Learning models on students' learning outcomes. To find out the model that has a more significant effect on students' learning outcomes, a comparative post-Anava test is not needed because there are only two learning model variables, namely Project-Based Learning and Discovery Learning, so we need to only see the marginal mean. Based on the table of the marginal mean of the learning models, the marginal mean on the Project-Based Learning model is higher than that of the Discovery Learning model. The Project-Based Learning model has a marginal mean of 78.4, while the Discovery Learning model has a marginal mean of 71. Thus, it can be concluded that students who are taught by applying the Project-Based Learning model have better learning outcomes than those who are taught using the Discovery Learning model.

In the source analysis, the F value is 8.071, and the significance is 0.006. The F value of 8.071 > F_{table} 4.08 and sig. 0.006 < α 0.05 indicates that H_0 is rejected. This means that there are differences in the effect of high and low analytical skills on students' learning outcomes. To find out the analytical skills that have a more significant effect on students' learning outcomes, a comparative post-Anava test is not needed because there are only two analytical skill variables, namely high and low analytical skills. Thus, we only need to see the marginal mean. Based on the table of the marginal mean of the analytical skills, the marginal mean on the high analytical skill is higher than that of the low analytical skill. The high analytical skill has a marginal mean of 76.9, while the low analytical skill has a marginal mean of 72.4. Thus, it can be concluded that students with high analytical skills have better learning outcomes than those with low analytical skills.

In the source model* analysis, the F value is 0.698 and the significance is 0.407. The F value of 0.698 < F_{table} 4.08 and sig 0.407 > α 0.05 indicates that H_0 is accepted. This means that there is no interaction between the effect of the learning model and analytical skills on students' learning outcomes.

The Effect of PjBL Learning and Discovery Model on Learning Outcomes

The learning model as one of the teacher's efforts to maximize the interaction of students with students, students, and teachers, and students with learning resources really must be considered following the characteristics of the material so that students' learning outcomes become maximal.

The learning models used in this research are PjBL and constructivist-based DL models that are used together in a study group. Mourgues et. al (2016) states that constructivism-based learning in a DL model study group gives space for students

to share ideas and problems and rearrange concepts together with their closest friends before they talk in a larger group so that they build knowledge including their communication skills.

Project-Based Learning (PjBL) is one of the learning models that try to link problems in everyday life that are familiar with students with technology or school projects (Revelle, 2019; Titu, 2015). The products are in the form of miniatures and posters for each project with different themes. The active involvement of students in the PBL learning process can be seen: 1) when completing products on each project theme, the students looked for in-depth references from various sources as if they were an expert; 2) the completion of the project requires students to identify real problems and interact with various sources. At each completion of the project theme, in addition to discussing theoretically based on the bibliography, the students collaborate with the source of the environment; 3) fostering students' social interactions. Product completion for each project theme for students is fun because they find answers to problems with their peers. They were given the freedom to complete the product according to each group agreement based on the results of the student interaction with group friends or the wider external environment; and; 4) PBL allows students to become active learners. Product completion designs in the form of miniatures and posters for each project theme differ from one group to another depending on the activity of each group member.

This is in line with the result of research from Choi et al., (2019), which explains that project learning can show students' mastery of concepts better than the students facilitated by discovery learning. Furthermore based on Indriwati et. al., (2016), stated in her research that project-based learning strategies are effective to improve cognitive learning outcomes and life skills.

According to Chen and Yang (2019), Project-Based Learning has enormous potential to make learning experiences more interesting and meaningful for learners who demand analytical skills. In project-based learning, students are encouraged to be more active in learning because teachers are positioned behind, and learners take the initiative. Also, the teacher is tasked with providing convenience and evaluating the meaningfulness or application of projects to the students' lives.

Discovery learning provides an opportunity for students to actively participate in building the knowledge they will gain (In'am & Hajar, 2017). Student participation directs into learning that is student-centered, active, fun, and allows information between students, between students and teachers, and between students and the environment (Timostsuk & Jaanila, 2015).

But in reality, discovery learning does not produce results that are as expected. Several possibilities cause discovery learning to have learning outcomes lower than project-based learning as the discovery model has weaknesses, namely: 1) the ability of students to think rationally is still limited; 2) students are not familiar with discovery model learning; and 3) the teacher must change the old mindset that the information giver now is a facilitator, motivator and mentor and PjBL requires a longer time than conventional learning.

The Effect of High and Low Analytical Skills on Learning Outcomes

Analytical skill is the ability of students to describe a concept into more detailed parts and explain the relationship between them (Laksono et. al., 2017). Analytical skills are part of critical-thinking skills so that students with high analytical skills have a more in-depth understanding of the material concepts (Politsinsky et al., 2015). Also, students with high analytical skills tend to have great curiosity and logical thinking and try to solve problems by asking

or finding their solutions (Durotulaila et al., 2014).

The analytical skill is the provision for students to identify intentions and relationships-the right conclusion relationships among statements, questions, concepts, images, or other forms of representation that are intended to express beliefs, opinions, experiences, reasons, information, or opinions (Setiawan, 2017). Besides, analytical skills can be interpreted as the ability to explain or describe concepts into more detailed sections and the relationship between these parts. This is also reinforced by Bloom, who states that the ability to think analytically emphasizes the breakdown of material into more specialized or small parts and detects relationships between those parts, and the parts are organized (Diani & Syarlisjiswan, 2018). The analytical skill is one of the determining factors in the success of learning, especially science. The skill is a high order thinking skill each student has an analytical skill different from another (Pringle & Sowden, 2016). Students who have high analytical skills tend to be more skilled in describing the structure into components and more active, creative, and more capable of solving problems given and have a great curiosity about the phenomenon being studied. High analytical skills, of course, will have an impact on students' learning outcomes. Students who have high analytical skills will certainly have better achievements than those who have low analytical skills.

This is in line with the finding of (Durotulaila et al., 2014; Setiawan, 2017) that students with high analytical skills can master concepts better so that they have better learning outcomes than those with low analytical skills. This statement is supported by Stover and Pollock (2014), stating that learning that prioritizes analytical skills can support the achievement of learning outcomes.

The development of 21st-century skills makes analytical skills an important component that students must have. Low analytical skills not necessarily possessed by students as an innate nature but must be trained continuously so that they acquire high analytical skills (Figueroa, 2014). The teacher becomes an important factor in improving students' analytical skills. The teacher's learning should consider the students 'analytical skills, namely learning and questions that emphasize the use of students' analytical skills. Improvement of students' analytical skills can be done with students invited to solve non-routine questions, find relationships, prove and comment on the evidence, and formulate and show the truth of a generalization, in the analysis stage, not preparation stage (Valeeva & Bushmeleva, 2016). Thus, they can determine the parts of a problem and show the relationship between the parts, looking at the causes of an event or giving arguments that support a statement.

Interaction between Learning Model and Analytical Skills towards Learning Outcomes

Based on the results of the two-way ANOVA analysis, there is no interaction between the learning model and the analytical skill toward the students' learning outcomes. Students with high analytical skills will obtain high learning outcomes when taught with Project-Based Learning and Discovery Learning models. Likewise, students who have low analytical skills, obtain low learning outcomes when taught with both Project-Based Learning and Discovery Learning models. This is possible because many factors influence the acquisition of students' learning outcomes, from both internal and external factors, so that students are not limited to aspects of the learning model and analytical skills used in this research. Although the results of the data analysis showed no interaction, the class with the PjBL model had better learning outcomes than that with the DL model. This is because students in the PjBL class are better able to apply their analytical

skills to solve problems in the learning process.

CONCLUSION AND SUGGESTION

Conclusion

Based on the results of the analysis and discussion, several conclusions can draw as follows: 1) there is a significant effect difference between the students' learning outcomes using the PjBL model and those using the DL model. The students' learning outcomes with the PjBL model are better than those with the DL model; 2) there is a significant difference in the learning outcomes of the students who have high and low analytical skills. Students with high analytical skills have better learning outcomes than those with low analytical skills; 3) there is no interaction between the learning model and the analytical skill towards students' learning outcomes.

Suggestion

Science subjects are one of the difficult subjects. Science is a group of subjects full of experimental activities to prove a concept. Therefore, the curriculum for science subjects should be: 1) directing teachers and students towards the process of inquiry to support student performance in learning science and 2) designed to contain experiments or observations that are fun for students. For Science Teachers, analytical skills are the first drivers that will move students to study harder and their willingness to find deeper information about science. The effect of analytical skills on the results of this research to provide input to the teacher to understand the level of students' analytical skills, especially for science subjects. The teacher acts as a facilitator that must be able to generate students' analytical skills because the benefits of learning science are very important for the provision of students in everyday life. Besides, another factor that can influence students' learning outcomes is the teacher's learning model. Learning with Project-Based Learning and Discovery Learning can be a solution in designing learning that refers to the scientific approach. Learning is based on the scientific approach in addition to improving the ability of teachers as well as to increase student activity in learning. The results of this research can be used as a reference for similar researches with different subjects. For other researchers who will measure the students' levels of analytical skills can use other aspects or indicators that may be more in-depth in measuring students' analytical skills. This research can also be developed by adding other variables so that it is more in-depth in its scientific studies.

AUTHOR CONTRIBUTIONS

YP, MM, and UN prepared research design and reviewing literature, ZJ display data and writing result and discussion. MD and WS collected, analysed data and writing result and discussion.

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