Application of peer assessment in product performance assessment in Project-Based Learning on ecosystem materials

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ARTICLE INFO	ABSTRACT
	Peer assessment is required to facilitate the teacher in assessing the student's performance when students work in groups outside the class. Project-Based Learning is the proper method for applying peer assessment; it consists of stages of tasks that students in groups usually do. This research aims to describe the application of peer assessment in product performance assessment in project-based learning on ecosystem materials. This study uses a descriptive method involving 34 high school students in X grade. Students carry out peer assessments by assessing the products made by other students in their workgroup. In this research, peer assessment was applied three times at the product design, product assessment, and product presentation stages. An analysis of the performance assessment result by peer assessment is conducted, and it shows similarity to the teacher's assessment at each stage. The research results revealed that the student's ability to conduct the assessment is increasing, which is evidenced by the similarity of teacher assessments and peer assessments at each stage. The similarity between peer assessment and teacher's assessment in the product design stage was 58.8%; in the product assessment stage was 64.7%, and in the product presentation stage was 70.6%. Based on the student response questionnaire, the application of peer assessment provided many benefits to students. This research concludes that peer assessment can be an alternative in overcoming the teacher's difficulties assessing student performance when project work is performed outside class hours through project-based learning.

Introduction

In the 21st century, collaboration skill among students is needed. Responding to this, Partnership for 21st-Century skills surveyed to map the 21st-century skills, which includes: 1) Learning and innovation skills, 2) Life and career skills, 3) Information and technology skills (P21, 2010). In overcoming various problems and challenges in the 21st century, the

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students must have 21st-century skills, especially in learning and innovation skills: communication, collaboration, critical thinking, and creativity and innovation or known as 4C (Trilling & Fadel, 2009). To create human resources with 21st-century skills, educational institutions play an important role in achieving and developing 21st-century skills through education for all Indonesian (Badan Standar Nasional Pendidikan, 2010).

Boss et al. (2013) reveals that 21st-century skills can be trained through project-based learning (PjBL). PjBL learning model allows students to be actively involved in constructing knowledge using their potential and skills, working collaboratively in diverse groups, and investigating any problems in the surrounding environment related to their everyday lives. Therefore, PjBL is considered the best method in preparing students' future.

Furthermore, Talat and Chaudhry (2014) state consistent results between the project-based learning model and the improvement of 21st-century skills. Thus, it is concluded that project-based learning can improve 21st-century skills. The stages of project-based learning developed by The George Lucas Educational Foundation are as follows: 1) Start with the essential, 2) Design a plan for the project, 3) Create a schedule, 4) Monitoring the student and the progress of the project, 5) Assess the outcome, 6) Evaluate the experience (Grossman et al., 2019).

In implementing project-based learning, the teacher often failed to conduct students' assessments due to limited time for monitoring student activities. The students usually create products outside the class hours, which makes it impossible for the teacher to acknowledge and monitor the student's overall performance and assess the student performance in the products creation process. In carrying out a student-centered performance or task, the teacher only serves as a facilitator for students to allow the student to assess their learning outcomes and work together in groups (Kartono, 2011). It means that the students must have knowledge of peer assessment which enables them to conduct an assessment against their peers.

Peer assessment shall be a tool for students to evaluate the quality or quantity of their peers' performance and stimulate students to reflect, discuss, and collaborate to facilitate learning acquisition at various levels (Planas Lladó et al., 2013). Furthermore, according to another opinion, peer assessment is when students or their peers grade assignments or tests based on a teacher's benchmark. Peer assessment is a form of formative assessment that involves student participation in the learning and evaluation process and provides feedback to students to guide students in the learning process (Gielen et al., 2010; López-Pastor & Sicilia-Camacho, 2015; Suñol et al., 2015).

Therefore, peer assessment can be helpful for the students to improve their ability to work together, critically-thinking, be more responsible, and reflect on the weaknesses and strengths of previously made products so that in subsequent learning, they can produce better products. The students are expected to be motivated in doing their assignments to gain the respect of their peers for their achievements (Adams & Mabusela, 2017; Spiller, 2012). Wanner and Palmer (2018) express that it is easier for teachers to observe and reflect on what is happening and arrange practical interventions when peer assessment is carried out. Furthermore, the results of the peer assessment are consistent with the teacher's assessment, meaning that the peer assessment can be valid and can be used as an alternative in assessing student performance in groups (Sriyati et al., 2016).

Learning and assessment are inseparable. Assessment can be a reference for students to measure their learning completeness. For XI grade Ecosystem material learning, the students are given the material on the analysis of ecosystem components and the interactions that occur in each of these components. Thus, to enable the teacher to grade the skill competency in such material, the teacher often asks students to create a work related to interactions between components in various forms. In this research, the learning model used is PjBL which the teacher assigns students to make products to reflect food chains in an ecosystem. The ecosystem assigned to a group shall be different from the others.

The teacher may find difficulties in assessing the student's performance based on their contribution in creating the products. However, such difficulties can be overcome by applying peer assessment. It is consistent with Weaver and Esposto (2012) that it is difficult to acknowledge the contribution of each group member during the performance of their work, which then causes the assessment to be inaccurate. Such inaccuracy often raises students' complaints against the group assessment scoring system applied in group assignments. Therefore, it is necessary to apply peer assessment to assess students' performance as objectively as possible.

Peer assessment is applied at the designing, product results, and product presentation stages. The involvement of students in the assessment can also encourage students to make their products better. Based on this background, peer assessment was carried out in product performance assessment under project-based learning on Ecosystem material.

Method

The method used in this research is a descriptive method with a qualitative approach. This research was conducted in only one research class, and no special treatment was applied to such class. The goal is to describe the application of peer assessment in product performance assessment under project-based learning. The population in this research were X grade Mathematic and Natural Science major (MIPA) students at Public Highschool 1 (SMA Negeri) Lembang, Bandung Regency, who were studying ecosystem materials. This research was conducted in X grade MIPA 3 class, which was selected by cluster random sampling technique. Any other class had the same opportunity to be selected as the sample in the research.

In this research, four instruments were used during the project-based learning process. The four instruments are a product design assessment sheet, a product assessment sheet adapted from Forest Lake Elementary (2010), a product presentation assessment sheet adapted from Hafernik and Wiant (2012), and a student response questionnaire on the application of peer assessment. The four instruments went through a validation stage by two lecturers before being used. The research instrument is given based on Table 1.

In this research, three types of data were collected, namely: 1) Data on the assessment result against the student product performance by peer assessment which was done by taking the average score according to the assessments received from peers in a group; 2) Data on the similarity of product performance assessment by peer assessment and teacher assessments which taken by comparing both assessments results in the same assessment category; 3) Data of the student response questionnaire. As for how to determine the score of student product performance using the formula I proposed by Purwanto (2012).

Table 1.Research instrument The George Lucas Educational Foundation (2010)

No	PjBL syntax	Type of instrument	Purpose of instrument
1	Start with the essential		
2	Design a plan for the project	Peer assessment one assessment sheet on product planning	Provide assessment and comments on the results pf student assignments in the product planning phase
		Peer assessment one assessment rubric	Describe peer assessment one and provide input on student product designs
3	Create a schedule		
4	Monitoring the student and the progress of the project	Peer assessment two-sheet on the product outcome	Provide assessment and comments on the product outcome
		Peer assessment two rubrics on the product outcome	Describe the peer assessment on the product outcome
5	Assess the outcome	peer assessment three sheets on the product presentation	Provide assessments and comments on the product presentation
		peer assessment three rubrics on the product presentation assessment	Describe the peer assessment on the product presentation
6	Evaluate the experience	Student response questionnaire	Capture students' responses on the application of peer assessment

$$NP = \frac{\sum X}{\sum S} \times 100\% \dots\dots\dots\dots\dots\dots\dots(I)$$

The value percentage (NP) obtained from the total score obtained by the students ($\sum X$) be divided with a total score ($\sum S$) and multiplied 100% as a constant number. The percentage results are then interpreted and categorized into the assessment category in Table 2.

Table 2. Categorization of score percentage

Interval (%)	Category
0 – 20	Poor
20 – 40	Below average
41 – 60	Average
61 – 80	Good
81 – 100	Very good

(Arikunto, 2010)

The results of student responses to the questionnaire were calculated using the formula II.

$$Percentage\ (\%) = \frac{Students'\ score}{Max\ score} X 100\% \dots..(II)$$

The percentage results are then interpreted and categorized based on the percentage index of student questionnaires according to Sudijono (2007) in Table 3.

Table 3. Category of questionnaire percentage index

Percentage index (%)	Category
100	All respondents
76 – 99	Almost all respondents
51 – 75	Most respondents
50	Half respondents
27 – 49	Almost half of the respondents
1 – 26	Few respondents
0	None of the respondents

Results and Discussion

Students' product performance through *peer assessment* at the product designing stage

The application of peer assessment at the product design stage is a combined implementation of project-based learning stages one to three. Before starting the research, students were given a briefing about the purpose, objectives, and steps for conducting peer assessment. All students have the same understanding of peer assessment. Furthermore, students are divided into four large groups consisting of eight or nine members in each group. Each group was given a different ecosystem theme for their poster product project. The ecosystem themes are (1) forest, (2) sea, (3) home environment, and (4) rice fields. The students perform assessments through peer assessment against their peers in the same group. Students assess using the assessment sheet and peer assessment rubric 1 (product design assessment).

The assessment results obtained from their peers are then averaged and interpreted using the assessment categories proposed by Arikunto (2010). In addition to peer assessment, the teacher also carries out the product design assessment. The comparison between the teacher's assessment and peer assessment was conducted to obtain assessment reference, which aims to monitor the results of research conducted by students through peer assessment, so as not to cause prejudice between students as assessors and students being assessed (Bostock, 2000). Torres-Guijarro and Bengoechea (2016) states that social relations, friendship, hostility, and gender are important factors that must be considered in the implementation of peer assessment. Therefore, for the assessment to remain objective, the application of peer assessment against a student shall be carried out by several peers in addition to the assessment by the teacher.

The comparison of these assessment results also aims to calculate the percentage of similarity in the results of the product performance assessment through peer assessment and teacher assessment. The compared assessments are the assessment result with the same interpretation of the assessment obtained by each student through peer assessment and teacher assessment. The data recapitulation from the comparison of performance assessment results based on the assessment category interpretation and the percentage similarity of the assessment results through peer assessment and teacher assessment can be seen in Table 4.

Table 4.Comparison of performance assessment result between peer assessment and teacher assessment on product design

Assessment category interpretation	Number of students assessed by		Similarity
	Peer assessment	Teacher assessment	
Very good	23	18	15
Good	8	12	4
Average	3	2	1
Below average	0	2	0
Poor	0	0	0
Total number of students	34	34	20
The similarity percentage between teacher assessment and peer assessment is 58.8%			

Based on Table 4, there are differences in the assessment results conducted by peer assessment and teacher assessment. The assessment result by peer assessment mainly indicates a very good and good category. It means that the assessment given by peer assessment are in better grades than those given by teacher assessment. The results of this research are in line with research conducted by De Grez et al. (2012); Langan et al. (2008), which states that the results of assessments by students tend to be in better grades than those given by the teacher. In another study, most students had the assumption that the assessments made by the teacher were more accurate than the assessments made by their peers. However, according to Freeman (1995), there is no significant difference in the mean scores given by peers and teachers. Freeman (1995) also reports that scores given by peers are slightly higher than the teacher's score and can be used as relevant assessments for teachers.

The differences in the assessment results are caused by several factors, such as lack of experience in assessment, honesty, and friendship among a group of friends, which make the students reluctant to give poor grades to their peers (Bostock, 2000; Sriyati et al., 2016).

Based on Table 4, the assessment results show a 58.8% similarity between peer assessment and teacher assessment. Approximately 20 students have the same interpretation of the assessment category as the teacher assessment, which is average. The similarity of the assessment results shows the extent to which students understand the content of assessment rubrics that have been made. The student's understanding of assessment criteria in providing an assessment is essential because it will determine the final assessment provided by the students by peer assessment. According to research conducted by Lie and Angelique (2003), the determination of assessment criteria is the most crucial stage in conducting peer assessments because it can affect the quality of the assessments made by students. In-depth training and continuous involvement of students in providing assessments can also improve students' ability to interpret the assessment rubrics used. Furthermore, it can also increase students' responsibility and accountability in conducting assessments (Azhar, 2015; Li et al., 2020; Wang, 2016).

Students' product performance by *peer assessment* at the product outcome stage

Upon the student completing the design of the poster food chain assignment, the students will receive assessment feedback on their product design. The students are given time to understand the evaluation and input given by the teacher related to the suitability of the product design and assignments given by the teacher. The feedback enables the students to find out the shortcomings or advantages of the assignment; it is expected that the students are motivated to do better in the next assignment (Topping, 2009). Based on the evaluation given to the students' product design, the students will be assigned to create a revised and updated food chain poster based on the input given. The poster is then uploaded to their group's WhatsApp group to allow their peers and teacher to assess such poster using assessment sheet and peer assessment rubric 2 (Product Outcome Assessment). The recapitulation against the performance assessment result based on the category interpretation and similarity percentage between peer and teacher assessments can show in Table 5.

Table 5.Comparison of performance assessment results by peer assessment and teacher assessment at the product outcome stage

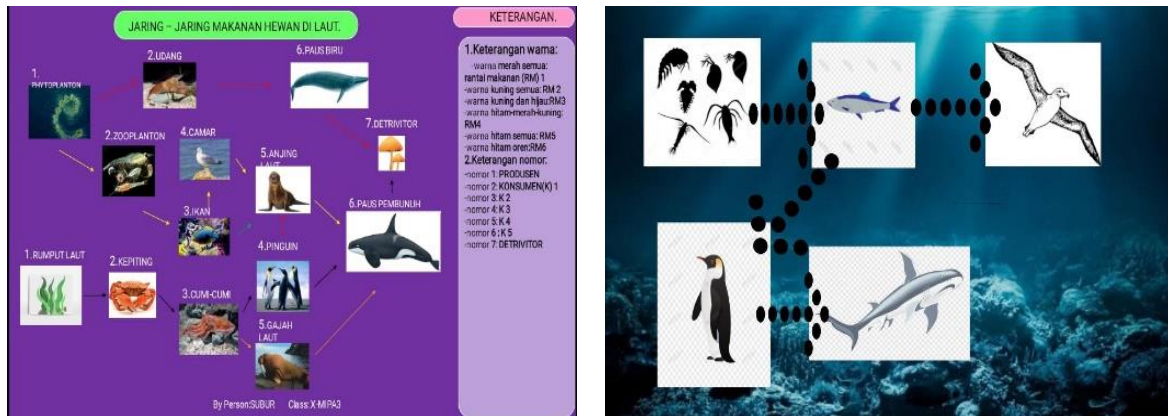| Assessment category interpretation	Number of students assessed by		Similarity
	Peer assessment	Teacher assessment	
Very Good	16	10	10
Good	13	13	7
Average	3	8	3
Below Average	2	3	2
Poor	0	0	0
Number of students	34	34	22
The similarity percentage between teacher assessment and *peer assessment is* 64.7%			

Figure 1. Example of food chain poster created by the students

Based on Table 5, the assessment result mainly indicates a very good and good category. Several factors influenced the above assessment. The students most likely did their poster assignment based on the input provided on the feedback sheet and the implementation of peer assessment. Bostock (2000) and Spiller (2012) states that if students are invited to play an active role in the assessment, students can learn from the weaknesses and strengths of other students, and in the end, students who assess get many ideas about their work so that they can create better products. The examples of products made by students are shown in Figure 1.

Based on Table 5, the assessment results show a 64.7% similarity between peer assessment and teacher assessment. It indicates that the similarity of the assessment result for product outcome assessment is considered in the good category. To effectively and efficiently improve students' ability in giving assessments, the students: 1) are required to take part in the assessment since the beginning of learning so that students can have a sense of ownership in conducting assessments, 2) Each assessment criterion must be opened so that students understand the learning criteria

thoroughly to achieve maximum results., 3) Students must be taught and trained to give assessments or providing feedback to be more competent in doing so (Wanner & Palmer, 2018). In addition, the students are expected to have the capability and be responsible in giving assessments to their peers (Seifert & Feliks, 2018), which allows them to overcome the difficulty in giving an assessment.

Students' product performance by *peer assessment* at the product presentation stage

The application of peer assessment at the product presentation stage is carried out through each student assessing the product presentation video from their group. Video presentations shall be made after students receive feedback from the teacher based on their poster assignment. Videos are uploaded to WhatsApp groups so that their peers and teachers can evaluate the presentation videos. The assessment towards the presentation video shall be given using peer assessment sheet 3 (assessment of product presentation). Table 6 shows the comparison of the performance assessment result based on the assessment category interpretation and the similarity percentage between peer assessment and teacher assessment.

Table 6.Comparison of performance assessment results by peer assessment and teacher assessment at the product presentation stage

Assessment category interpretation	Number of Students Assessed by		Similarity
	Peer Assessment	Teacher Assessment	
Very Good	22	14	14
Good	11	14	9
Average	1	6	1
Below Average	0	0	0
Poor	0	0	0
Number of students	34	34	24
The similarity percentage between teacher assessment and *peer assessment is* 70.6%			

Based on Table 6, the assessment results show a 70.6% similarity between peer assessment and teacher assessment, considered in the good category. Such percentage is achieved because the students are getting used to doing peer assessment, and the assessment rubric was made easier to use so that students and teachers have the same perception of the rubric used. The assessment criteria for the product presentation video have been provided to the students prior to their assignment. Determining assessment criteria is the most crucial stage in conducting peer assessment. The student's understanding of assessment criteria may influence the quality of the assessment provided by the students (Lie & Angelique, 2003). Furthermore, the students also become more proficient and responsible in conducting assessments so that the subjectivity in the assessment can be reduced (Seifert & Feliks, 2018; Wanner & Palmer, 2018).

Comparison of the similarity of product performance assessment results by peer assessment and teacher assessment at the product designing stage, product results, and product presentation

Furthermore, a comparison of the teacher assessment and peer assessment results at the product design stage, product outcome, and product presentation are shown in Figure 2.

Based on Figure 2, teacher and peer assessments' similarity tend to increase at each stage. The similarity at the product design stage is (58.8%) which is considered as in the average category, the similarity at the product outcome stage is (64.7%) which is considered as in good category, the similarity at the product presentation stage is (70.6%) which is considered as in good category.

Students' understanding may cause the increasing similarity percentage in conducting peer assessment. So that students are more experienced in conducting assessments which make it easier for students to understand the content of the rubrics used in conducting assessments and can minimize differences in perceptions between teachers and students on the criteria for each assessment (Planas Lladó et al., 2013; Seifert & Feliks, 2018). Furthermore, the student's involvement in providing assessment since the beginning of learning shall induce a sense of belonging in providing assessments which results in the improvement of their abilities to conduct peer assessment (Wanner & Palmer, 2018).

The ability to conduct peer assessments shall improve when it is repeated. The more practice a student does in providing peer assessment, the more similar it is to the teacher's assessment. The teacher may rely on the help of students in conducting assessments and overcome the teacher's difficulties in carrying out student performance assessments, especially on assignments carried out outside class hours. This analysis is supported by the opinion of Wang (2016), which states that students need plenty of practice in using rubrics to understand the assessment criteria in the rubric and its assessment instructions.

Student responses to the application of peer assessment in product performance assessment in project–based learning

The student response questionnaire consists of 11 questions covering the implementation of peer assessment, the benefits of peer assessment, and obstacles in the implementation. The results of the questionnaire analysis of student responses to the application of peer assessment are shown in Table 7.
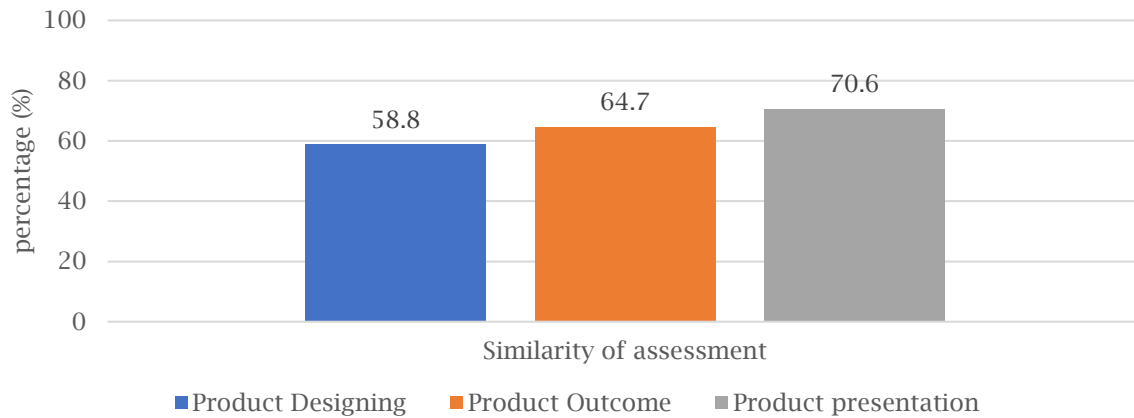
Figure 2. Comparison of similarity between peer assessment and teacher assessment at each stage

Based on Table 7, most students already know peer assessment, even though almost all of them have done it. Although most of the students (55.8%) had difficulty conducting peer assessment at the beginning, in the second assessment, students were getting used to it, as evidenced by only 29.4% who still found it difficult. This analysis is considered fair, and according to De Grez et al. (2012), students were concerned about their experience assessing their friends.

All students declare benefit obtained upon the implementation of peer assessment: 1) peer assessment helps the students to find out the strengths and weaknesses of their assignments, 2) plan their next assignments better, 3) improve the quality of their assignments, and 4) become more responsible in providing an evaluation to others or their peers. This finding is in line with the research results by Eshun et al. (2018), which states that peer assessment encourages the students to have positive experiences and perceptions of the peer assessment process. The students also expected to have positive views about the value of peer assessment, such as their perception of peer assessment as an aid to learning.

Almost all students express that peer assessments are suitable for project-based learning. In project-based learning, the students are usually given a project while assigning them to work in groups. Each group member shall contribute to complete the project, and their peers shall give an assessment based on such contribution, which may be difficult for teachers to do.

Table 7. Results of student responses to the application of peer assessment

No.	Statements	Responses (%)	Respondents
1.	Students already know peer assessment	58.8	Most of them do
2.	Students have already done peer assessment	73.5	Almost all of them
3.	Students have followed the steps for conducting peer assessment	73.5	Almost all of them
4.	Peer assessment makes the student acknowledge the advantages and disadvantages of any assignment made	100	All of them
5.	Peer assessment encourages the student to plan a product carefully	100	All of them
6.	Peer assessment encourages the student to make a better product	100	All of them
7.	Peer assessment encourages the students to improve the quality of their assignments	100	All of them
8.	Peer assessment makes the student more responsible in assessing others	100	All of them
9.	Peer assessment is suitable to be implemented in project-based learning assessment	97.0	Almost all of them
10.	Students find it difficult to do peer assessment	55.8	Most of them
11.	Students still have difficulty doing peer assessment for the second time	29.4	Almost half of them

Conclusion

The ability of students to conduct peer assessment shows an increase from each stage and is considered the "good category." Besides, the student gets many benefits from implementing peer assessment under project-based learning, as has been revealed in the discussion. The development of peer assessment instruments to assess various products from project-based learning may be needed to facilitate further research.

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