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Integration of Project-Based E-Learning with STEAM: An Innovative Solution to Learn Ecological Concept

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The Science, Technology, Engineering, Art and Mathematics (STEAM) approach is increasingly used as it is believed to be capable of facilitating students to understand subjects and adjust to the 21st century competency framework. Integrating a project-based learning (PjBL) model with STEAM is part of good teaching practice. The PjBL-STEAM learning is conducted online (e-learning) to facilitate students in accessing learning content due to the COVID-19 pandemic. The research analyzes the PjBeL-STEAM learning model on the improvement of students' concept mastery in ecological concepts. The learning emphasizes project activities by conducting an independent practicum and creating an animation of biogeochemical cycles. The research involves 72 students of Grade 10 in one of the senior high schools (SMA) in Jakarta. Instruments employed in the research include pretest and posttest of the mastery of ecological concepts. Data is analyzed using independent sample t-test. The research results indicate that the PjBeL-STEAM learning model improves students' mastery of ecological concepts. The research has a limitation related to the assessment of students' attitudes that is not conducted due to online learning.

Keywords: ecology, conceptual, project-based learning, STEAM, e-learning

INTRODUCTION

Current learning in senior high school should adjust to the 21st century competency framework where learning innovation is necessary to prepare creative and innovative students who are capable of thinking critically, communicate and collaborate (Kurfuss, 2014; Ndabeni-Abrahams, 2018). Challenges in the 21st century learning process are not merely in providing contents or memorizing facts but it orients to the development of

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intellectual and skills as well as the formation of attitudes (Zeidan & Jayosi, 2015; Hariyadi, Ibrohim & Rahayu, 2016).

Biology is one of the science subjects, especially at the secondary school level (Ristanto et al., 2018; Harahap et al., 2020). A science in biology that discusses a reciprocal relationship between organism and their environment is ecology (Aprilia & Suryadarma, 2020; Arnott, Palaiologou, & Gray, 2019). The fact is that in ecology-content learning incompleteness is still found due to students' weak mastery of concepts in connecting ecological concepts with other biological concepts (Andrews & Krathwoh.,2010; Cetin, Ertepinar, & Geban., 2015). The scope of ecological studies that are mostly unsupported by effective learning hours, only 45 min per meeting, makes it difficult for the teachers to explain the content in detail. The mastery of ecological concepts requires logic and critical thinking, and it is insufficient if learning is conducted by memorizing theories (Yorek, Ugulu, Sahin & Dogan, 2010). The current learning process provides less direct involvement of students and less training in thinking skills in solving problems (Yasa, 2013; Hermayani, 2015; Marlina, Utaya, & Yuliati, 2017).

Therefore, it requires learning that can answer the challenges. One approach that has 21st century learning characteristics is STEAM (Science, Technology, Engineering, Arts, and Mathematics)-based learning. STEAM is a contextual learning approach that integrates several scientific disciplines thus directs students to develop various skills, namely problem solving, critical thinking, and collaboration (Yakman, 2008; Guy, 2012; Messier, 2015). Results of STEAM approach studies (Swaminathan & Schellenberg, 2015; Liao, 2016; Colucci, Trowsdale, Cooke, Davies, Burnard., & Gray, 2017; Quigley, Herro, & Jamil, 2017; Perignat & Katz-Buonincontro, 2018) indicate that it is more effective in enhancing interest, creativity, problem-solving skills as well as cognitive and communicative skills (Blackley, Rahmawati, & Fitriani, 2018; Zubaidah, 2019).

The learning process concerns how students are capable of mastering the conveyed concepts, understanding the basic principles of a problem, processing data, and searching for sources of facts to master and able to implement learning applied by teachers (Nworgu & Otum, 2013; Hartini & Qohar, 2018). Achievement of success in the learning process indicates by the mastery of a concept by students (Made, Suranti, & Sahidu, 2016). Concept mastery is the main result of an educational process that consists of knowledge related to classification and categorization, and it connects two or more variables (Afifah, Ilmiyati, & Toto, 2019). According to Dahar (2011); Anderson & Krathwol (2015), concept mastery is the ability to classify and communicate an event.

Besides the STEAM approach, a learning model is required that has the capability in integrating various scientific disciplines and practical abilities based on the 21st century learning requirements and project-based learning (PjBL) is the appropriate model (Chiang & Lee, 2016; Yudiono, Pramono, & Basyirun, 2019; Wilson & Hawkins, 2019). The project-based learning (PjBL) model is a learner-centered learning model to understand a concept by looking for relevant solutions and implement them in project works and gaining a meaningful learning process by developing their knowledge (Chiang & Lee, 2016; Yudiono, Pramono, & Basyirun, 2019). A literature review states that PjBL is able in improving student involvement, motivation, and attitude in learning techniques (Viswambaran & Shafeek, 2019; Basilotta Gómez-Pablos, Martín del Pozo, & García-Valcárcel Muñoz-Repiso, 2017; Sudjimat, Nyoto & Romlie (2021), forming behavior of caring to the environment (Kılınç, 2010; Tseng, Chang, Lou, & Chen, 2013), science process skills (Özer & Özkan, 2012), and effective learning (Cook, Buck, & Park Rogers, 2012; Movahedzadeh, Patwell, Rieker, & Gonzalez, 2012); and enhancing learning motivation (Guthrie, Wigfield, & Vonsecker, 2000; Sudjimat, Nyoto & Romlie 2021). Optimizing student potentials in concept mastery will require an integration of appropriate learning strategies. A literature review on STEAM integration in the PjBL model suggests that it is capable of improving learning effectiveness, meaningful learning, supporting future careers (Tseng, 2013; Razali, 2021), motivating, enhancing higher critical thinking skills, and training problem-solving skills in real life (Capraro, Capraro, Morgan, & Slough, 2013; Allison, 2018; Viswambaran & Shafeek, 2019).

Previous studies indicate that integrating PjBL model-STEAM in the learning process improves learning quality; however, it has not been implemented in e-learning. Therefore, the current study modifies an e-learning-based project-based learning (PjBL) model-STEAM to meet the students' demand so that they can adapt and develop in a globally competitive information era. Learning that is relevant in preparing learners to become an innovator in a continuously developed world is necessary at present as well as in the future (Gonzales, Jones & Ruiz, 2014; Kennedy, 2019).

Literature Review

Ecological Concepts

A concept is an implicit and explicit scheme or theory related to how knowledge is mutually connected (Anderson, 2010). Another opinion explains that concept is a basis for a higher thinking process of formulating principles and generalization (Zacks & Tversky, 2010). Hahn & Ramscar (2010) opines that concept is part of cognitive that helps in simplifying and summarizing information.

Concept mastery is the students' ability to respond to varied questions (Bundu, 2006). It also defines as abilities to master ideas of a generalized particular situation due to relevant experiences (Widyastuti, 2017). Students are said to have mastered the concept if they can identify concepts, provide examples, and communicate them using their own understanding (Hartini & Qohar, 2018). Through concept mastery, students are competent in recognizing procedures and stating and interpreting ideas to provide oral and written simple inductive and deductive reasons or demonstrating them.

The mastery of ecological concepts is a cognitive skill to comprehend and master the science concepts through objects related to the surrounding nature. A method to measure students' concept mastery level is by applying Bloom's taxonomy. The cognitive dimension category consists of: [1] remember, this aspect refers to the ability to recognize and recalling a content; [2] understand, namely constructing the meaning of a subject content including what is stated, written, and drew by the teacher; [3] apply, which is implementing or using a procedure under a certain condition; [4] analyze, namely determine a relationship and solve a content; [5] evaluate, specifically making a decision based on criteria and/or standards; and [6] create by integrating parts to form something new to create a product.

STEAM requirement for learning

Current science learning provides less thinking insights and the development of students' scientific skills. This is due to the learning that focuses more on remembering the concept by memorizing with less implementation by educators against the learning process suitable to the 21st century demands. Therefore, strengthening science with STEAM is an effort to prepare students to compete in and face the 4.0-revolution (Dierking & Falk, 2016).

Integrating STEAM to learning directly affects students' interest in taking education. Increasing students' positive interest in science is not only improving knowledge mastery and achievement at secondary schools but also a starting point in producing future skillful workers (Wyss, Heulskamp, & Siebert, 2012; Ibrahim, Ayub, Yunus, Mahmud & Bakar, 2019)

Previous studies indicate skills developed as a result of STEAM learning include all creativity skills for the 21st century, critical thinking, collaboration, and innovation based on STEAM knowledge (Banks & Barlex, 2014; Han, 2015; Kamisah & Marimuthu, 2010; Micari, VanWinkle, & Pazos, 2016). Additionally, this improves student motivation to actively participate in an effective teaching and learning process (Henrkisen et al., 2015).

Despite the current popularity of STEAM learning, this is still a new approach in Indonesia and only a few schools apply it. Therefore, integrating STEAM into the online PjBL model aims to motivate students to integrate the provided subjects and help to logically understand real problems in daily lives (Berry et al., 2012).

Integration of the Project-Based E-Learning with STEAM

STEAM learning emerges as a response to the need to improve student interest and skills in Science, Technology, Engineering, Art, and Mathematics. In learning activities with STEAM, teachers could convey subjects through experiments to foster students' skills in thinking logically, mathematically, practically, and scientifically in understanding the subjects. This is due to improvement of student motivation can be done through problem-solving by connecting the acquired lessons to real-life conditions (Bybee, 2010; Kang et al 2012)

Besides the STEAM application, a suitable learning model is necessary to bridge an academic knowledge gap and to apply concretely. Project-based learning (PjBL) is a learning model that encourages students to be active and able to apply their knowledge and developing various thinking skills and concrete skills (Özer & Özkan, 2012; Condliffe, Quint, Visher, & Bangser, 2017). Project learning involves students in authentic situations to explore and apply the obtained knowledge to solve problems and direct students to select and arrange learning activities and investigate and synthesize information (Han & Bhattacharya, 2010).

The 21st century information technology and communication development affect the instructional process and learning (Kurfuss, 2014; Ndabeni-Abrahams, 2018). Parallel to the development, information technology is often used as media in education, to search references and learning information sources (Keengwe & Georgina, 2012; Martins, 2015). Thus, online learning implementation is an effort to support learning amid the restriction of direct learning (face-to-face learning) due to the Covid-19 pandemic.

Based on the aforementioned, a modification of the PjBL model with STEAM is conducted aiming at analyzing the improvement of students' mastery of ecological concepts using application media of Google Classroom, Google Meet, and WhatsApp to upload learning content or facilitate discussion between teachers and students.

METHOD

Research Design

The research method employed was a quasi-experiment. The research design was pretest and posttest control group design (Sugiono, 2017). In the research design, a pretest was given to students prior to the treatment of the PjBeL-STEAM learning model for experimental class and e-learning model for control class. Posttest would be provided after the treatment. Therefore, the treatment results could be identified more accurately by comparing them to the previous condition before the treatment.

Population and Sample

The research was conducted at a public senior high school (SMA) in East Jakarta in the academic year of 2019/2020. The research population included Grade 10 of MIPA that consisted of 144 students. The sample selection used an equivalence test on four classes of MIPA by using the average score of Biology obtained in previous content. The test result indicated that Class of 10 MIPA A and Class of 10 MIPA D were equal. Next, the determination of experimental class and control class was done by involving biology teachers. The number of the research sample comprised 36 students of Class of 10 MIPA D as the experimental class and 36 students of Class of 10 MIPA A as the control class.

Instrument

Instruments utilized in the research comprised [1] instrument of the mastery of ecology was used to measure the mastery of ecological concepts in the form of essay test. The test referred to Bloom's Taxonomy C1 to C6 (Tabel 1). [2] A validation assessment sheet of the instrument of the mastery of ecological concept was utilized to obtain appropriate validity data. The construct and content tests were carried out on the instruments prior to their use. The tests were conducted by experts and obtained an average of 79.18 with criteria of feasible to be used. An empirical validation test was then carried out on instrument items resulted in r value > r statistic with a minimum range of 0.224 indicating that 15 questions tested were all valid. The reliability test derived a result of 0.949 > 0.6 from the minimum criteria, which meant that the instruments were reliable. [3] An assessment sheet of the STEAM product was employed to derive a score of the final product.

Table 1
Instruments of the mastery of ecological concepts

No	Indicator	Cognitive Level	Question
1	Ecosystem components	C3	Analyze the relationship of biotic and abiotic ecosystem components
		C4	Link the impact of human activities on the ecosystem
		C5	Sum up the results of observation on the influence of abiotic and biotic components on the ecosystem
2	Interaction in ecosystems	C1	State an example of commensalism symbiosis.
		C6	Create an observation design related to ecosystem interactions
3	Energy flows	C1	Name benefits of understanding the food chain to control agricultural pests
		C2	Define the existing energy flows in the ecosystem with food chain sequence
		C3	Create a food chain chart
4	Biogeochemical cycles	C1	Name parts of the oxygen cycle scheme
		C3	Create a nitrogen cycle chart according to the process
5	Succession	C2	Describe factors influencing succession
		C5	Provide examples of activities performed to avoid the recurrence of the events
		C3	Link the causal relationship of human activities to the ecosystem
		C4	Analyze doable efforts to reduce the impacts of imbalanced ecosystem
		C6	Determine appropriate tools, materials, and procedures of an observation

Procedure

The research was carried out using long-distance learning via an application with an Internet network. The research consisted of four meetings from March-April 2020. The research was conducted using long-distance learning (online) due to the Covid-19 pandemic. An observation was conducted prior to the research to discuss with biology teachers to determine the research samples and prepare a Lesson Plan (RPP) of ecology content for experimental and control classes, and a student worksheet (LKPD). The learning process in the experimental and control classes was aided with electronic media to facilitate learning and discussion that included WhatsApp, Google Classroom, and Google Meet. Students in the experimental class were taught using the PjBeL-STEAM learning model, whereas the control class was taught using the e-Learning model. Both classes received a pretest of the mastery of ecological concepts before the learning and research according to PjBeL-SETAM syntax (Figure 1). Once the learning was completed, the posttest was given to the experimental and control classes to identify improvement in the mastery of ecological concepts. Normality analysis was conducted once data obtained using the Kolmogorov-Smirnov test, whereas the homogeneity test carried out using Levine's test and hypothesis test used an independent t-test.

Figure 1
PjBeL-STEAM syntax

The PjBeL-STEAM learning comprises five stages and each stage aims to achieve a process specifically and effectively (Laboy & Rush, 2010). The five stages are (1) Reflection, a stage where students are provided with problem contexts for an inquiry process; (2) Research, which is a research activity carried out by students. Progress in learning occurs in this stage as students develop abilities of conceptual understanding and search for relevant information based on the project; (3) Discovery, students start to learn independently and it involves a research process and determines unknown information in the project preparation. Problem-solving process, collaboration, and cooperation between friends in a group carry out in this stage aiming at developing thinking skills for the process of design and designing a project; (4) Application, students in this stage test the product according to the criteria. The test result achieved will be used to improve the product to achieve a maximum result; (5) Communication, this last stage is a process of creating a project by demonstrating the product between classmates. The presentation is an essential step in the learning process in developing communication and collaboration skills as well as abilities to accept and apply good constructive feedback.

Data Analysis

Research data were analyzed statistically using SPSS 23. The data analysis employed was a descriptive statistic in the form of average score and standard deviation. The descriptive test results were based on the minimum completeness criteria (KKM) of the school, which is 75. Students are stated to have completely studied the ecology content if their score is above 75. The data analysis consisted of prerequisite tests and hypothesis testing. The prerequisite tests of data analysis employed normality and homogeneity tests. The hypothesis testing used an independent t-test to learn the differences in the score of the mastery of ecological concepts in the PjBeL-STEAM class and control class.

FINDINGS

Referring to Table 2, the normality value of a class taught with PjBeL-STEAM and a class taught with *e-Learning* indicated $p = 0.200$, which was greater than p (sig) = 0.05. This suggested that data derived from both classes were normally distributed. Next, the results of the homogeneity test using Levinne's test index indicated that the experimental class derived $p = 0.252$ and the control class was $p = 0.252$. As the p-value was higher than p(sig) = 0.05 then the calculated data were homogeneous. It implied that the students' mastery of ecological concepts indicated similar characteristics. The N-gain calculation results for the experimental class indicated a value of 0.35 with moderate category, whereas in the control class was 0.29 with low category. The results consistent with studies by Eksrootchi & Oskrochi (2010); Ode (2016); Anggraeni (2017); Susilawati (2018) indicating an improvement of students' mastery of ecological concepts from pretest score to posttest score using project-based learning although the resulted N-gain value of the current studies was different.

Table 2
Recapitulation of statistic tests of the mastery of ecological concepts

	PjBeL-STEAM Class		Control Class	
Component	Pretest	Posttest	Pretest	Posttest
N	36	36	36	36
Mean	39.35	60.37	38.29	56.58
N-gain	0.35 (moderate)		0.29 (Low)	
Standard Deviation	14.79	10.82	6.61	7.63
Minimum Value	11.67	28.33	26.67	41.67
Maximum Value	58.00	78.33	50.00	71.67
Normality Test (*Kolmogorov-Smirnov*) Significance Value (sig α = 0.05)	0.200 Normally distributed	0.200 Normally distributed	0.200 Normally distributed	0.200 Normally distributed
Homogeneity Test (*Levene's test)* Significance Value (sig α = 0.05)	0.252 Homogeneous		0.252 Homogeneous	

The independent t-test (Table 3) was employed to explain whether there were differences in the concept mastery between students who were taught with PjBeL-STEAM and e-Learning. Table 3 indicates that the sig value of the pretest was $p > 0.05$; therefore, rejecting H0. It can be interpreted that there were no differences or both classes had equal mastery of ecological concepts. The result of the independent t-test in both PjBeL-STEAM and e-Learning classes suggested that the sig. value of the posttest was $p < 0.05$; thus accepting H0. This meant that there were differences in the mastery of ecological concepts in both classes. This implied that the PjBeL-STEAM model and e-Learning affected the improvement of students' mastery of ecological concepts. It is supported by previous studies by Ode (2016); Anggraeni (2017); Maula (2104); Lutfi (2018) indicating that there were differences in students' mastery of ecological concepts with project-based learning model although the t-test results derived were different to the current research results.

Table 3
Results of independent t-test of the mastery of ecological concepts

Indicator	Pretest		Posttest	
	Sig	Description	Sig	Description
C1	0.096	There were no differences	0.002	There were differences
C2	0.209	There were no differences	0.000	There were differences
C3	0.374	There were no differences	0.004	There were differences
C4	0.133	There were no differences	0.001	There were differences
C5	0.439	There were no differences	0.000	There were differences
C6	0.481	There were no differences	0.005	There were differences

DISCUSSION

This study indicates that the PjBeL-STEAM learning model was capable of improving the students' mastery of ecological concepts. It is consistent with studies by Eksrootchi & Oskrochi (2010); Ode (2016); Anggraeni (2017); Susilawati (2018) that there was an improvement in the students' mastery of ecological concepts due to the application of project-based learning. It is supported by previous study results by Andrian (2012) & Kwon (2014) described that the application of project learning with the design of various scientific fields improved concept mastery and scientific work abilities.

Another result was that there were differences in the students' mastery of ecological concepts after the application of the PjBeL-STEAM learning in the experimental class by analyzing data using a t-test. This finding is similar to research by Ode et al., (2016); Anggraeni (2017) suggested that there were differences in the score of the mastery of ecological concept after the application of project-based learning.

The PJBeL-STEAM learning stages carried out in the research consisted of reflection, research, discovery, application, and communication (Laboy &Rush, 2010). In each stage, students would integrate the STEAM components during the project activities, namely (1) science that refers to understanding the content;(2) technology is related to the use of technology; (3) engineering explains techniques applied in solving the project, (4) art occurs from the student creativity in designing the project, and (5) mathematics relates to the calculation that is used in carrying out an experiment or a project.

The first stage in the PJBeL-STEAM learning is reflection. In this stage, students focus on problem contexts related to the content of ecosystem components, interaction of ecosystem components, energy flow, and biogeochemical cycles by carrying out activities of analyzing and connecting concepts. These activities indirectly train concept mastery indicator of understand (C2). Providing contexts that lead to project learning motivates students to achieve goals (Lamer & Mergedoller, 2017).

The second stage is research in which the learning process directly involves students in inquiry activities. Students analyze a learning video related to ecological issues. During this stage, students are trained to develop thinking skills, learn independently, and analyze data and information that indirectly train the concept mastery indicator of remember (C1).

The third stage is discovery, which is a process of developing a habit of mind from the designing process. The learning process integrates the STEAM approach to assist in completing the project as well as build concept understanding (Capraro, Capraro, Morgan, & Slough, 2013). The discussion between teacher and students also carries out in this stage so the teacher could determine whether there is a misconception among the students on the ecological content. It also trains indicators of apply (C3) and create (C6) of the students; thus, an improvement occurs and achieves high category.

The fourth stage is application, namely correcting or testing worksheets and projects completed by students and evaluate mistakes in the learning process. The teacher is responsible for monitoring activities during the learning process by facilitating each process. For example, the teacher provides an investigation in the form of questions related to the results of the answer to worksheets, experiments, and projects. The application stage that corrects or tests LKPD or projects done by the students and evaluates mistakes in the learning process. One of the methods in correcting misunderstanding in the ecology sub-content is by connecting it to ecological contexts that are easy to understand by students. Lamer & Mergendoller (2017) states that providing feedback and revisions during the learning improved achievement and makes the learning meaningful.

The fifth stage is communication. It is the final stage, which is presenting students' experiments and project results. The learning process aims to develop communication skills by using internet applications of WhatsApp, Google Classroom, and Google Meet. Several previous studies prove that learning using e-Learning aided project-based learning model improved students' concept mastery, learning motivation, and learning outcome (Wasis, 2013; Na'imah, Wardani, & Supartono, 2015; Made, Suranti, & Sahidu, 2016). The teacher will assess the achievement of students' understanding level and conduct reflection with the students regarding the overall learning activities and their experiences in completing the projects.

The STEAM learning must involve students actively and practically and is based on real situations. The form of real activity of students' project development on the STEAM (Science, Technology, Engineering, Arts, and Mathematics) aspect was an experiment on the interaction of biotic and abiotic components in an ecosystem and the creation of biogeochemical cycle animation. The experiment activities aimed to find out the influence of solutes on the growth of sprouted plants. Students had the freedom to determine treatments to be given to the experimental samples. Once the experiment activities were completed, students were asked to prepare a scientific report based on the experiment results. This was compliant with the STEAM learning objective, namely developing curiosity, the openness of experience, and developing knowledge by observing, finding, and investigating something in their surroundings (Perignat & Katz-Buonincontro, 2019). Figure 2 illustrates the results of plant growth experiments with different treatments thus influence plant growth and development rate.

Figure 2
Results of an experiment of interaction between abiotic and biotic components (the effect of chemical substances on plant growth and development)

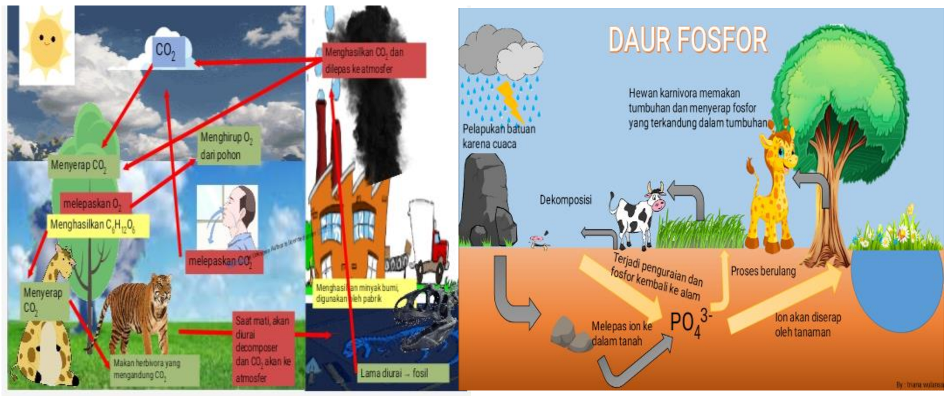

Figure 3
Result of animation work of geochemistry

Besides the experiment, students also developed creativity through a project of creating biogeochemical cycle animation after receiving knowledge on the subject and would present the work online. Kofac (2017) explained that STEAM contains scientific technology-based learning and skills in solving real-world problems. After the experiment activities and working on the project, students expressed that they were better understand the previously-experienced-difficulty ecological content. This was due to the students who did not feel compelled to learn (Lee & Butler, 2003); and was capable of stimulating creative thinking skills (Henrkisen, 2015).

The learning model also implements each STEAM aspect, namely: (1) science aspect refers to an understanding of ecological content, (2) technology and engineering aspect relates to the utilization and operating of internet application and Ms. Office to help in completing the work on the biogeochemical animation video; (3) mathematics aspect applies in independent experiment activity where students determine and read measurement results; (4) art aspect can be observed from the result of student creativity in the created biogeochemical cycle animation that varied from one another. Therefore, products generated by the students in the PjBeL-STEAM learning process can be categorized as satisfactory. It is consistent with research results by Park, Byun & Sim, (2016), stating that the STEAM approach helps students in developing convergent thinking and building characters; hence, it motivates students to solve problems in project-based independent learning.

Differences in the result of students' mastery of ecological concepts in the experimental and control class are due to the control class that has no activities of LKPD improvement or periodic review for each learning activity; therefore, learning achievement is not optimal and resulting in students still experience misconception in the ecology content. Sriyati (2010) explains that the feedback process in the learning process provides a diagnostic role, namely to identify student achievement and is capable of establishing students' habit of mind. Student motivation to learning interest cannot be observed directly.

CONCLUSIONS

The PjBeL-STEAM learning model can be recommended to assist secondary level students to understand a concept. It is supported by the results of overall learning that indicate an improvement in the mastery of ecological concepts. Despite the lack of application of the STEAM learning at the secondary level schools, students were interested and motivated in applying the science, technology, engineering, arts, and mathematics aspects in the form of experimental activities and projects. The focus of the PjBeL-STEAM is to create a product. In creating a product, the process is momentous compared to the end product since the process contains exploration, creative thinking, technique design, creative expression, evaluation, and re-design aspects (Perignat & Katz-Buonincontro, 2019). These aspects teach students to process through activities of observing, recognizing patterns, practicing creative thinking skills, cooperation, and communication skills in solving an assignment or project given by the teachers (Sochacha, Guyotte & Walther, 2016); Thuneberg, Salmi & Bogner, 2018). Moreover, in the process, children are required to think creatively and critically on new things obtained. Students are also encouraged to solve problems with teachers and their peers (Michaud, 2014)

LIMITATIONS AND IMPLICATION

There are various obstacles during the implementation of the PjBeL-STEAM regarding the comprehensive exploration process of interaction between teachers and students as the learning was conducted online. Additionally, non-test assessment (observation sheets) is necessary on student attitudes as a form of implementation of the ecology content in daily life.

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