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Problem Based Learning to Improve Creative Thinking Skills and Technological Literacy on Virus Material

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ABSTRACT

Creative thinking skills and technological literacy are important skills possessed by students in the 21st century. However, many students are still poorly trained these skills, so they need learning strategy that can improve them. This classroom action research aims to improve creative thinking skills and technological literacy through the application of PBL. The method used is Stephen Kemmis and Robyn McTaggart (2007) model, includes planning, acting, observing and reflecting stages in each cycle. The research subjects were 34 students of class X-10 State Senior High School 1 Batu. The results obtained in the form of the average value of creative thinking skills in the precycle of 55.37%, cycle I of 73.97%, while in cycle II of 84.19%, while the average score of technological literacy in the precycle of 66.43, cycle I of 75.62, while in cycle II of 87.68. This shows that the application of PBL can improve creative thinking skills and technological literacy in students of Class X-10 State Senior High School 1 Batu. The implication of this research is that the application of PBL develops problem solving skills, creative thinking in formulating solutions, and being able to utilize the role of technology appropriately so that students can continue to adapt in the digital era.

Keywords: Problem based learning, Creative thinking, Technological literacy

INTRODUCTION

Students and teachers have changed roles in the learning process. From teacher centered learning to student centered learning. The role of the teacher is no longer a source of learning that provides information to students. Instead, the role is to be an educator, guide, demonstrator, mediator, motivator, facilitator, and evaluator in order to improve the quality of learning and help achieve the expected learning competencies, so as to develop the potential in students (Daga, 2022; Minsih, 2018). Students are not only passive recipients of information conveyed by the teacher. But it plays a role as a learning subject by actively carrying out the process of thinking, searching, processing, constructing and using knowledge continuously, and solving problems (Farisi, Hamid, & Melvina, 2017). This can be realized through the Problem Based Learning model of Biology subject in virus material.

Problem Based Learning is a student centered learning model using authentic and meaningful problems, to help students to acquire 21st century skills, including scientific work, critical thinking, scientific communication, independent learning, working cooperatively, synthesizing findings to solve problems (Lewinsohn et al., 2015; Suwono et al., 2017). The learning model allows students to be actively involved in learning activities, have the opportunity to solve contextual problems in a collaborative environment, create mental

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models to learn constructively with the help of prior knowledge, as well as practice and reflection activities that can form a culture of independent learning (Yew & Goh, 2016). This problem-based learning involves 4C competencies including critical thinking and problem solving, communication, collaboration, creativity and innovation, so it is considered ideal and can fulfill the goals of 21st century education, as well as helping students to conduct investigations and inquiries in order to develop higher order thinking skills and learn independently (Arends, 2012; Zubaidah, 2018).

Creative thinking skills are thinking skills with sensitivity to problems that must be solved through creativity that produces solutions. Creative thinking skills are also defined as the ability to produce solutions to problems in order to produce a novelty (Marliani, 2015). This allows students to have diverse points of view, giving rise to many possible new ideas to solve problems in everyday life Creative thinking begins with forming ideas or generating ideas accompanied by factual information to be processed and evaluated (Montag-Smit & Maertz Jr, 2017). Students with creative thinking skills have innovative and special perspectives on problems (Ningrum & Marsinun, 2022). Students' learning will take place better, and can adapt to a competitive society if they have creative thinking skills. Students with creative thinking skills also need to be supported by proficiency in technological literacy (Yang & Zhao, 2021).

The 21st century learning requires teachers and students to acquire knowledge, skills, learning skills, innovation, life skills, abilities in technology and information, and careers. In implementing the technology, it is necessary to apply technological literacy. One of the 21st century skill categories is having enough knowledge to work, having information technology literacy, being able to use the right tools. According to Doyle, 2013, Technological literacy is the ability to understand technology, such as software and hardware, as well as ethics in utilizing technology (Griffin & Care, 2014). Students with high technological literacy tend to find it easier to obtain various learning resources that can develop their ability to learn (Santoso & Lestari, 2019). Technological literacy is done by using a digital environment with many learning resources, so it is expected to develop effective learning skills. Teachers and students with good basic technological literacy enable the learning process to take place effectively. This is supported by the opinion that, someone who is digitally literate using technology effectively can conduct research, reach information sources, read, write, comment efficiently, make reasonable choices, and make the right decisions (Ozdamar-Keskin et al., 2015). In addition, they must realize if there are technical problems that become obstacles, so that learning cannot take place effectively in accordance with the plan.

Based on the observation of learning activities carried out in class X-10 State Senior High School 1 Batu has not implemented learning strategies that can improve students' creative thinking skills and technological literacy. Based on the results of the pre-cycle creative thinking skills test, it is known that students of class X-10 State Senior High School 1 Batu have a sufficient category with an average percentage of 55.37%. Creative thinking skills are strongly related to learning outcomes, academic achievement, and influence how to maintain academic performance at a high level (Aytaç & Kula, 2020; Cintia et al., 2018; A. Wahyuni & Kurniawan, 2018). Students with low creative thinking skills tend to forget more quickly, have low learning outcomes, and are unable to apply theories to everyday life (Wahyudi et al., 2018). Furthermore, based on the results of the pre-cycle technology literacy questionnaire, it is known that students of class X-10 State Senior High School 1 Batu have a sufficient category with an average score of 66.43. Technological literacy affects the effectiveness and efficiency of learning activities (Shopova, 2014). Students with less skill in using technology tools can affect literacy achievement, as well as experience barriers in the learning process (Latip, 2020; Lee et al., 2022).

Learning activities at State Senior High School 1 Batu currently utilize the role of

technology, but the use of LKS that has not been integrated with valid learning resources and has not been in accordance with the syntax of the selected learning model, as well as learning activities carried out by writing a summary of the material, so that it has not developed the creativity and technological literacy of students. This learning activity certainly needs to be developed again through the selection of the right learning model to increase the potential of students. Classroom action research using Problem Based Learning has been widely conducted. However, the current research applies Problem Based Learning that integrates technological literacy indicators and collaborates them with creative thinking skills. Where technological literacy has also not been widely researched. The LKS developed and used as a learning tool has used Problem Based Learning syntax and valid learning resources such as scientific articles. Learning activities are carried out by presenting contextual problems, following the learning steps in Problem Based Learning through LKS, making 3D virus replicas and infographics on the role of the virus life cycle.

Problem Based Learning can be applied to improve students' creative thinking skills, because the learning process allows students to develop divergent thinking skills in solving problems with an average pretest score of 86.00 and posttest of 97.94 (Ningrum & Marsinun, 2022). High levels of students' problem-solving ability produce higher creative thinking skills when compared to the opposite (Mardiansyah et al., 2022). An increase was obtained from the average results of creative thinking skills with the application of conventional learning of 64.07, while the application of Problem Based Learning amounted to 75.81. The application of Problem Based Learning integrated with the computer environment in this case technological literacy can reduce a number of limitations, which may be found in traditional problem-based learning and contribute to the development of problem solving skills (Vekli & Çimer, 2017). The average N-Gain score with technology integration in Problem Based Learning was 56.65%, while the use of conventional methods amounted to 38.16% (Nurasiah et al., 2023). The research has not yet implemented technological literacy indicators according to 21st century competencies (Greenstein, 2012).

This research is important to do in order to provide information on the effectiveness of the application of Problem Based Learning as a recommendation for teachers in determining the right learning model, so that it can improve students' skills. The current research will integrate technological literacy indicators and collaborate them with creative thinking skills. These skills include 21st century competencies that students need to have in order to continue to adapt and be competitive in the era of transformation. It is of interest to examine the relationship between Problem Based Learning with creative thinking skills and technological literacy. This study aims to improve students' creative thinking skills and technological literacy through the application of the Problem Based Learning learning model in the biology subject of virus material class X-10 State Senior High School 1 Batu.

METHODS

This research was conducted through PPL I activities in semester 1 from November to December of the 2022/2023 academic year. The subject of this research was phase E students of class X-10 State Senior High School 1 Batu which amounted to 34 students including 21 girls and 13 boys. The research method used was classroom action research. The research method used, namely class action research. The classroom action research model used, namely Kemmis, McTaggart, & Nixon, 2014. The model was chosen in this class action research, because the implementation of acting and observing as stages that must be carried out in one unit of time, so they cannot be separated. This study consisted of two cycles with two meetings. There are four stages of this classroom action research, namely planning, acting, observing and reflecting in each cycle (Figure 1).

The planning activities that have been carried out are described as follows. Observing the teacher's learning techniques, classroom conditions, and students' attitudes during the learning process. Analyzing the learning tools used by the teacher. Identifying problems by looking for factors that become obstacles in the learning process that are deemed necessary for change. Developing learning tools with Problem Based Learning models that integrate creative thinking skills and technological literacy, and utilize the role of technology. Learning tools consist of teaching modules, learning media, student worksheet, assessment instruments, scoring rubrics, observation sheets of learning activities, and research instruments. Conducting pre-cycle tests of creative thinking skills and technological literacy, as well as cognitive diagnostic assessments.

Implementation activities that have been carried out, namely carrying out learning in class X-10 State Senior High School 1 Batu in accordance with the teaching module that has been designed by applying the syntax of Problem Based Learning according to (Arends, 2012). PBL syntax includes orienting students to the problem, organizing students to learn, guiding individual and group investigations, developing and presenting work, and analyzing and evaluating the problem-solving process. In cycle I, learning activities were carried out on the sub-material of the characteristics and structure of the virus and cycle II on the sub-material of the 3D virus model replica process. Creative thinking skills and technological literacy tests were conducted at the beginning and end of each cycle. Implementation of acting and observing (observing) as stages that must be carried out in one unit of time, so they cannot be separated. Observation activities that have been carried out, namely documenting and observing the implementation of learning activities according to the observation sheet format that has been prepared in each cycle by the observer.

The reflection activities that have been carried out are described as follows. Determining the strengths and weaknesses of learning activities that have been carried out in cycle I cycle. This is done to improve learning in cycle II. Evaluating and reflecting with the student teachers and observers regarding the learning activities and results obtained. The results of cycle I and cycle II in the form of the level of creative thinking skills and technological literacy of students are described in Tables 2 and 3.

Data collection instruments in this study, namely pre-research interview guideline sheets of biology education practitioners, observation sheets of learning activities, cognitive diagnostic assessments, creative thinking skills tests, and technological literacy questionnaires that refer to (Greenstein, 2012). The instrument was used to determine the needs of teachers and students, cognitive level, creative thinking skills, and technological literacy of students. The data collection techniques used were tests and non-tests. Data obtained from test results, namely cognitive diagnostic assessments and creative thinking skills. Data obtained from non-test results, namely pre-research interviews of biology education practitioners, observation sheets of learning activities, and technological literacy.

Data analysis techniques in this study were carried out descriptively qualitative. The stages of data analysis techniques include data reduction, data display, conclusion drawing and verifying. The data analysis technique in this study used a percentage test with quantitative methods. The results of data analysis, which are still in the form of percentages, are then interpreted with conversion value criteria or assessment qualifications. The criteria for interpreting the value of creative thinking skills refer to (Riduwan, 2003). The criteria for interpreting technological literacy scores refer to Djaali & Muljono, 2008.

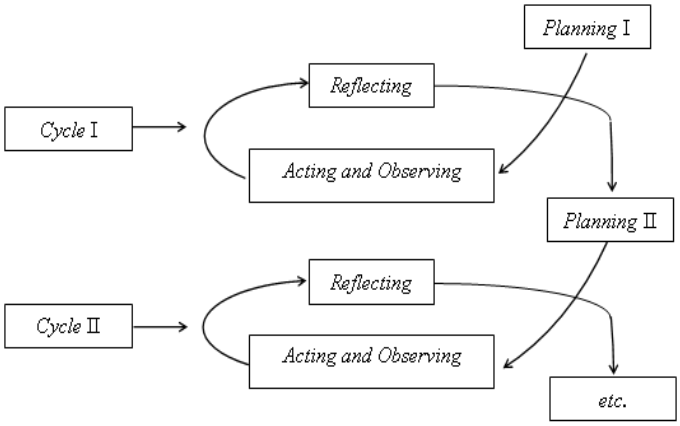

Figure 1. Stages of the Stephen Kemmis and Robyn McTaggart Classroom Action Research Model (Source: **Asrori & Rusman, 2020)**

RESULTS AND DISCUSSION

Results

This class action research was conducted on 34 students of class X-10 State Senior High School 1 Batu in the odd semester of the 2022/2023 school year with Biology subjects. The implementation of learning activities during the study took place according to the lesson plan. The learning activities arranged applied the PBL learning model which integrated creative thinking skills and technological literacy, and utilized the role of technology. This research was carried out in two cycles, each cycle consisting of one meeting for the implementation of the action. The data obtained in this study are in the form of cognitive diagnostic assessment results, creative thinking skills, and technological literacy before and after action activities. The results of the research that has been carried out are as follows.

Cognitive Dianostic Assessment Results

Cognitive diagnostic assessment was conducted before cycle I. Cognitive assessment questions are prepared using phase D and Phase F for class X with the High Order Thinking Skill (HOTS) category. The data from the diagnostic assessment were converted into percentages. The results of the data analysis which is still in the form of percentage, then interpreted with the conversion value criteria or assessment qualifications (Table 1). The results of the cognitive diagnostic assessment that has been carried out are as follows.

Tabel 1. Cognitive Dianostic Assessment Results

Value	Percentage (%)	Description
0-15	17.65	Low
16-42	67.65	Medium
43-100	14.71	High

Based on the results of the diagnostic assessment that has been carried out, it is described as follows. A total of six students got a value of 17.65% with a low category in the interval 0-15. A total of 23 students got a value of 67.65% with a medium category in the interval 16-42. A total of five students earned 14.71% with a medium category in the interval 43-100. This shows that many students still do not have basic knowledge related to virus material, so action needs to be taken.

In addition to the cognitive diagnostic assessment, a creative thinking skills test was also conducted. The data obtained in the pre-cycle was used to determine the level of students'

skills before the action was taken. The data obtained in cycle I and cycle II were used to determine the improvement of students' skills after the action was taken. The results of the creative thinking skills test that have been carried out are as follows.

Creative Thinking Skills Test Results

Data on the results of creative thinking skills were obtained through tests according to Greenstein's creative thinking skills indicators. The test and implementation of creative thinking skills include three indicators. The indicators consist of curiosity, fluency, and elaboration. The data from the creative thinking skills test were converted into a percentage. The results of the data analysis, which are still in the form of percentages, are then interpreted with the conversion value criteria or assessment qualifications (Table 2).

Tabel 2. Creative Thinking Skills Test Results

Skill Indicator Creative Thinking	Pre-Cycle (%)	Cycle I (%)	Cycle II (%)	Description
Curiosity	19.19	25.56	27.81	Increase
Fluency	16.13	24.19	28.75	Increase
Elaboration	23.5	26.25	30.00	Increase
Average	**55.37**	**73.97**	**84.19**	**Increase**

Based on the results of the creative thinking skills test, it is known that there is an increase in value in each cycle. The average percentage of values in the pre-cycle was 55.37% with a sufficient category. The average percentage of values in cycle I was 73.97% in the good category. The average percentage of values in cycle II was 84.19% with a very good category. In Table 2, it can be seen that the curiosity and fluency indicators need to be improved by implementing actions. Before the action was taken, the average total value of the curiosity indicator in the pre-cycle was 19.19%, while after the action there was an increase in cycle I by 25.56%, and cycle II by 27.81%. Before the action was taken, the average total value of fluency indicators in the pre-cycle was 16.13%, while after the action there was an increase in cycle I by 24.19%, and cycle II by 28.75%. This shows that the application of PBL can improve students' creative thinking skills.

In addition to the creative thinking skills test, a technology literacy questionnaire was also filled in. The data obtained in the pre-cycle was used to determine the level of skills of students before the action was taken. The data obtained in cycle I and cycle II were used to determine the improvement of students' skills after the action was taken. The results of the technology literacy questionnaire that has been carried out are as follows.

Technology Literacy Questionnaire Results

Data on the results of technological literacy were obtained through a questionnaire in accordance with Greenstein's technological literacy indicators. Questionnaires and implementation of technological literacy include five indicators. The indicators consist of knowing computer-based technologies, digital and multimedia products, technicality, selection and utilization, legal or ethical. The data from the technology literacy questionnaire were converted into scores. The results of the data analysis, which are still in the form of scores, are then interpreted with the conversion value criteria or assessment qualifications (Table 3).

Tabel 3. Technology Literacy Questionnaire Results

Indicator Technology Literacy	Pre-Cycle	Cycle I	Cycle II	Description
Knows computer-based technologies	25.56	27.34	30.66	Increase
Digital and multimedia products	19.03	23.23	25.95	Increase
Technicality	20.13	23.30	25.73	Increase
Selection and utilization	18.78	21.44	25.94	Increase
Legal or ethical	10.75	15.13	21.88	Increase
Average	**66.43**	**75.62**	**87.68**	**Increase**

Based on the results of the technology literacy questionnaire, it is known that there is an increase in scores in each cycle. The average percentage score in the pre-cycle was 66.43 in the moderate category. The average percentage score in cycle I was 75.62 in the good category. The average percentage score in cycle II was 87.68 with a very good category. In Table 2, it can be seen that legal or ethical indicators still need to be improved by implementing actions. Before the action was taken, the average total score of legal or ethical indicators in the pre-cycle was 10.75, while after the action there was an increase in cycle I by 15.13, and cycle II by 21.88. This shows that the application of PBL can improve students' technological literacy.

Discussion

Planning activities are carried out by conducting cognitive diagnostic assessments. Cognitive diagnostic assessment is carried out to measure the prior knowledge and abilities of students, so that teachers can identify and design differentiated learning according to the needs of diverse students (Sugiarto et al., 2023). Based on the results of the diagnostic assessment (Table 1) that has been carried out, the following data is obtained. Students with low categories were 17.65%, medium categories were 67.65%, and high categories were 14.71%. The results showed that there was a gap between students with high, medium, and low cognitive levels. Based on research that has been done, this gap can be overcome by peer tutor learning, as evidenced by the increase in student activity between one cycle to the next (Putu, 2013; Rosanti, 2018; Wali et al., 2020).

Learning groups consist of students with low, medium, and high categories. This is expected to occur through peer tutoring, where students with high categories help other students' learning difficulties, and will increase their understanding Students are grouped heterogeneously based on the results of the diagnostic assessment, so that differentiated learning occurs so that the potential of each student in a group can complement each other (Subhan, 2022). The results of the diagnostic assessment in this study were used to organize the work of students according to the PBL syntax. In line with research that states the results of diagnostic assessments follow up by providing appropriate treatment based on student difficulties have a significant effect in developing problem solving skills (Arifin et al., 2019). Peer tutor learning through the Problem Based Learning model that integrates creative thinking skills and technological literacy is carried out to overcome the knowledge gap of students.

Implementation of Problem Based Learning on Creative Thinking Skills

Creative thinking skills are one of the 21st century competencies of the four competencies, namely 4C (Critical Thinking, Communication, Collaboration, and Creativity) as a new paradigm learning concept that students must have to face a challenge (Indraswati, Marhayani, Sutisna, Widodo, & Maulyda, 2020). Creative thinking skills are the ability to produce something new (Rosnaeni, 2021). Creative thinking skills show that a person can think imaginatively, has good curiosity, a desire to explore and try new things or challenges, and owns and understands ambiguity (Tohani & Aulia, 2022). This certainly cannot be realized just like that, so it is necessary for the role of the teacher to familiarize students with applying creative thinking skills in their daily lives.

Based on the results of the creative thinking skills test, it is known that there is an increase in value in each cycle. The average percentage of values in the pre-cycle was 55.37% with a sufficient category. The average percentage of values in cycle I was 73.97% in the good category. The percentage of the average value in cycle II was 84.19% with a very good category. This shows that the application of PBL can improve students' creative thinking skills. Mardiansyah, Haryanto, & Gusti, 2022 said that, the level of problem solving ability of high students resulted in higher creative thinking skills when compared to the opposite. An

increase was obtained from the average results of creative thinking skills with the application of conventional learning of 64.07, while the application of Problem Based Learning amounted to 75.81. Other research also states that PBL can develop students' creative thinking skills (Utomo, 2023; Wijayanto et al., 2023). Students' creative thinking skills have been fulfilled by applying the PBL model in the learning process (Sahida, 2018). If learning does not pay attention to the development of creative thinking, then students will have difficulty in solving problems (Irdalisa et al., 2022).

In Table 2, it can be seen that the indicators of curiosity and fluency need to be improved by implementing actions. Before the action was taken, the average total value of the curiosity indicator in the pre-cycle was 19.19%, while after the action there was an increase in cycle I by 25.56%, and cycle II by 27.81%. This is in accordance with research that states the application of Problem Based Learning can increase students' curiosity (Setyaningrum, Riani, & Wardani, 2020). Before the action was taken, the average total value of the fluency indicator in the pre-cycle was 16.13%, while after the action there was an increase in cycle I by 24.19%, and cycle II by 28.75%. This is in accordance with research which states that the application of Problem Based Learning can improve students' fluency (Herdiawan et al., 2019; Yulianingtias et al., 2016).

Implementation of Problem Based Learning for Technological Literacy

Learning in the current era should integrate 21st century skills such as technological literacy. Technological literacy can provide convenience in reviewing, evaluating, managing, and using the information obtained (Nuraini et al., 2022). Technological literacy is defined as the ability to use ICT in terms of communicating information, creating, evaluating, finding, and using (Yazon et al., 2019). This requires technical knowledge and skills.

Based on the results of the technology literacy questionnaire, it is known that there is an increase in scores in each cycle. The average percentage score in the pre-cycle was 66.43 with a sufficient category. The average percentage score in cycle I was 75.62 in the good category. The average percentage score in cycle II was 87.68 with a very good category. This shows that the application of PBL can improve students' technological literacy. This is in line with the results of the study, if the average N-Gain Score with technology integration in Problem Based Learning is 56.65%, while the use of conventional methods is 38.16% (Nurasiah et al., 2023). In line with other research, that information retrieval skills through technological literacy are important for creative problem solving, which contributes to web search problem solving performance by influencing critical thinking procedures, creative thinking, and reasoning collectively (Kuo & Hwang, 2014).

In Table 2, it can be seen that legal or ethical indicators still need to be improved by implementing actions. Before the action was taken, the average total score of legal or ethical indicators in the pre-cycle was 10.75. While after the action there was an increase in cycle I by 15.13, and cycle II by 21.88. Legal or ethical indicators are trained by paraphrasing and writing citations to avoid plagiarism in other people's work or writing (Madani & Ardianti, 2021). Commonly, acts of plagiarism can occur in primary, secondary, tertiary, and higher education, so it is important to train students of State Senior High School 1 Batu (N. C. Wahyuni, 2018). This statement is in accordance with the descriptor of the legal or ethical indicator on technological literacy, namely I have a deep understanding of legal and ethical issues such as copyright (Greenstein, 2012).

Based on the findings and discussion in this study, it is described as follows. The novelty of the research developed is the application of PBL by collaborating indicators of creative thinking skills and technological literacy. The application of PBL is proven to improve students' creative thinking skills and technological literacy. However, this research also has some limitations. The results of students' creative thinking skills and technological literacy are

only analyzed based on the results of tests and questionnaires. It is hoped that further research can use several other methods to determine the development of students' creative thinking skills and technological literacy, so that the data obtained is more representative.

CONCLUSION

Based on the results of classroom action research that has been carried out with the application of the Problem Based Learning learning model can improve creative thinking skills and technological literacy in students of Class X-10 State Senior High School 1 Batu. The average percentage results of creative thinking skills values in the pre-cycle were 55.37% with a sufficient category, cycle I was 73.97% with a good category, while in cycle II it was 84.19% with a very good category. The average score of technological literacy in the pre-cycle was 66.43 with a sufficient category, cycle I was 75.62 with a good category, while in cycle II it was 87.68 with a very good category. These results show an increase in the next cycle. The implication of this research is that the application of Problem Based Learning develops problem solving skills, creative thinking in formulating solutions, and is able to utilize the role of technology appropriately so that students can continue to adapt in the digital era. The results of this study can be a recommendation for further research to conduct research on the application of a learning model that can improve 21st century skills in addition to creative thinking skills and technological literacy, so that it is expected to provide information and recommendations in determining the right learning strategy for educators.

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