



Implementation Of Problem-Based Learning Based Multiple Representations To Improve Students' Critical Thinking, Communication, And Collaboration Skills On Digestive System Material.

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Abstract

The purpose of this study is to analyze the effectiveness of the Problem-Based Learning (PBL) model with multiple representations to enhance students' critical thinking, communication skills and collaboration skills in the digestive system material. The study was Quasi-Experimental using non equivalent control group design, with the subjects being students of classes XI-1, XI-2 and XI-3 at SMA Negeri 14 Semarang, selected through purposive sampling. The independent variable in this study was the Problem-Based Learning (PBL) model with multiple representations, while the dependent variables were students' critical thinking, communication skills and collaboration skills. The research results showed that Students' critical thinking skills in the experimental class that implemented PBL model with multiple representations were higher (89,97) than the control class (58,8). The improvement in critical thinking skill of experimental class students had higher N-gain criteria (0.85) than the control class (0.45). Students' oral communication skills in the experimental class that implemented PBL model with multiple representations were higher (81) than the control class (29). Students' written communication skills in the experimental class that implemented PBL model with multiple representations were higher (99) than the control class (83). Students' collaboration skills in the experimental class that implemented PBL model with multiple representations were higher (94) than the control class (60). Based on the result, it can be concluded that the PBL model with multiple representations was effective in improving students' critical thinking, creativity, communication skills in the digestive system material.

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INTRODUCTION

Developments in the 21st century require the next generation who are not only proficient in academics, but also have high-level thinking skills. High-level thinking skills are often known as 21st-century skills. The skills included in it include critical thinking, problem solving, collaboration, communication, and creativity (Muliana et al., 2024; Zubaidah, 2019). These 21st-century skills are explicitly mentioned in the independent curriculum with the term Pancasila student profile character. The Pancasila student profile consists of six elements or dimensions, namely (a) faith, devotion to God Almighty, and noble character, (b) global diversity, (c) mutual cooperation, (d) independence, (e) critical reasoning, and (f) creative. One of the important characteristics is critical reasoning, namely the ability of students to analyze, evaluate, and make decisions based on logical thinking and appropriate solutions. Mutual cooperation means that students collaborate, communicate, work together, have a sense of caring and sharing.

Based on initial observation data, teachers more often use the student-centered learning model. Teachers who still use conventional methods are usually fixated on books, do not activate students' communication and collaboration skills in the learning process, making students bored in participating in learning (Isna Nurhayati et al., 2019).

In the PBL model that has been implemented, teachers present problems as material for student discussion in the form of news texts. Students have difficulty understanding the problem because it is only presented in one form of presentation. This makes it take students longer to be able to solve the problem, so that learning activities become less effective. In addition, the PBL model that only presents problems in one form of presentation, such as through lectures, tends to be monotonous and has the potential to cause boredom in the learning process. When teachers present problems monotonously, students need more time to understand and solve them, so that the effectiveness of learning is less than optimal. Additional forms of representation or multiple representations are needed as material for student discussion. Students tend to have difficulty in describing the structure of organs in the digestive system, linking the relationship between structure and function of digestive system organs and the mechanism of the food digestion system in the body. The concept of biological object material that cannot be observed directly will be easier and more effective if expressed in representation formats such as verbal, diagrams or images, and graphs (Marpaung & Simanjuntak, 2018).

PBL can help students become critical thinkers, able to collaborate and communicate in groups. This is because in PBL students are invited to discuss to solve contextual problems (Apriyani et al., 2017). The representations that will be used in this study are human torsos, images, videos, and tables. Multiple representations can build deeper understanding, namely increasing abstraction, building relationships between representations, and helping generalization (Marpaung & Simanjuntak, 2018).

PBL based on multiple representations confronts students with problems presented in more than one presentation through power point media and Student Discussion Sheets (LDS) which contain problems equipped with multiple representations in the form of images, videos, and tables. Videos and images are used to explain the mechanism of food digestion, anatomy and physiology of the human digestive system, while tables are used to explain the relationship between lifestyle and digestive system disorders. Multiple representation-based PBL provides students with the opportunity to discuss in solving problems. The application of the Multiple representation-based Problem Based Learning (PBL) model is carried out as an effort to overcome boredom that is often experienced by students during the learning process. Additional forms of representation or multiple representations are needed as discussion materials for students so that the discussion process becomes more interesting, fun, and not monotonous. Based on the description in the background, it is necessary to conduct research to analyze the effect of the application of Multiple representation-based Problem Based Learning (PBL) on students' critical thinking, communication and collaboration skills on the digestive system material. The application of Multiple representation-based PBL is expected to be able to improve students' critical thinking, communication and collaboration skills on the digestive system material.

RESEARCH METHOD

This research was conducted at SMA N 14 Semarang in the even semester of the 2024/2025 academic year. The population of this study included all eleventh-grade students, consisting of 9 classes. The sampling technique used was purposive sampling. The sample selected comprised three classes, namely XI-1, XI-2, and XI-3 based on the research objectives. The data in this study included students' critical thinking, creativity, communication skills, implementation of learning and student responses. Student responses were assessed using a Likert scale to evaluate their perceptions of the learning model. All data were analyzed using descriptive quantitative methods.

RESULTS AND DISCUSSION

The purpose of this study is to analyze the effectiveness of the Problem-Based Learning (PBL) model with multiple representations to enhance students' critical thinking, communication skills and collaboration skills in the digestive system material. The effectiveness of the Problem-Based Learning (PBL) model with multiple representations in the digestive system material is measured based on predetermined effectiveness indicators, namely: critical thinking, oral communication skills, written communication skills, collaboration skills in the experimental class were higher than the control class.

Students's Critical Thinking

Pretest was given before the related material was delivered. This test is given to determine the ability of students before getting digestive system. Posttest is used to determine the ability of students after the material is delivered using the respective learning models in the classroom. The following data on the average pretest and posttest scores are shown in figure 1.

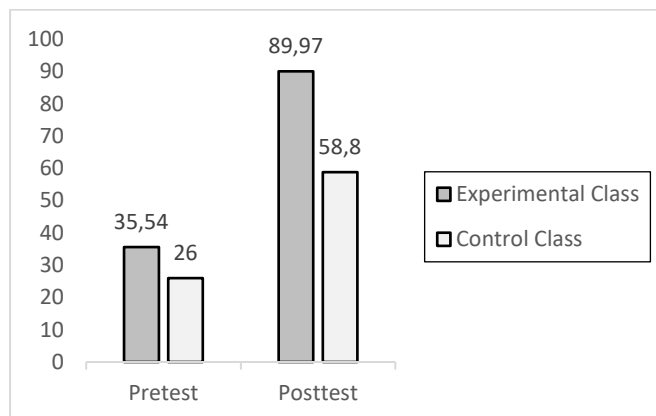


Figure 1 Bar Diagram of Pretest and Posttest Data

The results of the study showed that the average initial abilities of students in the experimental and control classes were equivalent. Furthermore, students were given a post-test at the end of the learning process to measure final abilities and analyze improvements in critical thinking skills. The average results of critical thinking skills in experimental class students who applied the PBL model based on multiple representations were higher (89.97) compared to the control class (58.8).

The application of the Problem Based Learning model allows students to have critical thinking skills because the syntax of the PBL model develops students to think critically through the ability to yaitu interpretation, analysis, evaluation, inference, explanation, and self-regulation stated in the student discussion sheet. Discussion sheet with critical thinking indicators trains students' critical thinking skills and contains problems with multiple representations that help students change verbal representations into visual ones, thus helping students solve problems. PBL assisted by multiple representations can improve students' critical thinking skills, this is because students are trained to interpret problems presented with multiple representations, namely articles, images, videos, graphs, tables and human torsos (Nirwana & Wilujeng,

2021).

The value of students' critical thinking skills in the experimental class and control class were then analyzed according to the indicators of the percentage of the results obtained based on the test results. Analysis of critical thinking skills indicators can be seen in Figure 2

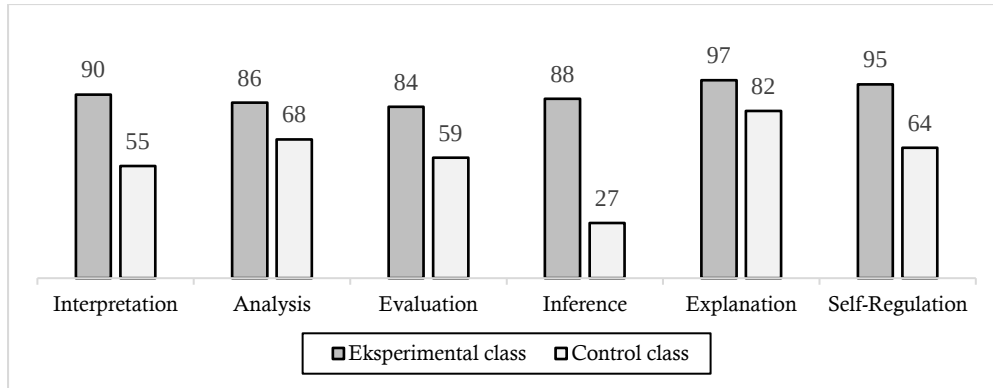


Figure 2 Bar Diagram of Average Value of Critical Thinking Skills Indicator of Experimental Class Students and Control Class Students

This study not only identifies the improvement of overall critical thinking skills but also analyzes the improvement in each indicator. Figure 2 presents a diagram of the improvement of critical thinking skills. The indicator with the highest improvement is explanation.

Multiple representations function as discussion materials so that students are involved in finding information on their own which can train critical thinking skills (Torkar, 2017). Presenting problems in multiple representations can help students understand problems (Hasbullah et al., 2019).

There is a significant difference in students' critical thinking skills. This happens because in the learning activities in the second PBL syntax, namely organizing students to learn, students are honed their critical thinking skills through presenting problems through LDS as discussion material. LDS contains problems about the digestive system that are arranged based on the subskill indicators of critical thinking skills so that they can hone students' critical thinking skills.

In the learning process in the experimental class, based on the syntax of the Problem Based Learning model, students are able to have critical thinking skills because the syntax of the model is able to train students to think critically about the ability to interpret, analyze, identify, evaluate, reason, and confirm problems that are stated in the student discussion sheet. Students are trained with questions that contain indicators of critical thinking skills, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. LDS with critical thinking indicators trains students' critical thinking skills and contains problems with multiple representations to help students change verbal representations into visuals so that they help students solve problems. Students have been trained through discussion activities to solve problems with critical thinking indicators equipped with multiple representations to make it easier for students to understand the problems, so that students can answer posttest questions that have been arranged with indicators of critical thinking skills. In the control class, students held discussions to solve LKS problems that did not contain critical thinking indicators based on multiple representations in the form of images, videos, diagrams, and so on. This is supported by Saputra (2020) research that only learning models that encourage students to discuss and provide opportunities for opinions and collaboration can develop critical thinking skills.

The concept of biological object material that cannot be observed directly will be easier and more effective if expressed in representation formats such as verbal, diagrams or pictures, and graphs (Marpaung

& Simanjuntak, 2018). Presenting problems with additional representations in the form of images, videos, graphs, tables and diagrams can help students identify, understand, analyze and solve problems (Tri Oktavia, 2022) .

The difference between learning implemented by applying multiple representations and learning that does not use multiple representations is that learning with a multiple representation approach has a significant impact on students' understanding abilities, so that it can overcome students' difficulties in understanding problems in learning activities (Hasbullah et al., 2019).

N-gain Test

The N-Gain test used data from the pretest and posttest scores of the class. N-gain shows the difference in scores from pretest to posttest on the use of learning models. The data was analysed to get a conclusion about the influence of the learning model. The N-gain test results are shown in the following table.

Table 1 N-Gain test data table of class

Data	Average score n-gain	Category
Eksperimental class	0,85	High
Control class	0,45	Medium

The improvement of students' critical thinking skills was known by conducting an N-gain test using students' pretest and posttest scores. The experimental class showed an average N-gain of 0.85 which was included in the high category. The high category achieved by the class showed that the learning model was effective in improving critical thinking skills.

The class has an average n-gain score of 0.85 which is included in the high category. The application of the PBL model based on multiple representations in the classroom is considered more influential in improving students' critical thinking skills. Overall, the PBL model based on multiple representations is able to improve students' critical thinking skills in all indicators. This shows that the combination of cooperative learning models with varied representations has succeeded in creating a fun learning environment, encouraging active participation, and improving students' understanding of complex digestive system material.

Students' Communication Skills

Oral communication skills are obtained through observation during the learning process. Observations are made when students are making presentations and discussions. The average value of oral communication skills of the experimental class was higher compared to the control class. The value of students' oral communication skills in the experimental class and control class were then analyzed according to the indicators of the percentage of the results obtained based on the observation results. Analysis of oral communication skills indicators can be seen in Figure 3

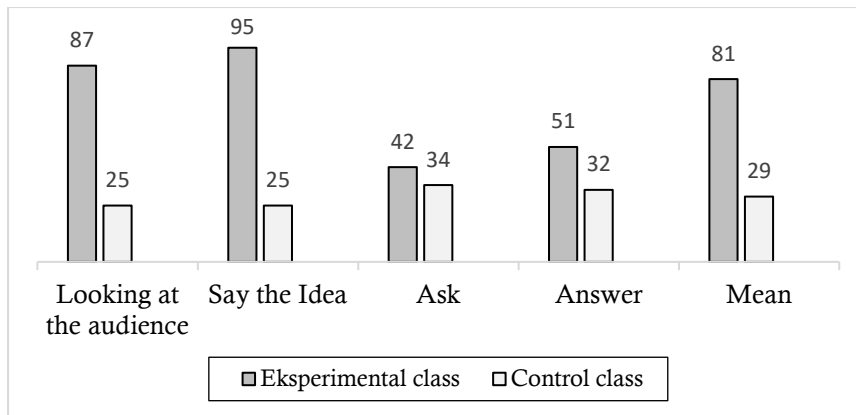


Figure 3 Bar Diagram of Average Value of Oral Communication Skills Indicator of Experimental Class Students and Control Class Students

The results of the analysis show that the most significant increase in communication scores is in the indicator of say the ideas. This study measures students' communication skills at each meeting assessed by an observer. Based on Figure 3, it is clear that there are differences in student activities in all indicators, which shows that the learning strategies implemented have succeeded in improving students' oral communication skills in the learning process.

In implementing the PBL learning model based on multiple representations, there is a syntax that is a reference for students to be able to communicate well. The fourth syntax is to develop and present the results of the discussion carried out by presenting the results of the LDS completion by each group in front of the class. The teacher directs students to do questions and answers between groups to develop the material. Students take turns communicating their opinions well. When students do a presentation, there is a question and answer session. Other friends will ask questions, respond to or add information that is lacking or has not been conveyed, then the presenter group will answer the questions according to their knowledge. Presentation performance is assessed as a communication skill. The teacher analyzes and evaluates the problem by providing confirmation of the results of the discussion as reinforcement for students' abilities.

Written communication skills are obtained through students' writing on the digestive system material at the end of the learning process. The average value of written communication skills of the experimental class was higher compared to the control class. The value of students' written communication skills in the experimental class and control class were then analyzed according to the indicators of the percentage of the results obtained based on the observation results. Analysis of written communication skills indicators can be seen in Figure 4

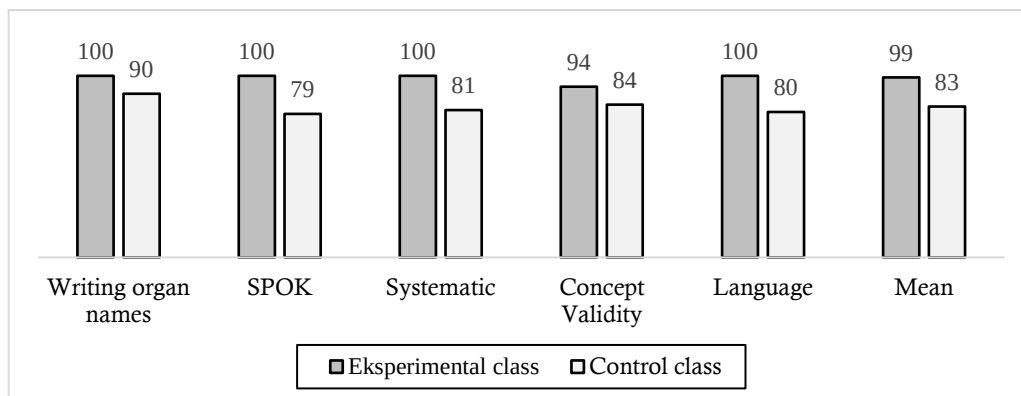


Figure 4 Bar Diagram of Average Value of Written Communication Skills Indicator of Experimental Class Students and Control Class Students

The results of the analysis show that the most significant increase in scores is in the indicator writing organ names, SPOK, systematic, and language. This study measures students' written communication at the end of the meeting. Based on Figure 3, it is clear that there are differences in student' communication in all indicators, which indicates that the learning strategy applied has succeeded in improving students' written communication skills in the learning process.

Students in the experimental class were asked to make a summary of the material during the learning activities. In writing, students process and conclude the results of learning activities using text, symbols and images. Data on written communication skills in this study include students summarizing the material at each meeting containing the sequence of human digestive organs, images of human digestive system organs and schemes or diagrams of the human digestive system mechanism. In doing these abilities, students' skills can be developed in writing.

Students' Collaboration Skills

Students' collaboration skills were measured using observation sheets during the learning process with 5 assessment aspects. The average value of the experimental class collaboration skills was higher than that of the control class. The collaborative skill values of the experimental and control class students were then analyzed based on the percentage indicator of the results obtained based on the observation results. The analysis of the collaboration skill indicators can be seen in Figure 5

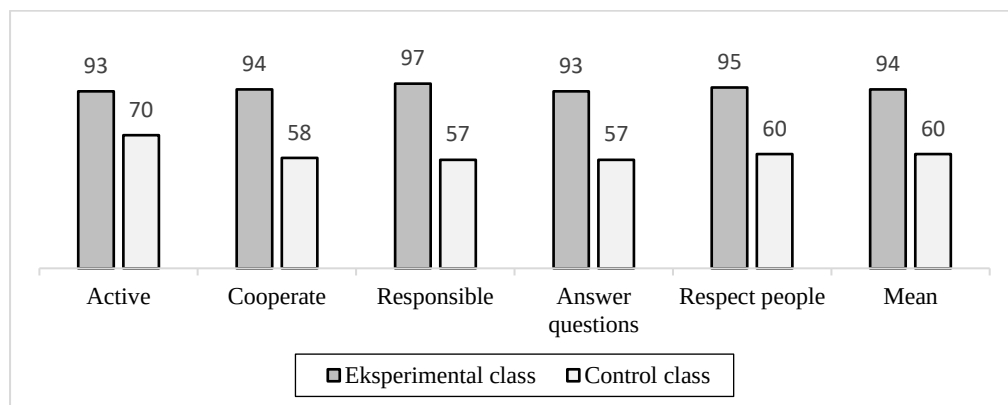


Figure 5 Bar Diagram of Average Value of Collaboration Skills Indicator of Experimental Class Students and Control Class Students

The results of the analysis show that the most significant increase in scores is in the indicator responsible. This study measures student collaboration during group learning. Based on Figure 3, it is clear that there are differences in student collaboration on all indicators, which indicates that the learning strategy implemented has succeeded in improving students' collaboration skills in the learning process.

Students' collaboration skills during the learning process on the digestive system material measured by five indicators, namely active, collaborating, being responsible, answering questions, and respecting friends' opinions, showed a consistent increase in each cycle. This increase shows that the third syntax of PBL, namely the teacher supports the investigation group by guiding and encouraging students to obtain information in solving problems in LDS through small group discussion activities consisting of 5-6 students in each group, has succeeded in making students work together well. when in groups, students can exchange

ideas, explore relevant sources, and develop creativity. This is in line with Gillies (2016) in his research that direct experience through group work can significantly improve collaboration skills.

Discussion activities carried out by students provide opportunities for students to express their ideas, actively discuss solving problems, provide opportunities for opinions, be responsible for tasks divided into groups, respect the opinions of group members and encourage cooperation so that collaboration skills increase. By contributing actively, students not only receive information passively but also play a role in creating their own learning experiences.

In the experimental class, high scores were obtained on the indicator of being responsible for tasks that have been divided into groups because the class uses Problem Based Learning (PBL) based on multiple representations where students are asked to work in groups to solve problems on LDS which does not occur in learning with conventional lecture models in the control class. On the indicator of being responsible for tasks that have been divided into groups, most students are actively involved and enthusiastic in finding ideas to solve problems. Despite experiencing difficulties, students continue to try to overcome them. In this indicator, students make observations and find solutions by utilizing various sources of information from books and the internet.

The applied learning model is one of the factors that contribute to improving students' critical thinking, communication and collaboration skills. Students gave a positive response to the application of the PBL model based on multiple representations in learning the digestive system material in this study. Students' problem-solving skills also show that students have critical thinking skills, because the process of understanding, analyzing and finding solutions requires good critical thinking skills (Dewi et al., 2016). Thus, collaboration skills play an important role in improving students' critical thinking skills. Biology learning is not only textual, some materials are difficult for students to understand if they only learn from textbooks. Therefore, biology learning must be done in a fun way to encourage student enthusiasm. The learning model used in this study succeeded in students' critical thinking, communication and collaboration skills based on student response questionnaires, with 68 students providing positive feedback on learning combined with multiple representations. Students also felt that the learning carried out in this study influenced their learning and activities during the learning process.

This study combines the PBL model based on multiple representations. Multiple representations are a re-presentation of concepts that have been learned through various forms at the macroscopic, submacroscopic and symbolic levels of representation. The multiple representations used in this study are in the form of student discussion sheets presented in the form of videos, images, and tables. Videos and images are used to explain the mechanism of food digestion, anatomy and physiology of the human digestive system, while tables are used to explain the relationship between lifestyle and digestive system disorders. PBL based on multiple representations confronts students with problems presented in more than one presentation through human torso media, power points and Student Discussion Sheets containing problems equipped with multiple representations in the form of images, videos, and tables. PBL based on multiple representations provides students with the opportunity to discuss in solving problems. The presentation of multiple representations acts as discussion material so that it helps students find information independently which can train students' critical thinking skills.

The first syntax of student orientation to the problem introduces material about the human digestive system. explains the digestive organs, mechanical and chemical processes, and enzymes involved in digestion and disorders that occur in the digestive system. Teamwork involves dividing students into groups of 5-6 members. Each group discusses the problem topic on the discussion sheet. presentation in front of the class that requires students to communicate and collaborate to respond to each question.

The application of the PBL model based on multiple representations in learning can improve students' critical thinking, communication and collaboration skills. This improvement is shown by the results of the

analysis and supported by previous studies. Apriyani et al. (2017); Sriyati Wela et al., (2020) stated that the PBL model is effective in improving students' critical thinking skills. (Dhitasarifa et al., 2023; Fitriyani et al., 2019; Oktaviani, 2022; and Sari, 2021) stated that the implementation of the Problem Based Learning (PBL) model can improve students' collaboration skills.

This study provides insight into the application of the multiple representation-based PBL model in learning the digestive system material. A series of analyzes were conducted to observe the improvement of the learning model on students' critical thinking, communication and collaboration skills. However, this study also has limitations, such as the material is limited to one subtopic of the digestive system, and the limitations of this study are the number of samples that are still too small by using 102 samples divided into two groups, namely the experimental group of 68 samples and the control group of 34 samples and this study cannot be generalized. This limitation can affect the generalization of research results to a wider population. To prove the effectiveness of the Multiple Representation-based Problem Based Learning (PBL) model requires a larger scale trial, namely by involving more schools, classes and students.

Student Feedback Questionnaire

Student responses were given after the entire series of learning models were given to determine the response to the PBL learning model based on multiple representations in the treatment class. The questionnaire consisted of 10 statement items with five answer choices. The score was calculated based on the response for each indicator. The response results were obtained from 68 students. The percentage of results for each indicator is presented in table 2

Table 2 Results of Student Responses to the PBL learning model based on multiple representations

No.	Questionnaire Indicator	Percentage	Criteria
1.	The implementation of learning helped me formulate problems.	87	Very positive
2.	I understand the digestive system material better regarding the mechanisms that occur in the body if it is presented in video form.	87	Very positive
3.	Presentation of problems with the help of multiple representations makes it easier for me to understand the problem. (Interpretation)	86	Positive
4.	The implementation of learning makes it easier for me to identify a problem. (Analysis)	89	Very positive
5.	The implementation of learning makes it easier for me to draw conclusions to solve a problem. (Inference)	89	Very positive
6.	The implementation of learning makes it easier for me to draw conclusions to solve a problem. (Evaluation)	87	Very positive
7.	The implementation of learning makes it easier for me to find evidence to strengthen my opinion. (Explanation)	89	Very positive
8.	The implementation of learning makes it easier for me to validate my opinion. (Self-Regulation)	87	Very positive
9.	The implementation of learning makes it easier for me to express my opinion	89	Very positive
10.	The implementation of learning makes it easier for me to work together with friends	91	Very positive
Average		88,1	Very positive

Based on the percentage in the table above, students' responses to the Problem-Based Learning Based Multiple Representations are very positive, with a percentage of 88,1%. The application of PBL based on multiple representations is said to have received a positive response from students if $\geq 75\%$ of statements reach

the positive to very positive category. This means that the Problem-Based Learning Based Multiple Representations has an impact during the learning process.

CONCLUSION

Based on the analysis and discussion, it can be concluded that the Problem-Based Learning model with multiple representations was effective in improving students' critical thinking, creativity, communication skills in the digestive system material. This is indicated by the average of students' critical thinking skills in the experimental class being higher (89.97) compared to the control class (58.8). The increase in critical thinking skills of students in the experimental class has a higher NGain criterion (0.85) compared to the control class (0.45). Students' oral communication skills in the experimental class are higher (81) compared to the control class (29). Students' written communication skills in the experimental class are higher (99) compared to the control class (83). Students' collaboration skills in the experimental class are higher (94) compared to the control class (60).

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