

## Fostering communication and collaboration skills in biology education through Problem-Oriented Project-Based Learning (POPBL)

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### ABSTRACT

The 21<sup>st</sup>-century education requires students to be able to master 21<sup>st</sup>-century skills, namely communication and collaboration skills. Communication and collaboration skills are very important for students to develop their personalities in learning, because they cause individual and group interaction to gain knowledge and learning experience from each other. 21<sup>st</sup>-century skills can be practiced through the study of biology, because biology has values of scientific nature, cooperation, respect for the opinions of others, and openness to various phenomena that have just occurred. This study aims to measure the influence of problem-based and project-based learning on the communication and collaboration skills of grade X students of SMA Negeri 10 Malang. The implementation of this study used the Problem-Oriented Project-Based Learning (POPBL) model to direct students to create creative products. The method used in this study is a quasi-experimental research using the pretest post-test nonequivalent control group design. Communication and collaboration skills were measured using instruments in the form of self-assessment and peer assessment questionnaires. The results of the questionnaire were analyzed using the analysis of covariance (ANCOVA) test. The results of the study showed that the implementation of Problem-Oriented Project-Based Learning (POPBL) has a significant effect on students' communication and collaboration skills. These findings suggest that problem-based and project-based learning models can develop students' communication and collaboration skills.

**Keywords:** Collaboration skills, communication skills, POPBL

### INTRODUCTION

Education is becoming increasingly important to ensure that students have learning skills, innovate, use technology, and information media to learn, work and survive (Arifin, 2017). These skills can be achieved by organizing 21<sup>st</sup> century education. 21<sup>st</sup> century education aims to empower students' skills to become individuals who are ready to face current and future challenges (Zubaidah, 2016). Education in the 21<sup>st</sup> century requires educational institutions to produce quality students so that they can compete globally. The demand in question is that students are able to master communication and collaboration skills (Gonzales-Perez & Ramirez-Montoya, 2022). Communication and collaboration skills are important so that students can learn effectively

and productively in a school environment (Owens & Hite, 2022).

According to Urwani et al. (2018) learning at school is still often dominated by teachers rather than students, so students tend to be silent and focus on the teacher's explanations. Winarni et al. (2016) also said that in biology learning, teachers who use the lecture method dominate the learning process so much that students become passive. Several factors cause the low collaboration skills of students. Riskayanti (2012), said teachers still often use the lecture method, where the learning process is not centered on students in developing collaboration skills such as student cooperation in study groups. Nurwahidah et al. (2021) also found that the low collaboration skills of students are caused by teachers still using

biology teaching materials that do not direct students to scientific activities. Mas'ud (2018), said teachers must be able to present material with a learning process that can improve student skills. Teachers act as facilitators to help relate the initial knowledge that students already have with the new information they will learn, provide opportunities for students to learn according to their own learning methods and styles, and encourage students to take responsibility for the learning process carried out (Bara & Xhomara, 2020).

Based on the results of interviews with class X biology teachers at SMAN 10 Malang, it is known that students are not used to learning to use problems that come from the environment around where they live. The learning applied by teachers still rarely fosters students' communication and collaboration skills so that learning is still teacher-centered. Teachers still dominate learning so students tend to be passive in the classroom. Based on the results of the interview, the researcher chose SMAN 10 Malang as a research site to measure the communication and collaboration skills of class X students in biology. Therefore, teachers must be able to present material with a learning process that can improve student skills (Mas'ud, 2018). This does not mean that teachers hand over learning control to students completely, teachers still regulate and supervise every learning process (Nichols, 2013). Every student learns differently, so teachers are challenged to find ways to help students learn effectively. Teachers need to implement learning that allows students to connect with the real world, which helps students find value, meaning, and belief in what they are learning and can apply it in daily life (Nichols, 2013). The learning in question is problem-oriented, student-centered learning, students work in groups, and students work together to complete projects (Barge, 2010; Rongbutstri, 2017).

Problem-based and project-based learning is an ideal learning model to meet the goals of 21st-century education, as it involves

communication and collaboration skills (Zubaidah, 2018). The research result on problem-based learning and project-based learning show that these learning provides advantages for students to learn (Zubaidah, 2018). Trilling and Fadel (2009) explain that problem-based and project-based learning shows good learning outcomes and a range of 21st-century skills from students. Latada & Kassim (2017) also said that the implementation of problem-based and project-based learning is able to train students with the learning experiences they experience to improve students' skills. To achieve high learning outcomes in the realm of knowledge, skills, and attitudes, proper learning planning is needed (Ibrohim et al., 2014). Woods (2014) also said that problem-based and project-based learning directs a change in the role of the teacher from being a source of knowledge to a facilitator for students to acquire knowledge.

The learning model that is problem-oriented, working on projects, and learning in groups to solve problems is called the Problem-Oriented Project-Based Learning (POPBL) model (Rongbutstri, 2017). Problem-oriented and project-oriented learning can be applied to various subjects in school such as biology (Sari, 2023). Biology is a science that studies living things to find out and understand life in nature. Biology has scientific values, such as curiosity, cooperation, respect for other people's opinions, and openness to various new phenomena (Darmawan et al., 2021). Based on the description above, this study aims to determine the influence of the POPBL learning model on communication and collaboration skills in Biology material for grade X students of SMA Negeri 10 Malang.

## **METHOD**

### **Research design**

The type of research used is quasi-experimental research with a quantitative approach. Quasi experiment is a study that provides treatment on independent variables to

determine their effect on bound variables, but the influencing variables cannot be strictly controlled (Abraham & Supriyati, 2022). The research design used is a pretest-posttest non-equivalent control group design (Table 1). The research was conducted from August to November 2023 on grade X students of SMA Negeri 10 Malang. The experimental class was given treatment in the form of the Problem-Oriented Project-Based Learning (POPBL) model and the control class was treated in the form of the Problem Based Learning (PBL) model.

Table 1. Research design

Group	Pretest	Laerning Model	Posttest
X <sub>1</sub>	O <sub>1</sub>	POPBL	O <sub>2</sub>
X <sub>2</sub>	O <sub>3</sub>	PBL	O <sub>4</sub>

Notes:  
 O<sub>1</sub>, O<sub>3</sub> = Pretest  
 O<sub>2</sub>, O<sub>4</sub> = Posttest  
 X<sub>1</sub> = Experiment class  
 X<sub>2</sub> = Control class

### Sample

The sample of this study is students who take biology subjects (N = 70), which are divided into two classes – experimental class and control class. The sampling technique uses random sampling to select 2 equivalent classes. The research class contains male and female students aged 15-16 years. Before conducting the treatment, research permission was obtained from the relevant education office and the school principal. All students agreed to participate in this study. We ensured the confidentiality of the samples by securing the anonymity of the data.

### Research instrument

Communication skills research instrument in the form of a Likert scale questionnaire 1-4. This research test uses a paper-based test that is carried out for 30 minutes. Communication skills indicators consist of: oral communication, receptive communication, discerns intentent, uses communication, communicates clearly for a purpose, and presentation skills adapted and

modified from Greenstein (2012). Collaboration skills indicators consist of: contribution indicators, time management, team support, problem solving, interactions with others, and reflection which are adapted and modified from Ofstedal & Dahlberg (2009). The instruments used have been tested for validity and reliability with valid and reliable results.

### Data collecting procedure

Treatment is carried out for 8 weeks with one meeting in each week. Pretest is done before treatment and posttest is done after treatment. The subject matter used in this study is viruses and biological technology innovations. This research uses a learning model that raises problems in the environment around students, such as symptoms of the Covid-19 virus, environmental pollution, and food containing Genetically Modified Organisms. The Covid-19 pandemic has caused a significant impact on various sectors. The polluted environment is caused by the amount of plastic waste in nature that is difficult to decompose. While, the GMOs have the potential to address issues like food security and agricultural sustainability. Based on these problems, the teacher was posed questions: "why do these problems happen? How do we tackle these problems?". Meanwhile, students will identify the cause of the problem to find a way to overcome it. The solutions proposed by students will be the theme of the project in this POPBL learning.

### Data analysis

First, a questionnaire with a clear statement that respondents will rate on that scale, where 1 usually represents "Strongly Disagree" and 4 represents "Strongly Agree." Once the questionnaires are distributed and the responses are collected, each response is assigned a numerical value according to the selected choice of the Likert scale. After entering the data into a spreadsheet or statistical software, the next step is to clean up the data by checking for any incomplete or invalid

responses. To calculate the average of each item, add up all the numerical values of the answers and divide by the total number of respondents. This average value reflects the average of responses that indicate the overall trend of the group. The higher the average score, the more positive the group's response to a particular item. Furthermore, to see the homogeneity and harmony of communication and collaboration skills data scores, Levene's Test of Equality of Error Variances and One-Way Ancova tests were carried out. Meanwhile, hypothesis tests were carried out with ANACOVA at a significant level of 5%.

## RESULTS AND DISCUSSION

The normality test of students' communication skills and collaboration skills uses the Kolmogorov-Smirnov test. The results of the normality test based on table 2 show that the significance value for the pre-test on communication skills is  $0.073 > 0.05$ , which means that the communication skill data has been distributed normally. The significance value of the post-test on communication skills was  $0.067 > 0.05$  which means that the communication skills data had been distributed normally. The significance value for the pre-test on collaboration skills was  $0.053 > 0.05$  which means that the collaboration skills data had been distributed normally. The significance value of the post-test on collaboration skills was  $0.090 > 0.05$ , which means that the collaboration skill data has been distributed normally.

The data homogeneity test was carried out using Levene's Test of Equality of Error Variances. The results of the homogeneity test based on table 2, show that the significance value for the post-test on communication skills is  $0.380 > 0.05$ , which means that communication skills have been homogeneously distributed. The significance value for the post-test on collaboration skills was  $0.089 > 0.50$ , which means that collaboration skills have been homogeneously distributed. The results of the

homogeneity test showed that the data on communication skills and collaboration skills between one class and another were homogeneous.

Table 2. Prerequisite test

Test Type		N	P	alpha
Normality	Pretest	70	0.07	0.05
Normality	Posttest	70	0.07	0.05
Homogeneity	Posttest	70	0.38	0.05

The research results measured based on the bound variables, namely communication skills and collaboration skills, have met the prerequisite tests so that they can continue to conduct hypothesis tests analyzed using the *One-Way Ancova* test with the help of SPSS.

### a. Differences in communication skills between POPBL and PBL classes

The results of Ancova data analysis of communication skills that have a significance value of treatment for the learning model are  $p = 0.000 < \alpha = 0.05$  which means that the research hypothesis is accepted and  $H_0$  is rejected. These results show that there is a significant difference in communication skills between one class and another. The results of the average score statistical test were corrected, from the influence of the learning model on the communication skills of students taught in two classes, namely the experimental class (POPBL) and the control class (PBL) listed in Table 3.

Table 3. The result of ANCOVA on the communication skills of SMAN 10 Malang

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2680.3 <sup>a</sup>	2	1340.2	330.8	.000
Intercept	1590.1	1	1590.1	392.5	.000
PreKKM	1189.9	1	1189.9	293.7	.000
Perlakuan	1875.3	1	1875.3	462.9	.000
Error	271.5	67	4.1		
Total	353695.0	70			
Corrected Total	2951.8	69			

Based on Table 4, the results of the analysis of research data using the One Way Ancova test were obtained that a significance value of  $p\text{-value} < 0.05$  showed that there was an influence between the POPBL learning model on communication skills in the Biology material of SMA Negeri 10 Malang students. In addition, based on Table 4, the results of the LSD post hoc test on communication skills show that there is a difference in average scores between classes taught using the POPBL learning model and classes taught with the PBL model. The highest average score was obtained in the experimental class while the lowest average score was obtained in the control class. In addition, there was a difference in the average score in the initial test and the final test, which was obtained that there was an increase in the average score in both classes and the highest increase was obtained in the experimental class.

Table 4. Post Hoc LSD test results communication skills

Class	Pretest		Posttest	
	Mean	SD	Mean	SD
Experiment (POPBL)	46.6	6.9	75.4	4.3
Control (PBL)	48.4	4.1	66.2	5.0

The results of the hypothesis test of students' communication skills data showed that there was a difference between students who were taught with the POPBL model and students who were taught with the PBL model. The PBL model consists of the problem orientation stage, organizing students to learn, independent and group investigation, developing, presenting, numbing the work, and evaluating problem solutions. This shows the difference in the stages carried out, where in the control class that uses the PBL model, students are still not seen to be able to communicate well to achieve learning goals, because there are students who do not discuss with their fellow group friends or with teachers. Students' communication skills are also seen to be still rare to give responses during learning, students are very difficult to give questions or opinions

and students when presenting their discussion reports are still reading the report without paying attention to their friends. This causes students' communication skills in PBL classes to be lower compared to POPBL classes.

The POPBL model facilitates students in developing their communication skills. It can be seen when students use their ideas or ideas to design something different in creating solutions related to the problems found, thus helping students in developing their communication skills. Each stage of POPBL trains students to be able to communicate individually and in groups starting from problem orientation, problem formulation, project design, and project implementation. The first phase of POPBL is problem orientation and formulation. This phase empowers communication skills indicators, namely aspects of oral communication in the form of discussions and communication strategies. Teachers distribute LKPD to students about virus problems and biological technology innovations in Indonesia. Teachers direct students to understand the problems that have been read, so that they will raise questions related to virus problems and biological technology innovations. Students discuss these questions with their classmates, so that they can formulate problems related to viruses and biological technology innovations in groups. This problem-formulating activity is designed to help students discuss and convey their ideas clearly so that they can be understood by their peers (Pratama *et al.*, 2019).

The second phase of POPBL is to organize students to learn. Teachers instruct students to learn concepts related to viruses and biological technology innovations. Students individually explore knowledge related to viruses and biological technology innovations by reading books or searching the internet. Based on the knowledge obtained, students make concept maps or infographics related to viruses and biological technology innovations and their problems. This stage is useful in improving



students' written communication in the learning process, because it involves them in compiling summaries based on students' thoughts (Iftitahurrahimah *et al.*, 2020). The third phase of POPBL is to design and execute the project. Designing and executing the project is made based on the results of phases 1 and 2 of POPBL. In groups, students discuss to prepare a project plan related to the virus. The project design consists of the project topic, project objectives, how the project works, and the expected results of the project. Project work can be continued outside of class hours according to the situation and conditions of each one. In working on the project, it is tried in collaboration with proportional distribution. The length of time to work on the project is adjusted to the topic, level of complexity, and available time allocation. The indicators of empowered communication skills in this phase are verbal communication, receptive communication, understanding the purpose of communication, using communication strategies, and communicating clearly. This helps students to collect various information to design alternative solutions that will be used as the basis for student projects. Communication skills are proven when a person is able to participate in discussions as well as express their ideas in writing in a clear, structured, and systematic manner (Lufri *et al.*, 2021).

The fourth phase of POPBL or the last phase in the POPBL syntax is to present results and evaluations. The teacher gives directions to students to present the results of their projects. Students in groups presented the results of the project in various forms of creativity in turn. When the group finished the presentation, an evaluation was carried out by students and teachers. The aspects asked are the advantages and disadvantages of the product, the difficulties or obstacles faced during the work on the project, and solutions to correct the shortcomings of the product. Indicators of empowered communication skills in this phase are oral communication, receptive

communication, understanding the purpose of communication, using communication strategies, communicating clearly, and presentation skills. Students' communication skills are seen when students are able to explain their projects or assignments clearly, respond to questions from classmates, and come up with ideas related to the results of the projects they have done.

### b. Differences in collaboration skills between POPBL and PBL classes

The results of Ancova data analysis of collaboration skills that have a significance value of treatment for the learning model are  $p = 0.001 < \alpha = 0.05$  which means that the research hypothesis is accepted and  $H_0$  is rejected. The results show that there is a difference in the significance of collaboration skills between one class and another. The results of the average score statistical test were corrected, from the influence of the learning model on the collaboration skills of students learned in two classes, namely the experimental class (POPBL) and the control class (PBL) listed in table 5.

Table 5. The result of ANCOVA on the collaboration skills of SMAN 10 Malang

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	476.6 <sup>a</sup>	2	238.3	6.3	.003
Intercept	4795.2	1	4795.2	125.8	.000
PreKKB	23.9	1	23.9	.6	.431
Perlakuan	462.4	1	462.4	12.1	.001
Error	2554.5	67	38.1		
Total	389614.0	70			
Corrected Total	3031.1	69			

Based on Table 5, the results of the analysis of research data using the *One Way Ancova* test were obtained that the significance value was  $p\text{-value} < 0.05$  which showed that there was an influence between the POPBL learning model on collaboration skills in the Biology material of SMA Negeri 10 Malang students. In

addition, based on Table 5, the results of the LSD post hoc test on collaboration skills show that there is a difference in average scores between classes learned using the POPBL learning model and classes taught with the PBL model. The highest average score was obtained in the experimental class while the lowest average score was obtained in the control class. In addition, there was a difference in the average score in the initial test and the final test, which was obtained that there was an increase in the average score in both classes and the highest increase was obtained in the experimental class.

Table 6. Post Hoc LSD test results collaboration skills

Class	Pretest		Posttest	
	Mean	SD	Mean	SD
Experiment (POPBL)	47.3	5.4	76.9	5.3
Control (PBL)	47.9	6.2	71.8	6.9

The results of the hypothesis test of students' communication skills data showed that there was a difference between students who were taught with the POPBL model and students who were taught with the PBL model. The PBL model consists of the problem orientation stage, organizing students to learn, independent and group investigation, developing, presenting, numbing the work, and evaluating problem solutions. This shows the difference in the stages carried out, where in the control class that uses the PBL model, students are still not seen to be able to communicate well to achieve learning goals, because there are students who do not discuss with their fellow group friends or with teachers. Students' communication skills are also seen to be still rare to give responses during learning, students are very difficult to give questions or opinions and students when presenting their discussion reports are still reading the report without paying attention to their friends. This causes students' communication skills in PBL classes to be lower compared to POPBL classes.

Learning with the POPBL model can empower and develop collaboration skills. The POPBL model is a learning based on working on a project that is oriented towards real problems. The purpose of the POPBL learning process is to find solutions through the application of knowledge in the learning projects carried out by students, which in turn contributes to the improvement of education as a whole. Collaboration skills are essential in biology learning because students are expected to work together in their preparation efforts to prepare themselves to achieve student goals. The syntax of the POPBL model includes problem orientation, problem formulation, organizing students to learn, designing projects, and executing projects. The first phase of POPBL is the orientation and formulation of the problem. At this stage, students collaborate to identify existing problems. The teacher gives directions to students to formulate questions related to the problem. This is related to the improvement of student collaboration skill indicators, namely contribution, where students interact by sharing new ideas, information, and knowledge with their groupmates. This increase is due to increased motivation to find or investigate problems both individually and in groups which in turn improves the learning experience of students.

The second phase of POPBL is to organize students to learn. An indicator of empowered collaboration skills in this phase is contribution. Students discuss in groups to understand basic concepts related to the problems they face. Students in groups explore knowledge to understand concepts and problems related to viruses and biological technology innovations through various learning resources such as handouts, textbooks, or the internet and write down the results in the form of summaries or concept maps. Teachers check the information collected by students related to viruses and biological technology innovations. If the acquisition of information and understanding of concepts related to viruses and biological

technology innovations has not been completed, the teacher provides reinforcement carried out in groups. Students are encouraged to help each other in their own groups, encourage collaborative learning and take responsibility for each other in achieving common goals (Fitriyani *et al.*, 2019). Students will rebuild their knowledge by using various learning resources to generate solutions or ideas in solving problems.

The third phase of POPBL is the activity of designing and implementing projects. Students who have gathered enough knowledge and information, are expected to have solutions or ideas that can be realized in the form of projects. The design of this project is carried out collaboratively through discussions in accordance with the instructions contained in the LKPD. This activity is related to improving indicators of students' collaboration skills, including the ability to solve problems, manage time, and support teammates. Problem-solving indicators indicate that students are actively contributing to solving problems. Time management indicators illustrate that students use time efficiently and complete assignments on time. The team support indicator shows that students continue to support their teammates despite differences of opinion. These collaboration skills highlight effective and efficient performance and demonstrate respect for the diversity of team members, as well as shared decision-making. Team collaboration involves aspects of leadership, decision-making, and cooperation in completing tasks together. Leadership has an important role in designing projects so that collaboration becomes more effective in achieving common goals.

The fourth or final phase of the POPBL model is to present and evaluate the project results. The teacher gives directions to students to present the results of their projects. Together with the group, students presented the results of the project in various forms of creativity in turn according to the teacher's direction. When the group finished the presentation, an

evaluation was carried out by students and teachers. The aspects asked are the advantages and disadvantages of the product, the difficulties or obstacles faced during the work on the project, and solutions to correct the shortcomings of the product. One of the biological technology innovation products that has been made by SMA Negeri 10 Malang students is bioplastics (figure 1). Plastic products made from bioplastics have advantages compared to conventional plastics, namely bioplastic products are more environmentally friendly. Environmentally friendly means that bioplastics decompose faster in nature than conventional plastics. Bioplastics have disadvantages such as their rigid and brittle texture, so it is necessary to add glycerol as a plasticizer. From the results of the project evaluation, it can be seen that the indicators of collaboration skills are empowered, especially in terms of reflection, where students evaluate the results they have achieved and the collaboration that occurs in the work group. This evaluation has an important role in improving students' skills, improving professionalism, and students' ability to work together in developing products (Raiyn & Tilchin, 2015). This stage is in accordance with Vygotsky's learning theory which explains that learning in the form of interaction is a way to develop learning in groups without relying on individual thinking of students (van Compernelle & Williams, 2013).

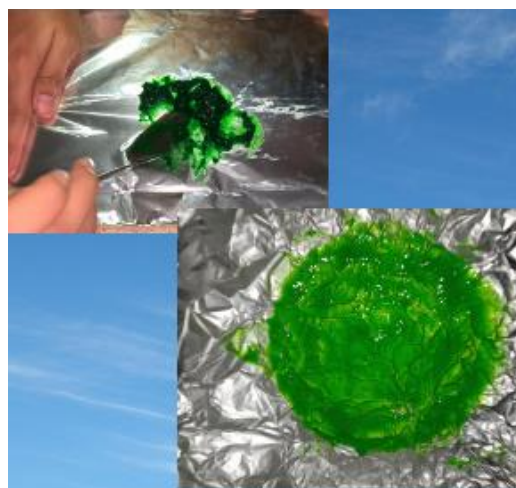


Figure 1. Bioplastic



Based on the difference between POPBL and PBL classes, that each stage of the POPBL model can facilitate students to communicate and collaborate in finding or searching, collecting, designing, and using ideas or ideas in making products that can solve problems because the POPBL learning process aims to find solutions through knowledge with project-based learning that students do so that it has an impact on learning for the better.

## CONCLUSION

Based on the results of the research and discussion, it can be concluded that the application of the Problem-Oriented Project-Based Learning (POPBL) model has an effect on the communication and collaboration skills of grade X students of SMA Negeri 10 Malang. Students who study biology with the POPBL model have higher communication and collaboration skills scores compared to students who learn with the PBL model. Learning using the POPBL model is more active than the PBL model. This is because each phase of POPBL requires students to be skilled in communicating and collaborating while learning, because each group is required to make solutions to overcome problems in the environment around students.

Based on the conclusion, future research is that teachers can develop biology learning by using the POPBL model to improve students' learning skills so that they can act relevant in dealing with problems in the student's living environment.

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