JPPIPA 10(12) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Needs Analysis for The Development of Biology E-Modules Based on Project-Oriented Problem-Based Learning (POPBL) to Improve Students' Critical Thinking, Creativity, and Collaboration Skillss

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Received: May 14, 2024
Revised: October 10, 2024
Accepted: December 25, 2024
Published: December 31, 2024

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DOI: 10.29303/jppipa.v10i12.9395

Abstract: Education should not merely provide students with knowledge; rather, learning in educational institutions serves as a process for acquiring knowledge, skillss, and competencies. The researchers conducted preliminary research to identify teacher and students need in biology learning, as well as the levels of students' critical thinking skills, creative thinking skills, and collaboration skills. The instruments used in this research are questionnaire and test sheets. The data that has been collected will then be analyzed both quantitatively and qualitatively. The sample of the study are biology teacher and students in Fase D at SMAN 1 Kabila, Gorontalo Regency. Based on the analysis of student and teacher needs in biology learning, it can be concluded that the majority of students find the learning process difficult and monotonous. Although students exhibit good collaboration habits, 80% of them have never engaged in projects, and they desire the integration of technology into teaching materials. The results of critical and creative thinking ability tests indicate a "very low" category, highlighting the need for intervention to improve these skills, possibly through the implementation of active learning methods such as Project Oriented Problem Based Learning (POPBL). Therefore, the development of digital teaching materials, such POPBL-based E-Module (Project Oriented Problem Based Learning), is essential to enhance students' understanding, engagement, and critical thinking skills, creative thinking skills, as well as collaborative skills at SMAN 1 Kabila, Gorontalo Regency in biology learning.

Keywords: Creative thinking skills; Collaborative; Critical thinking skills; e-module; POPBL

Introduction

The 21st century is characterized by advancements in technology, the development of ICT, and increasing globalization, along with a demand for innovation, highlighting the importance of mastering relevant skills and competencies (Chalkiadaki, 2018). The rapid advancement of technology, the spread of globalization, and the vast flow of information in the 21st century have raised concerns among practitioners, educators, and international organizations about the skills that students need to possess for the future (Afandi, Sajidan, Akhyar, & Suryani, 2019). Education should not merely provide students with knowledge; rather, learning in educational institutions serves as a process for acquiring

How to Cite:
Usman, N. F., Mustaqimah, N., & Latjompoh, M. (2024). Needs Analysis for The Development of Biology E-Modules Based on Project-Oriented Problem-Based Learning (POPBL) to Improve Students' Critical Thinking, Creativity, and Collaboration Skillss. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10859–10867. https://doi.org/10.29303/jppipa.v10i12.9395

knowledge, skills, and competencies (Gachino & Worku, 2019).

The essential skills required in the 21st century include: (1) Critical Thinking Skills; (2) Problem Solving skills; (3) Communication and Collaboration; (4) Creativity and Innovation; and (5) Information, Communication, and Technology Media Literacy. Together, these skills create a comprehensive set of competencies to address the challenges posed by globalization. Mastery in these areas is crucial to ensure one does not fall behind in a globalized world, but rather to be prepared to confront the challenges of our era (Alhamuddin et al., 2022).

Ken Kay, President of the Partnership for 21st Century Skills, presents three reasons why students should be ready to develop these skills. First, these skills are regarded as challenging to teach and assess comprehensively, resulting in their infrequent intentional inclusion in the overall curriculum. Second, these skills are essential for all students today as they confront challenges in the age of globalization. Third, they are vital skills needed for success in the workforce (Afandi et al., 2019).

The emphasis on enhancing student outcomes also requires an improvement in the quality of the teaching workforce. This indicates that educators play a crucial role in establishing effective teaching and learning environments. Ideally, all teachers, lecturers, and educators should not only focus on delivering knowledge but also inspire their students to apply this knowledge in real-world situations. Students should be encouraged to develop a specific set of skills, values, and inherent qualities that will advance them in their field. This calls for teachers to draw on these various qualities to prepare students for the real world. Additionally, it suggests that educators need to transition from traditional teaching methods to more engaging, outcome-based educational approaches (Alwi & Hussin, 2022).

One alternative learning approach that is widely utilized is project-oriented problem-based learning (POPBL), which can facilitate the achievement of this goal (Pucher & Lehner, 2011). POPBL offers students the chance to apply their knowledge while also gathering information. It can be described as a teaching and learning model that focuses on well-designed problems, prioritizing student-centered instruction by assigning projects to small groups (Li & Faghri, 2015).

The POPBL approach is based on Jean Piaget's cognitive theory, John Dewey's and Lewin's experiential learning, and Vygotsky's social cognitive theory. These theories share a common goal in learning—students are more likely to learn effectively when they actively engage in their own learning process. The most effective experiences are those that involve both active thinking and hands-on practice, requiring social interaction as well. POPBL provides more meaningful learning outcomes as a result of increased motivation. By learning in context, students find it easier to transfer and relate knowledge to other relevant contexts (Alwi & Hussin, 2022).

The POPBL model-based learning is flexible and can be applied across various school subjects, including biology. The aim of biology education is to provide opportunities for students to engage directly in scientific activities. Additionally, biology learning plays a crucial role in the development of students' competencies. Biology studies living organisms with the goal of understanding life in its natural environment. This field also instills values such as curiosity, collaboration, respect for diverse perspectives, and openness to new phenomena Sari (2023).

The use of the POPBL model is more effective when supported by relevant teaching materials. One effective teaching resource that teachers can use is e-modules. According to Hadianto & Festiyed (2020), E-modules are highly beneficial for increasing student engagement during learning activities by combining instructional models that enhance student abilities. Through the presentation of engaging material, no matter how difficult the content may be, if it is packaged attractively, it will facilitate students' understanding and motivate them to participate in classroom learning. According to Tama & Ibrohim (2024), the aim of the E-Module is to simplify abstract material, making it easier to understand and more engaging for students by utilizing multimedia elements such as audio, video, and animation. Additionally, with the accessibility of the E-Module through digital devices, students can learn anytime and anywhere, which can enhance their motivation and interest in the learning process.

Therefore, this study aims to determine the initial needs analysis of students and teachers in developing teaching materials in the form of e-modules based on the POPBL learning model. In addition, this study also aims to determine the level of critical thinking skills, creative thinking skills, and students' collaboration skills. Based on the results of this needs analysis, it will be continued by developing a POPBL e-module that accommodates students' critical thinking skills, creativity, and collaboration.

Method

This study uses survey method. Survey research is carried out to collect information and data that can help in making generalizations from observations that are not overly detailed, enabling the discovery of answers and solutions to specific problems (Prasetia, 2022). This

method is employed to collect data on the issues faced in schools within the context of learning, focusing on the levels of students' critical thinking, creative thinking, and collaboration skills. The research flow can be seen in Figure 1.

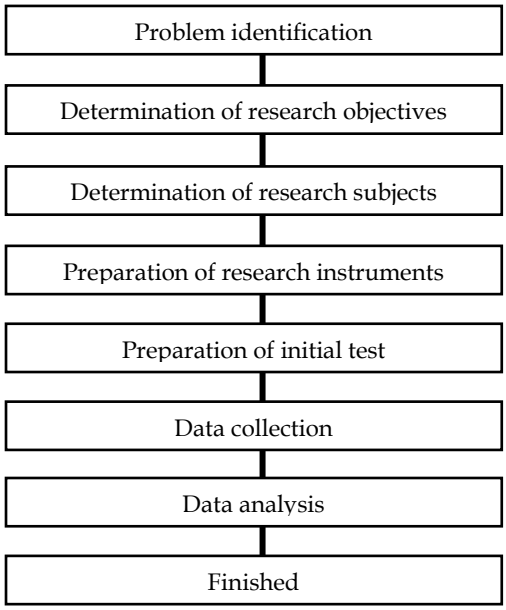

Figure 1. The Research Flow

The instruments used in this research are: (1) questionnaire for teacher needs analysis to collect information on teachers' perspectives and challenges related to the implementation of learning , (2) questionnaire for student needs analysis to collect information about students' needs, difficulties, and expectations related to the learning process; (3) test sheets to measure students' critical and creative thinking skills; and (4) a questionnaire to gather data on students' collaboration habits during learning. The data that has been collected will then be analyzed both quantitatively and qualitatively. The sample of the study are one biology teacher and 15 students in Fase D at SMAN 1 Kabila, Gorontalo Regency. The critical thinking test consists of 5 essay questions developed based on the indicators of critical thinking according to Ennis (1985), which can be described in Table 1.

Table 1. Indicator of Critical Thinking

Critical Thinking Skills Indicator	Description
Elementary Clarification	Focusing questions, analyzing arguments, as well as asking and answering clarification questions and challenging questions.
Basic Support	Considering credibility (criteria of a source), observing, and taking into account the results of the observations.
Inference	Making deductions and considering the results of the deductions, making inductions and considering the results of the inductions, making and considering decisions.
Advanced Clarification	Defining terms and considering definitions, identifying assumptions.
Strategies and Tactics	Deciding on an action

The creative thinking test comprises 4 essay questions that have been carefully developed based on the creative thinking indicators outlined by Guilford (1981), These questions are designed to assess various aspects of creative thinking, such as fluency, flexibility, originality, and elaboration. Each question targets a specific indicator to measure the students' ability. A more detailed explanation of these creative thinking indicators, as applied in the test, can be found in Table 2.

Table 2. Indicator of Creative Thinking Skills

Creative Thinking Skills Indicator	Description
Fluency	students can generate ideas and answers to solve problems
Flexibility	students can provide varied solutions (from all angles)
Originality	students can produce unique answers (using their own language or words that are easy to understand)
Elaboration	students can expand on an idea or elaborate on an answer in detail.

The data on students' collaboration skills was collected through a questionnaire consisting of 10 statements. These statements were developed based on the collaboration skills indicators proposed by Greenstein (2012), which include: working productively; contributing actively; maintaining a balance between listening and speaking; being committed to prioritizing group goals; demonstrating responsibility; appreciating each group member's contributions; controlling one's own emotions; participating respectfully in discussions,

debates, and disagreements; recognizing and trusting the strengths of each group member; and making decisions that include the perspectives of several members.

The data on students' critical thinking, creative thinking, and collaboration skills were thoroughly analyzed using quantitative methods. The results of the analysis were then grouped into several distinct categories, following the classification system developed by Ermayanti & Sulisworo (2016). This categorization allows for a more detailed and structured interpretation of the data, making it easier to assess students' strengths and areas for improvement. The criteria used in this categorization are outlined in Table 3.

Table 3. Categories of the Student Ability Percentages

Percentage (%)	Category
81,25 < X ≤ 100	Very high
71,50 < X ≤ 81,25	High
62,50 < X ≤ 71,50	Average
43,75 < X ≤ 62,50	Low
0 < X ≤ 43,75	Very low

Result and Discussion

Teacher Need Analysis

The results of the questionnaire filled out by the biology teacher regarding the learning process at SMAN 1 Kabila are presented in Table 4. These findings provide valuable insights into the teacher's perspectives on the curriculum, teaching methodologies, materials used, and student engagement in the classroom. The table includes key themes and specific responses that highlight the challenges in the implementation of biology instruction so far.

Table 4. The result of the teacher needs analysis

Question	Response
What is the average score of the students' biology daily tests?	Less than 75
What is the average number of students who do not meet the Minimum Completeness Criteria (KKM) after the daily test in one class?	6-10 students
What actions do you take for students who do not meet the Minimum Completeness Criteria (KKM)?	Providing remediation
In your opinion, which material is difficult to understand without real-life application examples in the biology lessons for Phase D in high school?	a. Cell b. Movement of substances through the cell membrane
What teaching method, approach, and teaching model do you usually use?	I often explain the material and evaluate students' understanding without applying specific approaches or teaching models.
Does the school where you work have supporting facilities for implementing IT-based learning that can be used by teachers and students? Please list the facilities available.	Yes, LCD projector and WIFI
Are students allowed to use mobile phones during biology lessons?	Yes
What teaching materials do you provide to the students?	Textbook
Have you ever developed IT-based teaching materials at school?	No
Is it necessary to develop teaching materials in the form of e-modules for biology content?	Yes
Have you implemented learning and assessment related to 21st-century skills?	No
Do students experience difficulties in participating in lessons that involve critical thinking skills?	Yes
Based on your observations and insights, how would you assess the creative thinking abilities of the students?	Still low
Have you ever assessed students' collaboration skills in biology learning?	No

The data obtained from interviews with the biology teacher at SMAN 1 Kabila provides a clear picture of the current condition of biology learning at the school. The average daily test scores in biology, which are below 75, indicate that students' understanding of the material being taught is still low. Additionally, there are 6 to 10 students in each class who do not meet the Minimum Completeness Criteria (KKM) after daily tests, highlighting an urgent need to improve teaching strategies.

The teacher stated that remediation is the action taken to assist students who do not meet the KKM;

however, there are further challenges when asked about difficult-to-understand material. Topics concerning cells and the movement of substances through the cell membrane are considered challenging without real-life application examples, underscoring the importance of relating learning to everyday contexts.

In terms of teaching methods, the teacher tends to use a lecture method to explain material and evaluate students' understanding without applying specific approaches or teaching models. Although the school has supporting facilities such as an LCD projector and Wi-Fi, and students are allowed to use mobile phones during lessons, the use of technology in teaching appears to be underutilized. This is reflected in the teacher's response, stating that they have never developed IT-based teaching materials, despite recognizing the importance of developing learning modules in the form of e-modules for biology content.

The use of e-modules based on Project Oriented Problem Based Learning (POPBL) is highly relevant in this context. By developing e-modules that integrate this approach, students can be encouraged to be more active in learning, collaborate, and apply critical and creative thinking skills. According to Yasin & Rahman (2011), a comprehensive curriculum with the right or suitable pedagogy and support must be introduced to students because teachers are catalysts in the development of values and behavior. Problem Oriented Project Based Learning (POPBL) is considered a potential approach in developing 21st-century skills, with the assumption that graduates will learn better when what they learn is meaningful, relates to their real-life situations, and allows them to experience it.

Student Need Analysis

The data from the student needs analysis obtained from a survey completed by 15 students provides a comprehensive picture of their perspectives on biology learning. The primary goal of this data collection is to understand the challenges they face and the unmet needs, so that the teaching and learning process can be improved. The results of the student needs analysis are presented in Table 5.

Table 5. The results of the student needs analysis

Question	Response	Percentage (%)
What is your opinion about biology learning?	Enjoyable	15%
	Average	25%
	Difficult	60%
Does the teaching conducted by the teacher in the classroom always relate the subject matter to events/phenomena or problems in everyday life?	Yes	40%
	No	60%
Does the biology teacher usually assign you to carry out projects?	Yes	20%
	No	80%
Is the teaching material used by the biology teacher monotonous?	Yes	80%
	No	20%
In your opinion, is it important to incorporate technology/digital elements into the teaching materials in biology lessons?	Yes	90%
	No	10%
Do the teaching materials that utilize technology in the biology learning process help you understand the learning material?	Yes, it helps	50%
	Somewhat helps	35%
	Doesn't help much	15%
What is your opinion on developing a digital teaching material that includes content, images, videos, exercises, and biology lesson materials?	Agree	100%
	Disagree	0%

The survey results indicate that the majority of students (60%) feel that the biology lessons they have experienced so far are quite difficult. This is a serious concern as it suggests that many students may struggle to understand the material being taught. Only 15% of students find the learning enjoyable, while 25% consider it average.

Students also indicate that the connection between the subject matter and real-life phenomena is not strong enough, with 60% of respondents stating that the teacher's instruction does not always relate the material to real-life examples. This highlights the need for a more contextual approach in biology teaching to enhance the relevance of the material in the eyes of students.

When asked about projects, only 20% of students reported that they are usually assigned to carry out projects. This indicates that opportunities for learning through practical and collaborative experiences are still very limited, which may contribute to students' low interest in the subject.

Interestingly, 80% of respondents consider the teaching materials used to be monotonous, with only 20% feeling otherwise. The monotony of these teaching materials may contribute to students' low interest and understanding.

More than half of the respondents (90%) agree that it is important to integrate technology or digital elements into the teaching materials for biology lessons. This shows that students recognize the potential of technology to enhance their learning experience. About 50% of students feel that technology-based teaching materials help them understand the content, while 35% find it somewhat helpful.

Finally, all students (100%) agree that developing digital teaching materials that include content, images, videos, exercises, and biology lesson materials is very important. This indicates a strong need for innovation in teaching methods and the development of more engaging and interactive learning resources.

The results of this student needs analysis underline the importance of developing e-modules based on Project Oriented Problem Based Learning (POPBL) that can help students enjoy and understand biology material better. With this approach, it is hoped that students can be more actively engaged, collaborate, and improve their critical and creative thinking skills in learning biology.

As expressed by Lehman, Christensen, Du, & Thrane (2008) in their research, it is emphasized that it is very important to apply a problem-oriented rather than a subject-oriented approach so that problems can be identified in more detail and problem solving can be done innovatively. Students can address issues relevant to their daily lives through interaction, mix, and diversity; aspects that will be involved in a problem-oriented and project-based learning approach.

Students' Critical Thinking Skills

Data on students' critical thinking skills were obtained through the administration of tests designed to measure aspects of critical and creative thinking skills. This step aims to provide an initial overview of the students' critical thinking ability levels, which will later serve as a reference for developing the POPBL-based E-Module. The critical thinking ability test consists of essay questions developed based on the indicators of critical thinking abilities according to Ennis (1985), which include Elementary Clarification (providing simple explanations), Basic Support (building basic skills), Inference (drawing conclusions), Advanced Clarification (providing further explanations), and Strategies and Tactics. The results of the students' critical thinking ability tests are categorized into several levels: very low, low, medium, high, and very high. The results of the students' initial critical thinking ability test are presented in Table 6.

Table 6. The Results of the Initial Critical Thinking Skills Test of Students

Critical thinking indicator	Average Score (%)	Category
Elementary Clarification	21	Very Low
Basic Support	23	Very Low
Inference	19	Very Low
Advanced Clarification	21	Very Low
Strategis and Tactics	23	Very Low

The data presented shows the results of the initial critical thinking skills test of students, measured through several indicators: Elementary Clarification, Basic Support, Inference, Advanced Clarification, and Strategic and Tactics. The average scores obtained for each indicator are below 25%, indicating that students' critical thinking abilities fall into the "very low" category. The score of 21% for the Elementary Clarification indicator shows students' difficulties in providing simple explanations, while the score of 23% for Basic Support reflects their inability to build the basic skills needed for further analysis. Additionally, the score of 19% for Inference indicates students' struggles in drawing conclusions, which is a key element of critical thinking. The score of 21% for Advanced Clarification shows limitations in providing more in-depth explanations, and the score of 23% for Strategic and Tactics signifies that students are not yet capable of formulating effective strategies and tactics in problem-solving.

This analysis indicates an urgent need to enhance critical thinking skills among students, as all indicators show scores below 25%. This low performance can hinder students' ability to conduct in-depth analyses and effective problem-solving, both in the context of biology learning and in everyday life. Therefore, the development of E-Modules based on Project Oriented Problem Based Learning (POPBL) is highly relevant to improve students' critical thinking skills.

According to research conducted by Suwistika, Ibrohim, & Susanto, (2024), the use of the Problem Oriented Project Based Learning (POPBL) model has been proven effective in enhancing students' critical and creative thinking skills. In POPBL learning, there is noticeable interaction among students during the learning process, as well as discussions related to solutions or projects through solving the problems they encounter. As expressed by Wan Husin et al. (2016) in their research that through this approach, students can be encouraged to actively participate in projects that require critical thinking, collaboration, and the application of knowledge in real-world situations. Thus, it is essential to conduct training and curriculum

development that emphasize critical thinking skills and employ more interactive and project-based teaching methods, which is expected to bring positive changes in enhancing students' critical thinking abilities in the future.

Students' Creative Thinking Skills

The creative thinking skills test was developed based on the indicators of creative thinking abilities according to Guilford (1981), which include flexibility (variety of ideas generated), fluency (number of ideas produced), originality (specificity and uniqueness of the ideas presented), and elaboration (amount of detail in the ideas provided). The results of the initial analysis of students' creative thinking abilities are presented in Table 7.

Table 7. The Results of the Initial Creative Thinking Ability Test of Students

Creative thinking indicator	Average Score (%)	Category
Flexibility	20	Very Low
Fluency	33	Very Low
Originality	30	Very Low
Elaboration	20	Very Low

The data on students' creative thinking abilities show concerning results across all indicators, with average scores indicating a "Very Low" level of performance. The flexibility indicator scored 20%, suggesting that students struggle to generate a variety of ideas, which is crucial for creative problem-solving. Similarly, the fluency score of 33% indicates a limited capacity to produce many ideas, reflecting difficulties in effective brainstorming. The originality score stands at 30%, indicating that students do not present unique or different ideas, a key component of creativity. Finally, the elaboration score of 20% shows that students provide little detail in their ideas, indicating a lack of depth in their creative outputs.

Overall, these results highlight a significant need for intervention to improve creative thinking skills among students. The low scores point to critical areas for development, suggesting that current teaching methods may be ineffective in encouraging or facilitating creative thinking. To address these shortcomings, it may be beneficial to implement instructional strategies that promote creativity, such as project-based learning, collaborative activities, and opportunities for students to engage in real-world problem-solving tasks. Such approaches can help create an environment where students feel empowered to think creatively and express their ideas more freely, ultimately enhancing their performance across these important indicators of creative thinking skills. According to Francisco, Ibrohim, & Susilo (2024), each stage of the POPBL model can assist students in thinking creatively by exploring, gathering, designing, and applying ideas to create products that can solve problems. This is because the POPBL learning process is designed to find solutions through knowledge developed by students through project-based activities, leading to positive changes in the learning process.

Students' Collaborative Skills

The data on students' collaboration skills were obtained through the completion of a questionnaire containing statements related to students' collaboration habits in learning activities, such as habits in expressing ideas, suggestions, responses, or solutions during discussions, actively working on group assignments, being open to feedback during discussions, and more. This questionnaire was designed using a Likert Scale with four response categories: Never, Sometimes, Often, and Very Often. After collecting the data, the results of the questionnaire were calculated as a percentage for each response category. The percentages obtained from the questionnaire were then grouped into assessment criteria. These criteria are used to determine the level of students' collaboration based on the distribution of data, allowing for analysis to identify the need for enhancing students' collaboration in learning. The results of the analysis initial collaborative skills of students are presented in the Figure 2.

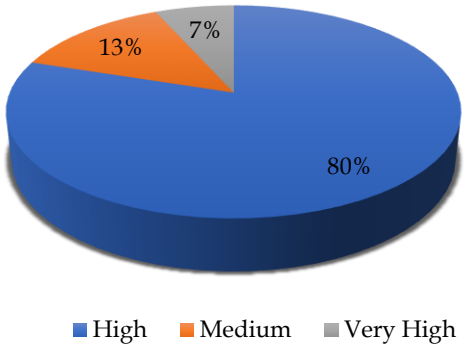

Figure 2. The percentage of Initial Collaborative Skills of Students

Based on the analysis of students' collaboration habits, it was found that the majority of students fall into the High category. A total of 12 students (80%) demonstrated collaboration habits classified as High, indicating that they often to very often engage in collaborative activities during learning. Meanwhile, there are 2 students (13.3%) in the medium category, showing that they have relatively sufficient collaboration habits, but not very often. Additionally, only 1 student (6.7%) is in the Very High category,

meaning that this student collaborates very frequently in various learning activities.

From this interpretation, it can be concluded that most students already possess good collaboration habits, with few students showing lower levels of collaboration. This indicates that a culture of cooperation among students has been established; however, more attention is needed to enhance collaboration habits for those students still categorized as Medium. The majority of students scored 2, indicating that they sometimes express ideas, suggestions, responses, or solutions during discussions, highlighting the need for special attention to improve their confidence in fostering these collaborative habits.

Conclusion

Based on the analysis of student and teacher needs in biology learning, it can be concluded that the majority of students find the learning process difficult and monotonous. Although students exhibit good collaboration habits, 80% of them have never engaged in projects, and they desire the integration of technology into teaching materials. The results of critical and creative thinking ability tests indicate a "very low" category, highlighting the need for intervention to improve these skills, possibly through the implementation of active learning methods such as Project Oriented Problem Based Learning (POPBL). Therefore, the development of digital teaching materials, such as POPBL-based E-Module (Project Oriented Problem Based Learning), is essential to enhance students' understanding, engagement, and critical thinking skills, creative thinking skills, as well as collaborative skills at SMAN 1 Kabila, Gorontalo Regency in biology learning.

Acknowledgments
The author expresses gratitude to the Institute for Research and Community Service (LP2M) of Universitas Negeri Gorontalo (UNG) for the research funding that made this study possible. Special thanks are also extended to the biology teacher of grade XI at SMA Negeri 1 Kabila for their assistance and support during the research process. Finally, the author expresses the deepest appreciation to all the grade XI Biology specialization students at SMA Negeri 1 Kabila for their participation and cooperation throughout the research activities.

Author Contributions
In this study, the author makes a different contribution. N.F.U: Conceptualization, methodology, data analysis, finalization of the article draft
NM: Validation, data analysis, data collector, writing—original draft preparation and M.L: Writing—review and editing, formal analysis.

Funding
This research did not receive external funding.

Conflicts of Interest
The authors declare no conflict of interest.

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