

DEVELOPMENT OF A PLANT TISSUE CULTURE TEXTBOOK BASED ON PROJECT-BASED LEARNING TO ENHANCE THE SCIENCE PROCESS SKILLS OF BIOLOGY STUDENTS

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ABSTRACT

This study aims to determine the feasibility of a Project-Based Learning (PjBL)-based Plant Tissue Culture textbook in improving the science process skills of biology students at Universitas Negeri Medan, based on evaluations from material experts and media experts. It also aims to identify the responses of lecturers and students toward the developed textbook and to assess its effectiveness in enhancing students' science process skills in plant tissue culture material at Universitas Negeri Medan. The study was conducted from August to November 2024 in the Department of Biology, Universitas Negeri Medan. The research employed the 4D development model, which includes the stages of define, design, develop, and disseminate. To measure the effectiveness of the developed textbook on students' science process skills, the N-Gain test was used. The results showed that the feasibility of the PjBL-based plant tissue culture textbook in improving biology students' science process skills, based on the assessment of material experts, obtained an average score of 76.66% (feasible), while the media experts gave an average score of 94.04% (highly feasible). The lecturers' response reached an average percentage of 95% (highly feasible). The students' responses were also very positive: the individual trial obtained 94.16%, the small group trial obtained 91.75%, and the large group trial obtained 90.92%, all categorized as highly feasible. Based on the N-Gain test results, the developed PjBL-based plant tissue culture textbook was found to be quite effective in improving the science process skills of biology students at Universitas Negeri Medan

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INTRODUCTION

Learning resources are any form of materials, information, or media that can be used in the learning process to help educators and students achieve learning goals. Learning resources can be in the form of books, videos, software, or a combination of various media formats that are able to support learning activities. According to , learning resources are everything that is designed or used to facilitate the implementation of teaching and learning activities. In today's digital era, books are still one of the main learning resources used by students in completing assignments and understanding lecture materials. However, the phenomenon that often occurs is that students often play the role of technology users rather than creators of scientific ideas. As a result, literacy activities and scientific thinking skills are less developed. In fact, scientific reading and writing activities are very important to foster creativity and critical thinking skills. (Lubis et al., 2023) Warsita (2008)

Based on the results of observations, Medan State University students showed low interest in textbooks, especially in plant tissue culture courses. The limited availability of textbooks causes students to look for other sources such as journals and online articles more often. In addition, some of the books available are not visually appealing, have difficult language to understand, and the presentation of the material is monotonous, so it does not support the learning process. (Kurniati & Ahda ,2019)

To improve students' understanding of network culture materials, directed practicum activities and teaching materials that are able to facilitate the development of science process skills are needed. The practicum serves as a means for students to prove theories through hands-on experience in the laboratory. In order for practicum activities to run effectively, appropriate teaching materials, such as manuals or practicum guides that are easily accessible and understood, are needed. In addition, assessments conducted during lectures often only emphasize the cognitive aspect, without involving systematic scientific process skill assessment instruments. In fact, science process skills are an important ability for biology students, because they can train them to think scientifically, solve problems, and apply concepts in daily life. Therefore, there is a need for teaching material innovations that are not only informative but also able to grow students' science process skills. One of the appropriate learning models to support this is (Rustman, 2005) (Agustina et al., 2019) *Project Based Learning* (PjBL). This model emphasizes project- and product-based learning activities, which allow students to play an active role, think critically, and work collaboratively in solving a problem. (Akhiruddin et al., 2016)

The *Project Based Learning-based textbook* is expected to be a solution to overcome the limitations of existing learning resources and be a guide that helps students understand and apply the concept of plant tissue culture more effectively. Based on this background, a research was conducted with the title "Development of Plant Network Culture Textbook Based on *Project Based Learning* to Improve Science Process Skills of Biology Students at Medan State University.

METHODS

This research is a development research using the Four-D (4D) model which consists of 4 stages, namely definition, design, development and dissemination. The subjects in this study include expert validators consisting of material experts, media experts, network culture lecturers at the State University of Medan and students of the non-teaching Biology study program Class C stambuk 22. The data collection technique consists of questionnaires and tests. The questionnaire was carried out by distributing validation questionnaires, lecturer response questionnaires and student response questionnaires. Meanwhile, tests are carried out to test the level of effectiveness of the product by providing *pretests* and *posttests*. The data analysis carried out in this study consisted of questionnaire data analysis and product effectiveness test data analysis. (Desy & Setyoko , 2017)

RESULTS AND DISCUSSION

Results

The development of the PjBL-based tissue culture textbook was carried out using a 4D development model consisting of 4 stages, namely the definition stage, the engagement stage, the development stage and the dissemination stage. (Mariyani et al., 2023)

Definition Stage

This stage consists of 5 steps, namely initial analysis, student analysis, task analysis, concept analysis, and learning objective analysis. Based on the front-end analysis, the product developed is a Project-Based Learning-based plant tissue culture textbook to improve the science process skills of biology students at the State University of Medan. The student analysis was carried out by providing a needs analysis questionnaire to several biology students who had studied the plant tissue culture course. The results of the needs analysis questionnaire showed that as many as 87% of students answered strongly that the textbook needed to be developed. The results of the assignment analysis show that the textbooks developed are compiled based on the CP-MK contained in the RPS tissue culture course, including CP-MK 1: Students understand the concepts, theories about cells and the concept of totipotency and CP-MK 3: Students know the various plant tissue culture media, know the characteristics, composition, manufacturing procedures and designation of media that are in accordance with the type of plant material to be grown with tissue culture techniques. The subjects developed in accordance with the results of the concept analysis include: 1) Introduction: Cell theory and the concept of totipotency, 2) Tissue culture media and 3) Creation of tissue culture media. Meanwhile, the learning objectives. The learning objectives are adjusted to the sub-material explained in each chapter. As for chapter 1: Introduction to tissue culture, the purpose of providing an explanation of material about the definition of plant tissue culture, the nature of cell totipotency, the history of tissue culture, types of plant tissue culture, the benefits of plant tissue culture and the advantages and disadvantages of tissue culture techniques. Chapter 2: Tissue culture media aims to provide material explanations about the components of the preparation of plant tissue culture media, types of media based on consistency and types of basic mediums. Chapter 3: The creation of cultural media aims to provide material explanations about the creation of MS media, Knudson media, Gamborg media, White media, Nitsch media, WPM media, VW media, N6 media and SH media. (Susanti, 2019) (Bhatia & Dahiya, 2015)

Planning Stage

The design stage is carried out by assembling instruments, selecting media, choosing formats, and designing initial designs. The instruments prepared are in the form of science process skill tests made based on the results of the analysis of learning objectives and student analysis. The PPP test that is prepared consists of 10 essay questions. This test is prepared based on 10 indicators of science process skills, which occur from observing, grouping/classifying, interpreting, predicting, proposing questions, formulating hypotheses, designing experiments, using tools or materials, applying concepts and communicating. The media chosen is a project-based learning based network culture book (Diella & Ardiansyah, 2019) which consists of three chapters, namely an introduction to network culture, network culture media and the creation of culture media. The book also contains supporting images, science process skill-based exercises and project assignments in the form of practicum activities on how to make media. (Renostini Harefa, 2026)

The format used consists of the book cover format, the systematic format of the book and the format of book presentation. The book cover is composed of several elements, namely the title of the book, the sub-title to be discussed, the university logo, the author's name, the synopsis of the book and is also equipped with images about network culture media. The systematics format is divided into 3 parts, which consist of an introduction, content and closing section. The components in the introduction of the book consist of an introduction, table of contents, list of

pictures, table list, instructions for using the book, brief description of the course, brief description of the textbook material, course learning outcomes and learning objectives. The components in the content section consist of three sub-materials, namely introduction to tissue culture, tissue culture media and the creation of culture media. Finally, the concluding section consists of a glossary, bibliography and a brief description of the authors. The following is the appearance of the developed textbook:



Figure 1. Textbook Display

Development

The development stage is carried out through two stages, namely expert validation and product trials.

a. Expert Validation

The book validation test was carried out by material experts and media experts. The results of the assessment from material experts and media experts on the curriculum developed are as follows:

Table 1, Results of Textbook Assessment by Material Experts

Yes	Aspects	Frequency				Number of questions	Total score	Max score	Average (%)	Criteria
		4	3	2	1					
1	Content eligibility	1	3	-	-	4	13	16	81,25	Worthy
2	Language qualifications	-	4	-	-	4	12	16	75	Worthy
3	Presentation of the material	-	7	-	-	7	21	28	75	Worthy
Total						15	46	60	76,66	Worthy

Based on Table 1, it can be seen that the assessment from the subject matter experts obtained an average score of 76.66% with a decent category. Furthermore, the material expert concluded that the textbook developed was suitable for use for the trial process in accordance with the revisions given.

Table 2, Results of Textbook Evaluation by Media Experts

No	Aspects	Frequency	Total score	Max score	Average (%)	Criteria
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		4	3	2	1	Number of questions				
1	Display	4	2	-	-	6	22	24	91,66	Highly feasible
2	Device engineering	1	3	-	-	4	13	16	81,25	Worthy
3	Cover design	6	-	-	-	6	24	24	100	Highly feasible
4	Content design	6	-	-	-	6	20	20	100	Highly feasible
Total						21	79	84	94,04	Highly feasible

Based on Table 2, it can be seen that the assessment from media experts obtained an average score of 94.04% with a very feasible category. Furthermore, media experts concluded that the textbooks developed were suitable for the trial process without revision.

b. Product Trials

The product trial was carried out by distributing response questionnaires to network culture lecturers and students who were studying network culture courses. The results of lecturers and students' responses to the textbooks developed are as follows:

1. Lecturer's Response

Table 3, Lecturers' Responses to Textbooks

No	Aspects	Frequency				Number of questions	Total score	Max score	Average (%)	Criteria
		4	3	2	1					
1	Book view	3	1	-	-	4	15	16	93,75	Highly feasible
2	Presentation of the material	5	1	-	-	6	23	24	95,83	Highly feasible
Total						10	38	40	95	Highly feasible

Based on Table 3, it can be seen that the lecturers' responses obtained an average score of 95% with a very decent category. Furthermore, the network culture lecturer concluded that the textbook that had been compiled was able to provide benefits to lecturers in carrying out the learning process of network culture in the classroom.

2. Student Response

The student response was divided into three stages, namely an individual trial of 3 people, a small group trial of 10 people and a large group trial of 46 people.

Table 4, Individual Trial Results

No	Aspects	Frequency				Number of questions	Total score	Max score	Average (%)	Criteria
		4	3	2	1					
1	The usefulness of books in tissue culture courses	7	2	0	0	9	34	36	94,44	Highly Worth It



2	Difficulty level of the question	6	0	0	0	6	24	24	100	Highly Worth It
3	Font and language selection	5	4	0	0	9	32	36	88,88	Highly Worth It
4	Book instructions	3	0	0	0	3	12	12	100	Highly Worth It
Total						30	113	120	94,16	Highly Worth It

Based on Table 4, it can be seen that the results of the individual trial obtained an average score of 94.16% with the very feasible category.

Table 5, Small Group Trial Results

No	Aspects	Frequency				Number of questions	Total score	Max score	Average (%)	Criteria
		4	3	2	1					
1	The usefulness of books in tissue culture courses	18	12	0	0	30	108	120	90	Highly Worth It
2	Difficulty level of the question	14	6	0	0	20	74	80	92.5	Highly Worth It
3	Font and language selection	23	7	0	0	30	113	120	94,16	Highly Worth It
4	Book instructions	4	6	0	0	10	34	40	85	Highly Worth It
Total						100	367	400	91,75	Highly Worth It

Based on Table 5, it can be seen that the results of the small group trial obtained an average score of 91.75% with a very feasible category.

Table 6, Results of Large Group Trials

No	Aspects	Frequency				Number of questions	Total score	Max score	Average (%)	Criteria
		4	3	2	1					
1	The usefulness of books in tissue culture courses	89	49	0	0	138	503	552	91,12	Highly Worth It
2	Difficulty level of the question	58	33	1	0	92	333	368	90,48	Highly Worth It
3	Font and language selection	91	45	2	0	138	503	552	91,12	Highly Worth It

4	Book instructions	29	16	1	0	46	166	184	90,21	Highly Worth It
Total						460	1673	1840	90,92	Highly Worth It

Based on Table 6, it can be seen that the results of the large group trial obtained an average score of 90.92% with the very feasible category.

Deployment

At this stage, a test of the effectiveness of the use of textbooks that have been developed is carried out to see if the book is effective in improving the science process skills of Unimed biology students in the tissue culture course. This effectiveness test was carried out through the provision of *pretests* and *post tests* to 46 students in the non-dik C class of 22. The measurement of the effectiveness level of books through *pretest* and *post test data* was carried out by the N-Gain test. The results of the *pretest* and *post test data* analysis and the results of the N-Gain test are as follows.

Table 7, Average Results of Students' Science Process Skills

No	Test Type	Average Student PPP (%)	Criteria
1	<i>Pretest</i>	50,67	Medium
2	<i>Post test</i>	83,04	Height

Based on Table 7, it can be seen that the average percentage of PPP scores from 46 students increased between the *pretest* results and the *post-test* results. Where during the *pretest*, the average result obtained was 50.67% in the medium category, while the average result obtained during the *post test* was 83.04 in the high category.

In addition to the results of the PPP test analysis based on the average totality, the results of the PPP test analysis based on the average per indicator can be seen in table 4.8 below.

Table 8, Average Results of Students' Science Process Skills Per Indicator

Yes	Science Process Skills Indicators	Pretest		Post test	
		Average score (%)	Criteria	Average score (%)	Criteria
1	Observing	52,17	Medium	82,17	Height
2	Grouping/classification	45,65	Medium	90	Height
3	Interpret	69,13	Height	88,69	Height
4	Forecasting	46,73	Medium	89,13	Height
5	Ask a question	66,95	Height	92,17	Height
6	Formulating a hypothesis	63,91	Medium	89,56	Height
7	Plan an experiment	58,26	Medium	88,69	Height
8	Using tools or materials	48,69	Medium	83,04	Height
9	Implementing the concept	35,65	Medium	61,73	Medium
10	Communicating	19,56	Low	65,21	Medium

Discussion

This research is a research on the development of a plant tissue culture textbook based on *Project Based Learning* (PjBL) to improve the science process skills of Biology students of the State University of Medan. This textbook functions as a learning medium that connects lecturers and students in network culture learning activities in the classroom and in the laboratory. The development model used is a 4D model which consists of four stages: define, *design*, *develop*, and *disseminate*. The definition stage aims to identify learning needs through initial analysis, student analysis, task analysis, concept analysis, and learning objective analysis. The result of this stage is in the form of a PjBL-based network culture textbook design consisting of three chapters, namely introduction to network culture, network culture media, and the creation of cultural media. At the design stage, the preparation of science process skill test instruments, the selection of media and formats, and the creation of an initial design of textbooks were carried out. The instrument is in the form of 10 essay questions that have been validated by expert lecturers. The initial design of the book includes an introduction, content, and conclusion, then reviewed by the supervisor to obtain input before the expert validation stage. The development stage includes expert validation and product trials. The results of the validation of the subject matter experts showed a feasibility percentage of 76.66% (feasible) with several suggestions for improvement such as adjusting citations and adding supporting illustrations. Media expert validation obtained a score of 94.04% (very feasible) without revision. The product trial stage was carried out to the teaching lecturers and students. The lecturer's response showed a score of 95% (very decent) with some technical improvements to the citations, images, and bibliography. The trial for students was carried out individually, in small groups, and large groups with consecutive results of 94.16%, 91.75%, and 90.92% where all were in the very feasible category. (Susanti, 2019)

The last stage carried out is the dissemination stage. At this stage, an effectiveness test was carried out on textbooks that had been validated and tested by lecturers and students in improving science process skills in the network culture course. The effectiveness test was carried out by providing *a pretest* and *posttest* consisting of 10 essay questions. The data obtained from the pretest and posttest were then analyzed through two stages, namely PPP data analysis and textbook effectiveness test analysis. The average percentage of student PPP at the *time of the pretest* was 50.57% with the medium category and the average percentage of student PPP at the posttest was 83.04% with the high category. (Kartikasari et al., 2018)

Then, then an analysis of student PPP data per indicator is carried out. From the results obtained, it can be seen that the observing indicator has increased the average percentage from 52.17% (*pretest*) to 82.17% (*posttest*). From these figures, it can be seen that the practicum-based project tasks they carry out are able to improve their ability to observe an object. This is because when carrying out project tasks, they can see firsthand various components in tissue culture in the laboratory. In the grouping indicator, there was an increase in the average percentage from 45.65% ((Mitsubishi & Royani , 2019) *Pretest*) to 90% (*Posttest*). From this figure, it can be seen that before being given a textbook, students already have a high ability to group various things according to their respective characteristics, but this ability increases when they use the textbooks that have been developed. (Setyabudi et al., 2020)

In the interpreting indicator, there was an increase in the average percentage from 69.13% (*Pretest*) to 88.69% (*Posttest*). From these figures, it can be seen that the practicum-based project activities they carry out are able to improve their ability to interpret an observation. In the forecast indicator, there was an increase in the average percentage from 46.73% (*Pretest*) to 89.13% (*Posttest*). From these figures, it can be seen that the practicum-based project activities they carry out are able to improve their ability to predict something that will happen based on the knowledge and experience they get from the practicum activities. (Sholihah & Pertiwi, 2019)

In the indicator asking questions, there was an increase in the average percentage from 66.95% (*Pretest*) to 92.17% (*Posttest*). From these figures, it can be seen that before being given a textbook, students already have a

high ability to ask questions according to the specified material, but this ability increases when they use the textbooks that have been developed. In the hypothesis formulation indicator, there was an increase in the average percentage from 63.91% (*Pretest*) to 89.56% (*Posttest*). From these figures, it can be seen that before being given a textbook, students already have a high ability to formulate various possible explanations of an event, but this ability increases when they use the textbooks that have been developed. (Rafiq et al., 2022)

In the indicator of planning experiments, there was an increase in the average percentage from 58.26% (*Pretest*) to 88.69% (*Posttest*). From these figures, it can be seen that the practicum-based project activities they carry out are able to improve their ability to plan experimental procedures related to tissue culture techniques. This is because when conducting practicum activities, all students are directly involved in carrying out the stages of tissue culture procedures in the laboratory so that it makes them easier to understand and be able to design similar experiments. These results are strengthened by research that explains that PjBL-based teaching and learning activities require students to be creative, collaborative, problem-solving and independent in learning both individually and in groups so that they can better understand what they are doing. There is an improvement in their science process skills in the indicator of planning experiments, it is hoped that students will be able to design and carry out experiments that are not only limited to tissue culture materials but also to all materials in lectures. (Cholifah et al., 2025) (Amalia et al., 2022)

In the indicator using tools or materials, there was an increase in the average percentage from 48.69% (*Pretest*) to 83.04% (*Posttest*). From these figures, it can be seen that the practicum-based project activities they carry out are able to improve their ability to know how to use a tissue culture tool. This is because when conducting practicum activities, all students have the opportunity to know how to use a tool and use it directly so that the knowledge they have is not just reading or memorizing.

In the indicator of implementing the concept, there was an increase in the average percentage from 35.65% (*Pretest*) to 61.73% (*Posttest*). From these figures, it can be seen that the practicum-based project activities they carry out are able to improve their ability to apply the concepts they have learned to new and new situations. The application of the *Project Based Learning* (PjBL) model in this study is in line with the principles of constructivist learning theory, which emphasizes that effective learning occurs when students play an active role in building their own knowledge through direct experience and authentic problem-solving faced in real contexts. Through project-based learning activities, students are encouraged to integrate the initial knowledge they already have with new concepts and ideas that emerge during the investigation process. This process not only deepens conceptual understanding, but also develops students' science process skills, as they are actively involved in formulating problems, designing solutions, collecting and analyzing data, and drawing conclusions based on the findings obtained. (Mother's Market & Simatupang, 2020)

In the communicating indicator, there was an increase in the average percentage from 19.56% (*Pretest*) to 65.21% (*Posttest*). From these figures, it can be seen that the practicum-based project activities they carry out are able to improve their ability to communicate the results of research into other forms to make it easy for readers to understand it.

The results of the analysis showed that all science process skill indicators (PPP) experienced a significant increase and were in the high category. This proves that the Project Based Learning (PjBL)-based textbooks developed are effective in improving every aspect of student PPP. These findings are in line with research that states that the PjBL model can develop and train students' science process skills, as well as affirming that PjBL has a positive effect on improving students' scientific abilities. The next stage of analysis is to test the effectiveness of the product using N-Gain. Based on the results of the analysis, the increase in PPP in 24 students was in the medium category, while the other 22 students were in the high category. Overall, the average N-Gain was 0.65 (medium category), while the average increase in all PPP indicators reached 0.67 (medium category). This

improvement shows that the application of the PjBL model in textbooks encourages students to be more active, independent, and directly involved in learning, thereby strengthening their ability to carry out scientific activities Chasanah et al. (2016) Maghfiroh et al. (2016) (Fitriyani et al., 2018).

Based on the results of the analysis, the percentage of student PPP N-Gain is 65% and the N-Gain per indicator is 67%, both of which are in the category of quite effective. Thus, it can be concluded that the PjBL-based tissue culture textbook developed has proven to be quite effective in improving the science process skills of Biology students of the State University of Medan.

CONCLUSION

Based on the results of the validation test of media experts, lecturer response tests and student responses, it can be known that the PjBL-based network culture textbook developed is in the category of very feasible. Meanwhile, based on the results of the validation test of material experts, it is known that the textbook is in the feasible category. Then, based on the results of the analysis of the N-Gain test, it can be concluded that the project-based learning plant tissue culture textbook developed is quite effective in improving the science process skills of biology students at the State University of Medan.

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