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# Development of Innovative Technology Electronic Modules Based on Orchid Potential in Nglanggeran Forest through Project-Based Learning on Biotechnology Material to Enhance Science Literacy and Learning Interest of High School Students

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**Abstract:** This development research aims to determine the effectiveness of an electronic module on technological innovation based on the potential of orchids in the Nglanggeran forest using the Project-Based Learning (PjBL) model for biotechnology materials, to enhance high school students' scientific literacy and learning interest. This study employs the Research and Development (R&D) approach using the 4D model (define, design, develop, and disseminate). The data were analyzed using N-Gain tests and Manova. The feasibility test results indicate that the electronic module is highly suitable for use. This is evidenced by the feasibility test scores, namely 96.2% from material experts, 89.5% from teaching material experts, and 86.1% from practitioners. Additionally, the electronic module is considered practical based on student responses, with a score of 86.7%. The effectiveness test results show a significance value of 0.000 < 0.05, indicating a significant difference in scientific literacy and learning interest between the experimental and control classes. Furthermore, the Test of Between-Subjects Effects revealed a significance value of 0.000 < 0.005, suggesting differences in scientific literacy and learning interest between the experimental and control classes. Thus, the Project-Based Learning (PjBL)-based electronic module positively impacts students' scientific literacy and learning interest.

**Keywords:** Electronic module; Learning interest; Project-based learning (PjBL); Science literacy

## Introduction

In the 21st century, technological developments are very rapid and experiencing major changes, especially with the emergence of technology 5.0. The era of technology 5.0 is an era where technology is integrated with various aspects of human life, one of which is education. Education in this era emphasizes learning that focuses on developing competencies and skills that are relevant to the 21st century (Fricticarani et al., 2023).

An advanced nation is usually characterized by its people who have a high level of literacy, advanced civilization, and are active in contributing to the progress of the nation. A society with a strong culture of literacy demonstrates the ability to think critically, collaboratively, creatively and communicatively which allows them to excel in global competition (Kementerian Pendidikan dan Kebudayaan, 2017). One of the basic literacies that every individual needs to master based on the World Economic Forum in 2015 is scientific literacy (Kementerian Pendidikan dan Kebudayaan, 2017).

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Scientific literacy is very important because advances in science and technology affect various aspects of life. Evaluation of scientific literacy is carried out together with mathematical literacy and reading literacy conducted by the OECD through the Program for International Student Assessment (PISA) every three years. The results of PISA 2018 showed that the average scientific literacy score was 489, while Indonesia only scored 396 and ranked 69 out of 71 participating countries (OECD, 2019). In 2021, the results of the PISA science literacy assessment obtained a score of 383, which means that there was a decrease in the science literacy assessment score from 2018 to 2021 with a decrease of 13 points (OECD, 2023). Based on these data, it can be seen that the science literacy skills of students in Indonesia are still below the international average score and are generally at the lowest level in the PISA measurement. Several similar studies also state that the science literacy of students in Indonesia is still relatively low.

The low scientific literacy is in line with the reality on the ground. The initial research conducted at SMA N 1 Banguntapan showed that the mastery of science competencies, understanding the aspects of explaining scientific phenomena, designing and evaluating scientific investigations was only 40%, which falls into the low category. This is also supported by interviews with biology teachers, where it was mentioned that the local education department once conducted a scientific literacy assessment at the school, and the results were still considered low. Moreover, in the learning and evaluation processes carried out by the teachers, there has not been a focus on assessing scientific literacy, but rather only on the evaluation of knowledge of the material taught. There are many factors that can contribute to the low level of scientific literacy in Indonesia.

There are many factors that can contribute to the low level of scientific literacy in Indonesia. Jufrida et al. (2019) stated that the low level of scientific literacy among students in Indonesia can be influenced by many factors, such as the choice of teaching models and methods, curriculum and education system, learning resources and learning facilities. This results in students' abilities being limited to only a few science topics and the application of complex and abstract concepts in everyday life (Dibyantini et al., 2023; Huryah et al., 2017; Jufrida et al., 2019; Karimah & Wulandari, 2023).

This condition causes students to feel bored with learning because learning is limited to conceptual understanding and results in low interest in learning in students. According to Irwan et al. (2020), low interest in learning is one of the factors causing low scientific literacy. Students who have an interest in learning will provide focus and attention during the learning process, thus triggering curiosity and the drive to learn the material to the maximum. High interest in learning has a significant impact and makes it easier to achieve learning goals (Angelita et al., 2023; Sakti et al., 2021). High interest in learning can make students overcome the difficulties they face, such as solving various problems in learning biology. Students can also produce creative ideas in solving a problem so that the level of scientific literacy becomes better (Caella & Yulianto, 2024; Hidayati et al., 2022; Rasyid et al., 2024).

In addition to the issue of scientific literacy, SMA N 1 Banguntapan also faces the challenge of low student interest in learning. Based on the preliminary data collected using a questionnaire, the following results were obtained: the level of enjoyment and enthusiasm for learning biology had an average score of 49.50%, categorized as low; and the enthusiasm and interest in learning biology was 48.32%. From the description of the data, the low student interest in learning is attributed to several factors, including: the learning is still conceptual, although some topics, such as environmental studies, are contextual; students find the material difficult to understand; and students are less involved in biology learning because they feel bored with the teaching methods applied by the teacher.

Based on an interview with a biology teacher at SMA N 1 Banguntapan, the most frequently used teaching method is discussion. In addition, one of the factors affecting students' low learning interest is the impact of the learning system during the Covid-19 pandemic. The learning system at that time was conducted online, which led to a decline in students' interest in learning during online classes. This is in line with Widiyono (2020), which states that since the spread of the Covid-19 virus in Indonesia in early March 2020, the implementation of education became very limited. All learning activities, which were traditionally conducted face-to-face at schools, shifted to online learning. This change resulted in a decrease in students' interest in learning during online classes (Widiyono, 2020).

This condition is evident during the learning process, where students pay little attention to the teacher's explanations. Additionally, students often wait for instructions from the teacher regarding the material they need to study. Many students are inactive in completing the given tasks and experience difficulties in analyzing and connecting concepts, as reflected in their inability to answer questions that require scientific analytical skills.

Teachers need to consider prioritizing active and enjoyable learning as a solution to overcome these problems. Project-based and contextual approaches in learning encourage students to identify and solve these problems. One learning model that can increase interest in learning is the Project-Based Learning (PjBL) model. The Project-Based Learning (PjBL) model is an innovative learning model that focuses on students, with teachers acting as motivators and facilitators. In this model, students are given the opportunity to create projects based on the material that has been studied, according to their respective creativity (Irfana et al., 2022). The Project-Based Learning (PjBL) model directs teachers to act as facilitators. As a facilitator, teachers focus more on initial preparations before learning, such as preparing learning resources, media, learning devices, and various other needs so that learning can run effectively and achieve the desired goals (Hamidah & Citra, 2021; Sarjani et al., 2023; Usman et al., 2024).

Biology learning as a science basically focuses on three main aspects, namely process, scientific attitude and product. Biotechnology is a material in biology that has many applications in life. Biotechnology materials is the application of biology and technology. This material includes the definition, basic principles and role of biotechnology in various fields such as: tissue culture, fermentation, cloning, genetic engineering, and others (Millah et al., 2012; Nurjanah et al., 2016; Wibisono, 2020). However, not a few students find it difficult to understand the concept of biotechnology materials as a whole. Basically, this material is quite difficult for students to understand because it is cause by several factors, namely: conceptual learning, lack of direct experience and lack of learning resources (Nurjanah et al., 2016; Tompe et al., 2022). Therefore, in learning biology on biotechnology materials, it is better to emphasize providing direct experience. With this approach, learning is not only conceptual but also contextual. Contextual learning is learning that integrates concepts with field conditions, this can enable students to connect these concepts (Tompe et al., 2022). Contextual learning will create constructivist learning. Referring to the curriculum currently used, namely the Merdeka curriculum. The Merdeka Curriculum is a curriculum with varied internal learning, and in the process it does not only strengthen concepts but learning pays attention to the process and is contextual (Hamrullah et al., 2023). Thus, it is hoped that this system will be able to create students who have life skills that can be implemented in community life (Alamin et al., 2024; Budiarso et al., 2022; Cholilah et al., 2023; Samsudin et al., 2023; Yani et al., 2021).

Based on the description of the problems above, there is a need for innovation in learning resources that can make learning not only conceptual but also contextual. The Project-Based Learning (PjBL) model can be packaged in the form of teaching materials in the form of electronic modules. Biotechnology materials that are oriented towards local potential can be presented using electronic modules and achieved using the Project-Based Learning (PjBL) model. Various learning resources, electronic modules can be selected to be developed as a support for learning activities. In the teaching and learning process, without using learning resources, students will face difficulties in understanding the material (Angelita et al., 2023). The integration of character values in learning modules can support the implementation of character education. The activities contained in the module can facilitate students to apply character behavior and values in everyday practice (Nurjanah et al., 2016). The purpose of this study was to determine the feasibility, practicality and effectiveness of the electronic module developed on scientific literacy and students' learning interests.

## Method

This type of research is research and development (R&D). The product resulting from this research and development is an electronic module of Project-Based Learning (PjBL) technological innovation on biotechnology materials that meets the criteria of feasibility, practicality and effectiveness used to improve science literacy and learning interest of high school students. The development model used refers to the 4D development model (define, design, develop, and disseminate).

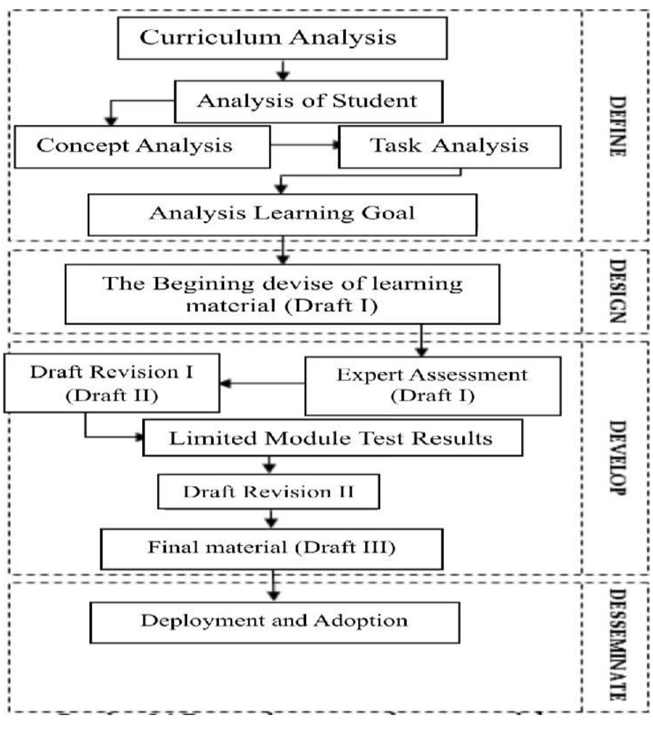


**Figure 1.** 4D research model schematic

In the definition phase, needs analysis, literature study, curriculum analysis, task analysis and concept analysis are carried out, this is done so that the product developed is right on target. In the second phase, namely the design stage by designing, in this phase, ideas and ideas will be put forward which are formed in the initial product format and the research instruments that will be needed are prepared. Furthermore, in the development phase, initial product development is carried out, feasibility tests are carried out by material experts and teaching material experts, practicality tests by teachers, validity and reliability tests, and limited scale tests. And finally, the dissemination phase, a large-scale test is carried out on students to determine the effectiveness of electronic modules in improving science literacy and learning interest. This research was conducted in April-May 2024. This study used a quasi-experimental non-equivalent pretest-posttest control group design, the sample was selected based on the cluster random sampling. The stages of the 4D model can be seen in Figure 1.

## Result and Discussion

*Define*

In the define stage, there are several steps, including initial and final analysis, student analysis, task analysis, concept analysis and formulation of learning objectives. The initial and final analysis serves to analyze and determine the problems that exist in biology learning in the field, in the initial and final analysis stage, several problems were obtained, including: students still have difficulty understanding the concept of biotechnology material as a whole. This is caused by several factors, namely: conceptual learning, lack of direct experience and lack of learning resources and teachers have never made learning resources specifically designed to improve science literacy and student learning interests. In the student analysis, researchers conducted interviews with teachers, apart from interviews, researchers gave questionnaires to students with the aim of obtaining information in the form of learning carried out by teachers which includes initial competencies, student ability backgrounds, knowing the learning resources used, and analyzing the learning process. Then, in the task analysis phase, it is an activity to analyze the competencies that must be achieved by students and the content of the material to be studied, this phase functions to analyze the substance of modern biotechnology material, especially in the sub-chapter of plant tissue culture. Researchers identify the completeness of the material, obstacles in learning, scientific literacy skills and learning interests of students in biology subjects. Furthermore, in the concept analysis phase, it aims to identify the principles, concepts, facts, and rules needed in learning. In this phase, researchers determine several things, including: analyzing competency standards in the form of learning achievements, learning objectives and learning goals flows with the aim of determining specific learning resources, analyzing learning resources used during the learning process. And at the stage of formulating learning objectives to determine the learning to be achieved.

*Design*

At this stage, the development of the initial product design of the electronic module was carried out. The initial product draft of the electronic module developed consisted of a cover, crew sheet, foreword, table of contents, introduction, Project-Based Learning (PjBL) model syntax, module feature list, concept map, materials, biologics, bio info, bio project, bio smart, bio reflection, bio review, bio test, glossary, answer key, bibliography and author profile. The following draft of the electronic module can be seen in Figure 2.

Results of the feasibility assessment also include suggestions and input used to improve the module prototype. The following are the results of the validation of the electronic module by expert and practitioner assessments.

**Table 1.** Results of electronic module validation by material experts

| Rated Aspect | Σx | Σxi | % | Category |
|---|---|---|---|---|
| Completeness of the Material | 20 | 20 | 100 | Very valid |
| Accuracy of the material | 18 | 20 | 90 | Very valid |
| Activities that support the Material | 12 | 12 | 100 | Very valid |
| Currency of the material | 9 | 12 | 75 | Valid |
| Supporting material for students' science competencies | 12 | 12 | 100 | Very valid |
| Developing process skills | 8 | 8 | 100 | Very valid |
| General presentation organization | 12 | 12 | 100 | Very valid |
| Presentation considering meaningfulness and Usefulness | 8 | 8 | 100 | Very valid |
| Proper and correct Indonesian language | 4 | 4 | 100 | Very valid |
| Clarity of language | 4 | 4 | 75 | Valid |
| Language suitability | 12 | 12 | 100 | Very valid |
| Project Based Learning (PjBL) | 8 | 8 | 100 | Very valid |
| Average | 127 | 132 | 96.2 | Very valid |


a. Cover b. Introduction c. Bio Info

d. Bio Project e. Bio Smart f. Author Profile

**Figure 2.** Draft of the electronic module

**Table 2.** Electronic module validation results by teaching materials experts

| Rated aspect | Σx | Σxi | % | Category |
|---|---|---|---|---|
| Presentation systematics | 6 | 8 | 75 | Valid |
| Product presentation Graphics | 21 | 24 | 87.5 | Very valid |
| Product usage | 8 | 8 | 100 | Very valid |
| Selection of learning Models | 12 | 12 | 100 | Very valid |
| Electronic module display | 16 | 20 | 80 | Very valid |
| Linguistics | 15 | 16 | 93.7 | Very valid |
| Project Based Learning (PjBL) | 8 | 81 | 100 | Very valid |
| Average | 86 | 96 | 89.5 | Very valid |

*Development*

At the development stage, the prototype of the electronic module that has been prepared is then validated by material experts and teaching material experts. In addition, responses are also obtained from biology teachers as practitioners. Validation of the electronic module is carried out based on the instruments that have been created, with assessment data in the form of a score of 1-4 which is then converted into a percentage.

**Table 3.** Biology teacher response results

| Rated aspect | Σx | Σxi | % | Category |
|---|---|---|---|---|
| Electronicmodule display | 16 | 20 | 80 | Very valid |
| Electronic module presentation graphics | 19 | 24 | 79.1 | Very valid |
| Use of electronic modules | 11 | 12 | 91.6 | Very valid |
| Completeness of materials | 19 | 20 | 95 | Very valid |
| Activities thatsupport the material | 11 | 12 | 91.6 | Very valid |
| Linguistics | 9 | 12 | 75 | Valid |

| Rated aspect | Σx | Σxi | % | Category |
|---|---|---|---|---|
| Project BasedLearning (PjBL) | 8 | 8 | 100 | Very valid |
| Average | 93 | 108 | 86.1 | Very valid |

Based on tables 1, 2 and 3, the total overall value obtained by material experts is 96.2%, teaching material experts 89.5% and biology teachers 86.1 so that it is categorized that the electronic module is very valid for use in the next test. Of course, from this assessment, suggestions and input are obtained for improving the module to be better.

*Disseminate*

At the dissemination stage, this module underwent a small-scale field test, namely a practicality test aimed at determining readability by students and a large-scale trial aimed at determining the effectiveness of the electronic module. The results of the small-scale test showed that the developed electronic module was practical, efficient in terms of usage time, and the material presented was clear and coherent in accordance with the concept of the material. The average results of the small-scale test scores can be seen in Table 4.

**Table 4.** Electronic module readability test results by students

| Rated aspect | ΣX | ΣXI | % | Category |
|---|---|---|---|---|
| Electronic module display | 324 | 384 | 84.3 | Very worth it |
| Electronic module presentation graphics | 334 | 384 | 86.9 | Very worth it |
| Use of electronic modules | 225 | 256 | 87.8 | Very worth it |
| Accuracy of material | 220 | 256 | 85.9 | Very worth it |
| Learning Support Materials | 115 | 128 | 89.8 | Very worth it |
| Linguistics | 223 | 256 | 87 | Very worth it |
| Project Based Learning (PJBL) | 224 | 256 | 87.5 | Very worth it |
| Average | 1665 | 1920 | 86.7 | Very worth it |

The results of the students' responses to the electronic module obtained an overall score of 86.7%, which shows that the electronic module very feasible to be used in real field tests. After conducting a small-scale trial, the next step is to conduct a large-scale field trial. The large- scale trial aims to see the effectiveness of the product being developed. The effectiveness test was conducted in a real class, namely class X of SMAN 1 Banguntapan and used 2 classes. One class is an experimental class and the other class is a control class. Each class consists of 36 students. Learning in the experimental class is carried out using electronic modules, while learning in the control class is carried out without electronic module products. Furthermore, the results of the product effectiveness test can be seen and concluded based on the N-Gain score obtained from the control and experimental classes and the results of the manova test from the pre-test and post-test scores. The results of the N-gain score test can be seen in Table 5.

**Table 5.** N-Gain score test results

| Aspect | Science Literacy | | Interest in Learning | |
|---|---|---|---|---|
| | Control | Experiment | Control | Experiment |
| Pre-test | 39.24 | 37.72 | 55.12 | 55.33 |
| Post-test | 60.30 | 86.36 | 64.34 | 69.48 |
| N-Gain Score | 0.33 | 0.77 | 0.19 | 0.31 |
| Criteria | Medium | Tall | Low | Medium |

Based on the table above, it can be concluded that the increase in scientific literacy of students in the control class was lower than that of the experimental class. The increase in the control class was 21.06, while in the experimental class it reached 48.64. Likewise, with learning interest, the learning interest of students in the control class experienced a lower increase compared to the experimental class.

**Table 6.** Manova test results

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| Intercept | Pillai's Trace | .947 | 562.173[b] | 2.000 | 63.000 | .000 |
| | Wilks' Lambda | .053 | 562.173[b] | 2.000 | 63.000 | .000 |
| | Hotelling's Trace | 17.847 | 562.173[b] | 2.000 | 63.000 | .000 |
| | Roy's Largest Root | 17.847 | 562.173[b] | 2.000 | 63.000 | .000 |
| Model learning | Pillai's Trace | .657 | 60.270[b] | 2.000 | 63.000 | .000 |
| | Wilks' Lambda | .343 | 60.270[b] | 2.000 | 63.000 | .000 |
| | Hotelling's Trace | 1.913 | 60.270[b] | 2.000 | 63.000 | .000 |
| | Roy's Largest Root | 1.913 | 60.270[b] | 2.000 | 63.000 | .000 |

The increase in learning interest in the control class was 8.91, while in the experimental class it reached 14.15. This shows that scientific literacy and learning interest of students in the experimental class experienced a higher increase compared to the control class. Thus, the use of the Project-Based Learning (PjBL) electronic module has a positive effect on increasing scientific literacy and learning interest of students. This is also proven by the N-gain score obtained from each class, where the N-gain score of the control class for scientific literacy ability is 0.33 with moderate criteria and the class is 0.77 with high criteria, and the N-gain score of the control class's learning interest is 0.19 with low criteria and the experimental class is 0.31 with moderate criteria. This is in line with research which states that electronic modules based on Project-Based Learning (PjBL) can improve scientific literacy and learning interest (Kampourakis, 2019; Reski et al., 2021; Sinurat, 2020; Tompe et al., 2022).

Furthermore, the manova test shows the influence of the learning model as seen from the statistical figures of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root showing a significance level of 0.000 < 0.05. So based on these results, it shows a significant difference in the ability of scientific literacy and learning interests of students together between students in the experimental class and the control class. The following results of the manova test can be seen in Table 6.

Furthermore, in the manova test, the effect of the learning model on the dependent variable can also be seen. This can be seen in the between-subjects effects table, based on the learning model column on scientific literacy has a significance value of 0.000 < 0.005, which means that H0 is rejected and Ha is accepted. This means that there is a difference in scientific literacy skills between the experimental class and the control class. Furthermore, it can be seen that the learning model on learning interest has a significance value of 0.000 < 0.005, which means that H0 is rejected and Ha is accepted. This means that there is a difference between the control and experimental classes.

Thus, it can be concluded that the Project-Based Learning (PjBL) electronic module tends to be able to improve students' scientific literacy and learning interest. This can be seen in the following table.

**Table 7.** Test of between-subjects effects

| Source | Dependent Variable | Type III Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Corrected Model | Literacy | 31593.407[a] | 1 | 31593.407 | 93.745 | .000 |
| | Interest in learning | 8036.680[b] | 1 | 8036.680 | 36.167 | .000 |
| Intercept | Literacy | 203532.999 | 1 | 203532.999 | 603.933 | .000 |
| | Interest in learning | 137137.458 | 1 | 137137.458 | 617.151 | .000 |
| learning model | Literacy | 31593.407 | 1 | 31593.407 | 93.745 | .000 |
| | Interest in learning | 8036.680 | 1 | 8036.680 | 36.167 | .000 |
| Error | Literacy | 21568.812 | 64 | 337.013 | | |
| | Interest in learning | 14221.465 | 64 | 222.210 | | |
| Total | Literacy | 256695.218 | 66 | | | |
| | Interest in learning | 159395.603 | 66 | | | |
| Corrected Total | Literacy | 53162.219 | 65 | | | |
| | Interest in learning | 22258.145 | 65 | | | |

a. R Squared = .594 (Adjusted R Squared = .588)
b. R Squared = .361 (Adjusted R Squared = .351)

## Conclusion

The Project-Based Learning (PjBL) electronic module developed is effective in improving scientific literacy and learning interest. This is evident from the multivariate test results, which show a significance level of 0.000 < 0.05, indicating that H0 is rejected and Ha is accepted, meaning that there is a significant difference in scientific literacy and learning interest between students in the experimental class and the control class simultaneously. Additionally, the results of the Test of Between-Subjects Effects show a significance level of 0.000 < 0.005, which means that H0 is rejected and Ha is accepted, indicating a difference in scientific literacy and learning interest between the experimental and control classes.

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