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Development of an Interactive E-Module Based on Project Based Learning (PjBL) Integrated with Pancasila Student Profile Strenghtening Project (P5) in Learning Plant Growth and Development

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Abstract

The teaching materials in the current Merdeka Curriculum have not yet fully met students' needs. Based on a needs analysis, it was found that there is a demand for teaching materials that can integrate the Pancasila Student Profile Strengthening Project (P5) with the learning process. Initial observations also showed that students' creativity and science process skills were at a low level. Therefore, this study developed an interactive e-module based on Project Based Learning (PjBL) integrated with P5 on the topic of plant growth and development. The purpose of this research was to examine the validity, readability, effectiveness, practicality, and describe the characteristics of the developed e-module. This research employed a Research and Development (R&D) method using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The e-module was proven to be highly valid based on evaluations by content experts and media experts. The e-module demonstrates a high level of readability. The e-module was shown to be effective in enhancing students' creativity and science process skills, as evidenced by cognitive and performance test results. Feedback from both teachers and students indicated that the e-module is highly practical for classroom use. Overall, the developed e-module has shown characteristics that integrate P5 activities on the topic of plant growth and development through project based learning.

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INTRODUCTION

The learning process in schools needs to be aligned with the dynamic development of the curriculum in Indonesia. In the 2022/2023 academic year, the government began implementing a new curriculum, namely the Merdeka Curriculum. This curriculum organizes three complementary types of learning activities: intracurricular learning, which focuses on strengthening conceptual understanding and improving students' basic competencies; co-curricular learning, which is implemented through the Pancasila Student Profile Strengthening Project (P5); and extracurricular learning, which is tailored to students' interests and the availability of resources within the school environment (Wahyudin *et al.*, 2024).

The uniqueness of the Merdeka Curriculum lies in the Pancasila Student Profile Strengthening Project (P5), a project based co-curricular learning approach designed not only to enhance academic competence but also to build students' character in accordance with Pancasila values. This project serves as a platform for students to develop various aspects of the student profile, such as collaboration, critical thinking, independence, and creativity through structured activities that are relevant to real life situations (Wahyudin *et al.,* 2024). Thus, the Merdeka Curriculum emphasizes not only cognitive aspects but also strengthens the development of attitudes and character, which are the distinctive features of Indonesian education.

Learning can be considered optimal under the Merdeka Curriculum when facilities and infrastructure, learning resources, teaching methods, and instructional materials meet the needs of students (Magdalena *et al.*, 2020; Samsinar, 2020; Abnisa & Zubaidi, 2022; Agustira & Rahmi, 2022; Chaerunisa *et al.,* 2023). With the implementation of the new curriculum, updating instructional materials has become essential to support and optimize the learning process. Based on interviews with science teachers at junior high schools in Kembang District, Jepara Regency, Central Java Province, it was found that the number of available textbooks is insufficient to meet the needs of all students. Furthermore, the existing instructional materials are considered inadequate for fully achieving the learning objectives. Teachers also face challenges in preparing materials for both the Pancasila Student Profile Strengthening Project (P5) and learning activities. Therefore, teachers have expressed a strong need for the development of instructional materials that can integrate both types of activities.

Based on observations of students, it was found that 51% of them expressed a desire for interactive electronic learning materials. A total of 85.8% preferred interactive materials that include images or illustrations, 65% liked materials that incorporated audio elements, 80.8% favored the use of videos, and 72.5% expected the inclusion of project based learning. Additionally, in the suggestion section, several students also expressed a desire for the integration of game elements into the learning process. Alongside identifying the need for instructional materials, an initial observation was also conducted on students' levels of creativity and science process skills. The results showed that the average creativity score was 57, and the average score for science process skills was 38, both of which fall into the low category.

These facts highlight the need for efforts to develop students' creativity and science process skills so that they can think more innovatively and become more proficient in applying scientific methods in science learning. Both of these skills can be improved through a project based learning approach (PjBL) (Paramita *et al.*, 2023; Parwati *et al.*, 2023; Novita *et al.*, 2024; Suryani, 2024). In the PjBL model, students are involved in completing real projects or solving actual problems that require innovative thinking. Through these activities, students are trained to think creatively in designing strategies, organizing projects, and finding solutions (Paramita *et al.*, 2023; Parwati *et al.*, 2023). During this process, students' scientific process skills are also developed through the project activities carried out (Novita *et al.*, 2024; Suryani, 2024).

Based on the identified issues, there is a need for teaching materials that can help integrate intrakurricular and co-curricular activities, presented in an interactive electronic format, providing meaningful and contextual learning, designed in an engaging way to prevent boredom, and supporting the development of students' creativity and scientific process skills. Therefore, this study aims to develop an interactive e-module based on Project Based Learning (PjBL) that is integrated with P5 activities under the entrepreneurship theme, focusing on the topic of plant growth and development. The P5 activities based on

PjBL involve a project to make organic fertilizer, which begins with the observation of organic waste problems around the students. In this P5 based PjBL activity, students will carry out the project of making organic fertilizer, starting with identifying the issue of organic waste in their surrounding environment. Students are then guided to find solutions by processing the waste into fertilizer that has practical use and market value. The benefits of this organic fertilizer will be demonstrated through an experimental project investigating the effect of the fertilizer on plant growth, which is also conducted using a project based learning.

RESEARCH METHOD

The method used in this study is Research and Development (R&D) employing the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) (Branch, 2009).

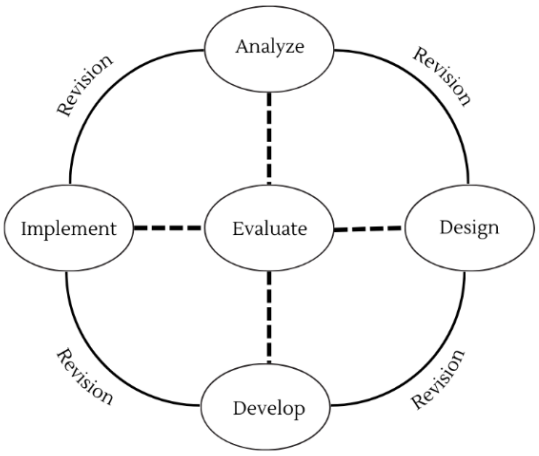

Figure 1. Research Model

The analysis of teaching material needs was conducted through interviews with science teachers, observation of student needs, preliminary observation of students' creativity and science process skills levels, as well as a review of learning objectives and outcomes. The e-module was designed using the Canva application and presented in a flipbook format with the help of Hyzine software. The structure of the e-module consists of three main sections: introduction, main content, and conclusion. Two key activities featured in the e-module include a P5 activity with an entrepreneurship theme involving the production of liquid organic fertilizer and its application to water spinach plants as a project under the topic of plant growth and development.

During the development stage, the e-module underwent a validity test by content experts and media experts, a readability test by prospective users, and a small scale trial of the assessment instruments. The module's validity was analyzed using Aiken's V. The readability test results were analyzed using One Way ANOVA followed by an LSD test in SPSS. The trial results of the assessment instruments were analyzed using Aiken's V and ITEMAN software.

The implementation stage was carried out in an experimental class using a one group pretest posttest design to measure the effectiveness of the e-module in enhancing students' creativity and science process skills. Data collected included results from cognitive tests and performance tests. The cognitive test data were analyzed through normality tests, homogeneity tests, paired sample t-tests, and N-Gain calculations. Additionally, responses from teachers and students regarding the use of the e-module were gathered to assess the practicality of the product. Evaluation was conducted comprehensively at each development

stage. If shortcomings, feedback, or suggestions were identified during this research, they were used as a basis for improving the e-module.

RESULTS AND DISCUSSION

This study produced a teaching material product in the form of an interactive e-module based on Project Based Learning (PjBL) integrated with P5 on the topic of plant growth and development. The e-module development process is explained in the results and discussion section, covering five main aspects: validation of the e-module based on assessments by content experts and media experts, the readability level of the e-module, the effectiveness of the e-module in enhancing students' creativity and scientific process skills, the practicality of the e-module based on teacher and student responses, and a description of the characteristics of the developed e-module.

Validity of the E-Modul

The validity level of the e-module was analyzed based on the validation results conducted by content experts and media experts. Based on the assessments from four content experts, the average score obtained through Aiken's V analysis was 0.98. Meanwhile, evaluations from four media experts yielded an average score of 0.99. Both scores exceed the critical value in the Aiken's V table, which is 0.92, indicating that all instruments are considered significantly valid. The detailed validity scores of the e-module for each component are presented in Table 1 and Table 2.

Table 1. Content Experts Validation

Validation Aspects	Percentage	Category
Content eligibility	97.66%	Very Valid
Presentation feasibility	98.44%	Very Valid
Linguistic appropriateness	97.92%	Very Valid
Contextualized assessment	100.00%	Very Valid

The four aspects validated by the content experts received a very valid category. This is because the developed e-module effectively presents material that is relevant and aligned with the latest scientific developments. The examples provided in the e-module are contextual and taken from the students' surrounding environment, which facilitates understanding. Additionally, the e-module broadens students' insights into entrepreneurial concepts using limited capital and allows them to directly observe the impact of nutrient application on plant growth. The content in the e-module is considered complete, in depth, accurate, and up to date, while also capable of expanding understanding, stimulating students' knowledge and creativity, and training scientific process skills. In terms of presentation, the material is organized systematically and consistently. The language used in the e-module is straightforward, communicative, dialogic, and interactive, in accordance with language rules and the cognitive development level of the students.

In line with the results of this study, Nisrina *et al*. (2021), Mustika (2022), Sriwindari *et al.* (2022), and Rahmawati (2023) also developed e-modules based PjBL and received validity ratings ranging from valid to very valid from content experts. E-modules that achieve valid and very valid categories indicate that the e-modules have good content quality, meet the needs of teachers and students, and are suitable for implementation to support learning achievement.

Table 2. Media Experts Validation

Validation Aspects	Percentage	Category
Graphical feasibility	98.75%	Very Valid
Linguistic appropriateness	100.00%	Very Valid

The two aspects validated by the media experts received a very valid category. This is due to the harmonious presentation of the e-module, featuring a consistent layout, and alignment among its components. The choice of appealing colors and simple fonts also supports readability and user comfort. Additionally, the language used in the e-module is considered straightforward, communicative, dialogic, and interactive, in accordance with language rules and appropriate for the students' cognitive development stage.

The findings of this study are supported by the results of studies conducted by Nisrina *et al*. (2021), Mustika (2022), Sriwindari *et al.* (2022), and Rahmawati (2023), which received ratings ranging from valid to very valid from media experts. The valid and very valid categories indicate that the developed e-modules have good design quality, attractive appearance, and are easy for users to understand.

Readability of the E-Modul

The readability of the e-module was analyzed based on how easily it could be read by prospective users, namely students with varying levels of ability (high, medium, low). The results of the e-module readability analysis are presented in Table 3.

Table 3. Results of the E-Module Readability

Student Ability Level	Percentage	Readability Category
High	94.13%	High
Medium	91.88%	High
Low	84.25%	High
Average Percentage	**90.08%**	**High**

The high readability level of the e-module indicates that the language used is easy to understand, with concise and straightforward sentences. Explanations regarding the P5 project, plant growth experiments, and the overall presentation of the material are clear and not confusing. The use of visual elements such as illustrative images and videos further enhances students' understanding of the content. The organization of the material and learning flow is logical and easy to follow, featuring a systematic structure, clear subheadings, and easily identifiable key points. The choice of font type, color combinations, and appropriate layout provides reading comfort. Overall, the e-module's content is engaging and motivates students to read through to the end. The exercises provided are relevant to the material and use simple, easily understood language.

Variations in readability levels among the three groups of students are influenced by several factors, both from the e-module itself and from the characteristics of the students as readers. Factors such as language structure, sentence length, number of words per paragraph, and the use of certain terms also affect readability (Rahima *et al.*, 2022). Students with high and medium cognitive abilities tend to understand the e-module content more easily because they have better comprehension capacity and higher learning motivation. This aligns with Slavin (2018) assertion that students with higher cognitive capacity can process information more effectively. Woolfolk (2016) also emphasizes that students' motivation and cognitive ability play a significant role in their success in understanding learning material.

Effectiveness of the E-Modul

The effectiveness of the e-module was analyzed after its implementation in an experimental class using a one group pretest posttest design. This implementation produced data in the form of students' cognitive test results and performance tests measuring indicators of creativity and scientific process skills. The cognitive test data were further analyzed and found to meet the assumptions of normality and homogeneity. The paired sample t-test results showed a significance value (sig.) < 0.05, indicating a

significant difference between the pretest and posttest results after using the e-module. Additionally, the effectiveness of the e-module was analyzed using the N-Gain test, with the results presented in Table 4.

Table 4. Results of the N-Gain Analysis

	N-Gain Score	Category	N-Gain Percentage	Category
Creativity	0.58	Medium	57.80%	Fairly Effective
Scientific Process Skills	0.61	Medium	61.31%	Fairly Effective

Based on the N-Gain test analysis results, the N-Gain score for the creativity aspect was 0.58, which falls into the medium category, with an improvement percentage of 57.80%, categorized as fairly effective. This is attributed to the opportunity given to students to design projects based on questions they formulated themselves. The process was built on the students' own ideas, allowing them to think flexibly about how to solve problems and turn them into project designs. Developing these project designs trained students to think originally, as they were required to construct knowledge from their prior real life experiences.

After designing the project, students were guided to plan the implementation steps, which trained their fluency in generating multiple ideas for executing the project in a structured yet free manner. This freedom created a more engaging and meaningful learning experience. In scheduling tasks, students were required to think in detail, carefully, and learn how to organize by allocating time and dividing group tasks fairly. The group based project execution helped students develop fluency, flexibility, originality, accuracy, and precision in dealing with unforeseen challenges.

These findings indicate that using the e-module integrated with project based learning activities positively contributes to students' creativity development. This result aligns with findings by Cahyani et al. (2020), Mustika (2022), Sriwindari et al. (2022), Ramadhanti et al. (2023), Firdausia et al. (2024), Fitriana (2024), Rani & Alfiandra (2025), and Mutia et al. (2025), who concluded that e-modules complemented with project activities effectively foster students' creativity.

Regarding science process skills indicators, an N-Gain score of 0.61 was obtained, which is in the medium category, with an improvement percentage of 61.31%, also categorized as fairly effective. This result stems from the observation stage, where students were required to carefully observe each project and the problems encountered throughout the process. Students learned to formulate questions based on their observations to gain a deeper understanding of the topic. They gathered data from various sources, including books, articles, and relevant online materials. Students analyzed and connected the data or information obtained to identify patterns, cause and effect relationships, or scientific explanations related to the project. They presented their work results to teachers or peers both orally and in writing. After completing all project stages, evaluation and reflection were conducted to assess student achievement and serve as a basis for future improvement.

These results indicate that the use of e-modules during the learning process successfully supported the development of students' science process skills. This finding is supported by studies by Yuniarti (2024) as well as Prihastuti & Sukaesih (2024), which showed that project based e-modules significantly enhance students' science process skills.

The results of students' creativity performance are presented in Table 5, while the results of students' scientific process skills performance are presented in Table 6.

Table 5. Results of Students' Creativity Performance

Performance Test Results on Creativity Indicators	P5 Project – Organic Liquid Fertilizer	Learning Project – Plant Growth
	Percentage (%)	Percentage (%)
Fluency	91.80	91.41
Flexibility	91.19	94.30
Originality	92.49	93.26
Elaboration	94.92	95.31
Evaluation	94.82	95.85

Curious	94.06	96.25
Imaginative	93.36	95.70
Feeling Challenged	92.23	95.08
Risk Taking	93.26	93.52
Appreciative	92.97	94.92
Average	**93.42**	**94.98**
Category	**Highly Creative**	**Highly Creative**

The average result of students' performance tests in the liquid organic fertilizer project reached 93.42%, which falls into the very creative category. Students' ability to present various ideas, solutions, and opinions to address environmental issues reflected the fluency indicator. They also completed tasks throughout the liquid fertilizer production process quickly. In terms of flexibility, students demonstrated adaptability in exploring various ways to utilize organic waste while considering environmental, social, and economic aspects. They were also able to apply principles and concepts from the fertilizer making experiment to tackle waste problems in their surroundings. Student creativity was also evident in their ability to generate original and useful ideas, including combining organic waste with other materials. Additionally, students could describe in detail the fertilizer making process from budgeting, fermentation stages, product packaging design, demonstrated accuracy in evaluation, and decision making when facing obstacles.

Regarding curiosity, students actively delved deeper into environmental issues and relevant solutions, including asking critical questions and being receptive to feedback from teachers, peers, and their surroundings. Their attentiveness and precision were visible during the observation and reporting process, and they showed enthusiasm in researching waste management methods. They displayed imaginative ability by predicting the negative impacts of unmanaged waste and designing practical solutions for daily application. Student involvement spanned all project stages, from planning to final production. In terms of risk taking, students were unafraid to express answers even when unsure of their correctness and accepted criticism with an open mind. They also showed appreciation for guidance, teamwork, and recognized the value of their emerging talents and potential.

Meanwhile, in the project analyzing the effect of liquid organic fertilizer on the growth of water spinach plants (*Ipomoea aquatica*), the average student creativity performance reached 94.98%, also classified as very creative. Students demonstrated creative thinking in proving the influence of nutrients as external factors on plant growth. They were able to quickly express various ideas, suggestions, and answers (fluency) and propose a wide range of alternatives for using organic fertilizer (flexibility). Through experiments, students applied scientific concepts and principles to test the effects of their homemade fertilizer and showed originality in the methods and treatment combinations used. They also developed fertilizers with varying concentrations and explained in detail all experimental stages, from preparation to reporting results (elaboration and evaluation).

In addition, students exhibited high curiosity, as shown by numerous questions related to nutrient deficiencies and plant growth factors. They took into account insights from various sources, were meticulous during the experiment, and were keen to verify the benefits of organic fertilizers made from local waste. Students were able to imagine the effects of nutrient deficiency and design applicable solutions for everyday life. Throughout the process, they showed courage in taking risks, weren't afraid to make mistakes, and demonstrated confidence in their designs and experimental solutions. They also exhibited respect for teacher guidance and effective team collaboration.

Table 6. Results of Students' Scientific Process Skills Performance

Performance Test Results On Scientific Process Skills Indicators	P5 Project – Organic Liquid Fertilizer	Learning Project – Plant Growth
	Percentage (%)	Percentage (%)
Observing	94.73	95.90
Questioning and Predicting	93.23	94.27
Planning and Conducting Investigation	96.72	96.33
Processing, Analyzing Data and Information	96.22	95.70
Evaluating and Reflecting	95.47	94.84
Communicating Results	95.31	95.70
Average	**95.70**	**95.65**
Category	**Highly Skilled**	**Highly Skilled**

The average result of students' science process skills performance tests in the liquid organic fertilizer project reached 95.70%, which is categorized as highly skilled. Students demonstrated the ability to observe by utilizing various senses and tools to identify environmental problems, particularly those related to organic waste, both in their surroundings and during the fertilizer production process. They were able to recognize and compare the characteristics of healthy versus problematic environments, gather relevant facts, and record observations systematically. Moreover, students actively posed questions to gather further information about waste issues, the fermentation process in fertilizer production, budgeting, and product design. They could connect prior knowledge with new information acquired and were able to predict the consequences of unresolved environmental issues.

During the planning and implementation phase, students developed step by step solutions to organic waste problems through fertilizer production, including selecting tools, materials, and determining parameters to be observed. They carried out the project in an orderly manner, understood the function of tools and materials, and carefully recorded their observations. The data obtained from the experiments were presented in tables, graphs, or other visual models, and students were able to explain and analyze the data using scientific understanding and secondary data sources. They drew conclusions based on scientific evidence and compared the findings with relevant theories, identifying strengths, weaknesses, and challenges during the process. The experiment results were then compiled into well organized reports, both oral and written, and presented attractively using either digital or non digital media according to the given format.

Meanwhile, in the project examining the effect of liquid organic fertilizer on the growth of water spinach plants, students achieved an average score of 95.65%, which also falls into the highly skilled category. Students used their senses and tools to directly observe the impact of nutrients from the homemade organic fertilizer on the growth of test plants. They gathered important information, recorded their observations, and actively asked questions to deepen their understanding of the relationship between fertilizer nutrients and plant growth. They were able to link learned theories with practical fieldwork and predict the effects of using various concentrations of organic fertilizer on plant growth. Students designed the experimental procedure, determined the tools and materials needed, and developed observation parameters in a systematic manner.

In implementing the project, students work on each stage starting from making fertilizer, planting test plants, observing experimental parameters, and recording results collaboratively and regularly. Observational data were presented in tables, graphs, or other visual models and analyzed using scientific knowledge and supporting data sources. Based on their findings, students drew conclusions and evaluated project results by comparing them with theory, identifying weaknesses and obstacles encountered during the process. They also reflected on the usefulness of the knowledge gained for daily life and a sustainable future. All results were compiled into both written and oral reports supported by digital or non digital media, presented systematically according to the established reporting format.

Practicality of the E-Modul

After the implementation of the e-module in the learning process, teachers and students provided feedback regarding its usage. These responses are detailed in Table 7 and Table 8.

Table 7. Results of Science Teachers' Responses to the E-Module

Assessment Indicators	Percentage	Category
Interest	100%	Very Practical
Content	100%	Very Practical
Language	96%	Very Practical
Helpfulness	100%	Very Practical

The responses from the three science teachers after using the e-module fell into the very practical category. The teachers stated that the e-module captured students' attention, made the learning process more enjoyable, and was able to motivate and boost students' enthusiasm for learning. The material and language used in the e-module were considered to facilitate student understanding. Furthermore, the teachers expressed that the e-module was practical, easy to use and carry, and did not require high costs. The e-module greatly assisted teachers in providing learning resources aligned with the Merdeka Curriculum. All teachers agreed that using the e-module contributed to improving students' understanding, creativity, and scientific process skills.

Table 8. Results of Students' Responses to the E-Module

Assessment Indicators	Percentage	Category
Interest	95.47%	Very Practical
Content	93.36%	Very Practical
Language	92.38%	Very Practical
Helpfulness	97.14%	Very Practical

Students' responses after using the e-module showed a very practical category. The students felt attracted to the overall appearance of the e-module. The use of the e-module made learning science, especially the topic of plant growth and development, more interesting, enjoyable, and motivating, encouraging students to be more enthusiastic in their studies. Students rated the e-module as practical, easy to use, portable, and affordable. The e-module also helped guide students in utilizing organic waste into useful and marketable fertilizer, assisted students in understanding the material on plant growth and development, and supported them in conducting experimental projects on the effects of liquid organic fertilizer on plant growth.

Characteristics of the E-Modul

The developed e-module has integrative characteristics, combining P5 activities with the topic of plant growth and development in the e-module based on Project Based Learning (PjBL). This e-module presents authentic project based learning, namely the creation of liquid organic fertilizer as the P5 project, along with an experiment on the effects of using liquid organic fertilizer on water spinach plants as the learning project.

The e-module guides students through a series of learning activities to find solutions to the problem of organic waste by processing it into a valuable product, one of which is liquid organic fertilizer. The liquid organic fertilizer produced by the students becomes the independent variable in an experimental project that investigates the effect of nutrients on the growth of water spinach plants. This process encourages students to think creatively in producing liquid organic fertilizer from various types of surrounding waste and strengthens their scientific process skills during the experiment.

In addition, this e-module is interactive, combining text, images, audio, video, various types of educational games, and discussion columns that can be directly filled out by students. The use of simple language and sentence structure facilitates material comprehension, as evidenced by the high readability level of the e-module. Positive responses from teachers and students also indicate that this e-module is practical to use and effective in supporting the learning process.

In the development of this e-module, there are four main interconnected aspects that influence the quality of the teaching material: validity, readability, effectiveness, and practicality. Validity indicates the alignment of the e-module with learning objectives, content, student needs, and pedagogical principles, serving as the foundation for acceptance of the other aspects. Readability reflects the ease with which students understand the e-module's content through language, structure, and visual presentation appropriate to their cognitive level. Effectiveness assesses the extent to which the e-module achieves learning goals and enhances student comprehension, while practicality concerns the ease of use by teachers and students in real-world contexts. These four aspects must work synergistically, as weaknesses in any one aspect can reduce the overall quality and usefulness of the e-module.

CONCLUSION

The developed e-module has been proven to be highly valid based on assessments from content experts and media experts. The e-module exhibits a high level of readability. It has also been shown to effectively improve students' creativity and scientific process skills, as evidenced by cognitive and performance tests. The e-module received a "very practical" category based on feedback from teachers and students. Furthermore, the developed e-module demonstrates characteristics that integrate P5 activities with the material on plant growth and development into a single e-module based on Project Based Learning (PjBL).

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