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Development of an Integrated Project-Based Learning Module Based on Black Soybean Ethnoscience to Improve Students' Science Process Skills

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Abstract: Science process skills are one of the 21st-century skills that are important to optimize to train students to be skilled in solving problems. However, facts in the field show that science process skills are still relatively low because teachers do not yet understand how to develop science process skills, and there is a lack of teaching materials based on a scientific approach to developing science process skills. This research aims to develop an integrated Project-based Learning (PjBL) module for black soybean ethnoscience that is valid, practical, and effective for improving students' science process skills. The model for product development is ADDIE. The product's effectiveness was tested using a quasi-experiment with research subjects consisting of 91 students (46 experimental and 45 control group students). The results of the module developed meet valid and practical criteria. The results of product effectiveness tested using quasi-experiments show that the integrated PjBL module of black soybean ethnoscience effectively improves science process skills. They are increasing students' science process skills due to using contextual phenomena in learning.

Keywords: Ethnoscience; Module; Project-based Learning; Science Process Skills

Introduction

Knowledge and information have developed quickly in the last few centuries (Burgelman et al., 2019; Marburger, 2011). This rate of development covers various fields, including education (Meyer & Norman, 2020; Zawacki-Richter et al., 2019). For someone to be able to compete in the 21st century, students must have 21st-century life skills (Meyer & Norman, 2020; Wrahatnolo & Munoto, 2018). Several strategies are used to make 21st-century education successful, one of which is learning through activities (Kim et al., 2019). Activity-based learning has improved students' science process skills (Saavedra & Opfer, 2012). This strategy can be implemented by providing meaningful learning experiences to students through investigative activities (Albar & Southcott, 2021).

Investigation activities will optimize students' knowledge and skills (Bai & Song, 2018). One of the 21st-century skills in science learning is science process skills (Afandi et al., 2019). Science process skills are skills to optimize the skills of identifying and defining variables, collecting and processing data, creating tables and graphs, describing relationships between variables, interpreting data, designing materials, retrieving data, formulating hypotheses, designing investigations, and drawing conclusions (Uştuk & Costa, 2021).

Science process skills are essential to develop in the learning process because they are important for students to solve their daily problems (Suryanti et al., 2020). Through science process skills, students can use scientific information to conduct scientific investigations in solving problems (Aka et al., 2010). Science process skills can help students face various challenges that arise

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along with the development of science (Ekici & Erdem, 2020). However, based on facts in the field, students' science process skills in Indonesia are still relatively low (Darmaji et al., 2020), especially in the aspect of assessing (classification) (Gasila et al., 2019; Lepiyanto, 2017), interpreting and reasoning skills (Lepiyanto, 2017).

The low level of science process skills is caused by several factors, including the learning process not facilitating students to carry out investigations, the learning process emphasizing memorization skills, less relevant literature books, and learning that is not contextual (Akmala et al., 2019; Anggrella et al., 2020; Darmaji et al., 2020). One learning innovation that can improve science process skills is Project Based Learning (PjBL) (Anggriani et al., 2019).

PjBL is a learning model based on a problem involving students solving problems and producing a valuable work product. PjBL will facilitate students in formulating questions, designing and conducting investigations, analyzing data, solving problems through scientific activities/projects, testing results, and evaluating. The PjBL model will be more effective if it uses contextual learning by integrating ethnoscience (Ardianti & Raida, 2022; Rahayu et al., 2023; Sudarmin et al., 2019). Based on previous research shows that there is the influence of the ethnoscience-based PjBL model on scientific literacy (Sholahuddin et al., 2021), creative thinking skills (Rahayu et al., 2023), conceptual understanding (Ardianti & Raida, 2022), entrepreneurial character, entrepreneurship (Carnawi et al., 2017) and science process skills (Rahayu & Ismawati, 2022). The ethnoscience approach creates a learning environment that integrates cultural characteristics as a process in science learning. The aim of implementing ethnoscience in education is that students become more familiar with the environment's social and cultural aspects (Khoiri & Sunarno, 2018).

Learning will be more effective if students learn to use the surrounding environment, such as social and cultural life, because it can stimulate curiosity, which raises questions, makes observations, draws conclusions, and gains experience through the scientific process (Kristiantari et al., 2023). The experiences gained from the scientific method are more durable, recorded, and remembered by students (Ardianti & Raida, 2022).

Ethnoscience encompasses knowledge and practices from particular cultures, traditions, and societies (Khoiri & Sunarno, 2018). Integrating ethnoscience elements in science learning makes the material more meaningful for students and respects and preserves local wisdom (Wahyu, 2017). One exciting material in this context is black soybeans, which have cultural value and potential in natural sciences (Khosravi & Razavi, 2021; Nurrahman, 2015; Wardani & Wardani, 2014). Modules for student's learning are needed as guidelines and learning resources as well as steps for student activities so that students can learn independently and improve their quality of learning (Ihsan & Pahmi, 2022). Students can learn independently through teaching modules to discover concepts and conduct investigations (Septiani & Listiyani, 2021).

Research on developing ethnoscience-based modules has been carried out and can improve students' science process skills (Ni'mah, 2022). In line with this information, ethnoscience research has never been carried out by integrating the PjBL learning model, so developing students' science process skills through the ethnoscience-integrated PjBL Module is essential.

Method

Research Design

This research is development research using the ADDIE model, which includes Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). The ADDIE development model was chosen because the procedures are structured, and each stage has an evaluation so that the shortcomings of each step can be identified. Each stage of the development procedure in this research is related, as presented in Figure 1.

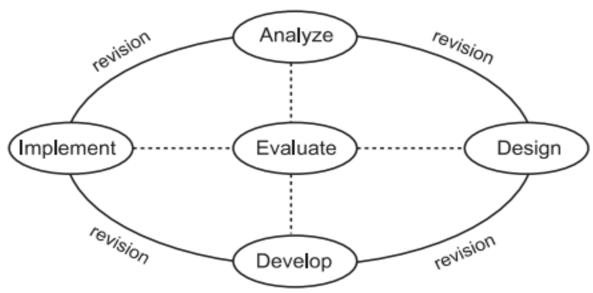

Figure 1. ADDIE Development Model

The product's effectiveness was tested using a Quasy experiment with a non-equivalent pretest-posttest control group design. The quasi-experimental research design is shown in Table 1 in more detail.

Table 1. Quasi-experimental research design

Group	Pretest	Treatment	Posttest
E	Y1	X	Y2
K	Y1	-	Y2

Information:
E = experimental group
K = control group
X = black soybean ethnoscience-based PjBl module
Y1 = pretest
Y2 = posttest

Subjects of Study

The sample in this study was grade XI students, totaling 91 people in one of the high schools in Malang (46 experimental and 45 control group). Sample selection is carried out randomly.

Research Instrument

The research instruments used in this study are comprehensive validation of material experts, teaching material experts, and field practitioners. In addition, there are also instruments to measure students' science process skills in the form of pretest and posttest questions.

Data Analysis Techniques

Validity

Analysis of module validity is performed using the following formula.

$$V_{h/pl} = \frac{Tse}{Tsh} \times 100\% \quad (1)$$

Information:

$V_{ah/pl}$ = Validation of experts/field practitioners
Tse = Validator's total empirical score achievement
Tsh = Maximum expected score
100% = Constanta

Modules can be considered valid and practical if the minimum validity level is 60%. The criteria for validity and practicality of assessment questionnaire data from validators can be seen in Table 2.

Table 2. Validity Criteria for Expert Validation

Value score (%)	Information
81-100	Very valid; very practical; can be used tapa repair
61-80	Valid; practical; usable but needs minor improvements.
41-60	Quite valid; reasonably practical; Recommended not to use
21-40	Less valid, less practical, unusable
0-20	Invalid; impractical; unusable

Module Effectiveness

The effectiveness of the module was analyzed using descriptive and inferential statistical techniques. Descriptive statistics are used to measure students' science process skills scores. Descriptive analysis was conducted to determine the average science process skills in the experimental and control groups. The inferential analysis is used to see the effectiveness of using modules implemented through inferential statistical analysis conducted through ANCOVA.

Result and Discussion

Validation Results

Learning Subject Expert

The purpose of material validation is to test the validity of the content or material of the developed module. The validation results by material experts obtained a total average of 90% with very valid criteria after several revisions. The results of material validation and indicators can be seen in Table 3.

Table 3. Validation Results of Learning Subject Expert

Aspects	Percentage (%)	Criteria
Material Organization	91	Very valid
Scope of Material	93	Very valid
Material Accuracy	95	Very valid
Language Feasibility in Understanding the Material	80	Valid
Presentation of evaluation	92	Very valid
Average	91	Very valid

Teaching Materials Experts

The purpose of teaching material validation is to test the validity of teaching materials in terms of module content and design. The analysis of each item of the student module assessment indicator obtained a total average for student modules of 94.75%. The validation results of the development of teaching materials in more detail can be seen in Table 4.

Learning Practitioners

In addition to being tested for validity by material and teaching material experts, the modules developed will also be tested for the practicality of their use, namely biology teachers. The validation results of learning practitioners obtained a total average of 97% with very valid criteria. The results of more recent validation of learning practitioners are shown in Table 5.

Table 4. Validation Results of Teaching Material Expert

Aspects	Percentage (%)	Criteria
Content Eligibility	98	Very valid
Module Meaning	92	Very valid
Language Eligibility Component	93	Very valid
Graphics	96	Valid
Average	94.75	Very valid

Table 5. Learning Practitioner Respons Results

Aspects	Yield (%)	Criterion
Clarity of components in modules	97	Very valid
Scope of material	95	Very valid
Module independence	100	Very valid
Suitability of the material presented with the development of science and technology	100	Very valid
Learning aspects	91	Very valid
Average	97	Very valid

The science process skills test used as a pretest and posttest refers to aspects of integrated science process skills, including identifying variables, interpreting data, formulating hypotheses, defining operationally, and conducting experiments. The results of the science process skills test are shown in Figure 2 and summarized in Table 6. The results of the ANCOVA test to determine differences in the achievement of science process skills in the control and experimental classes are shown in Table 7.

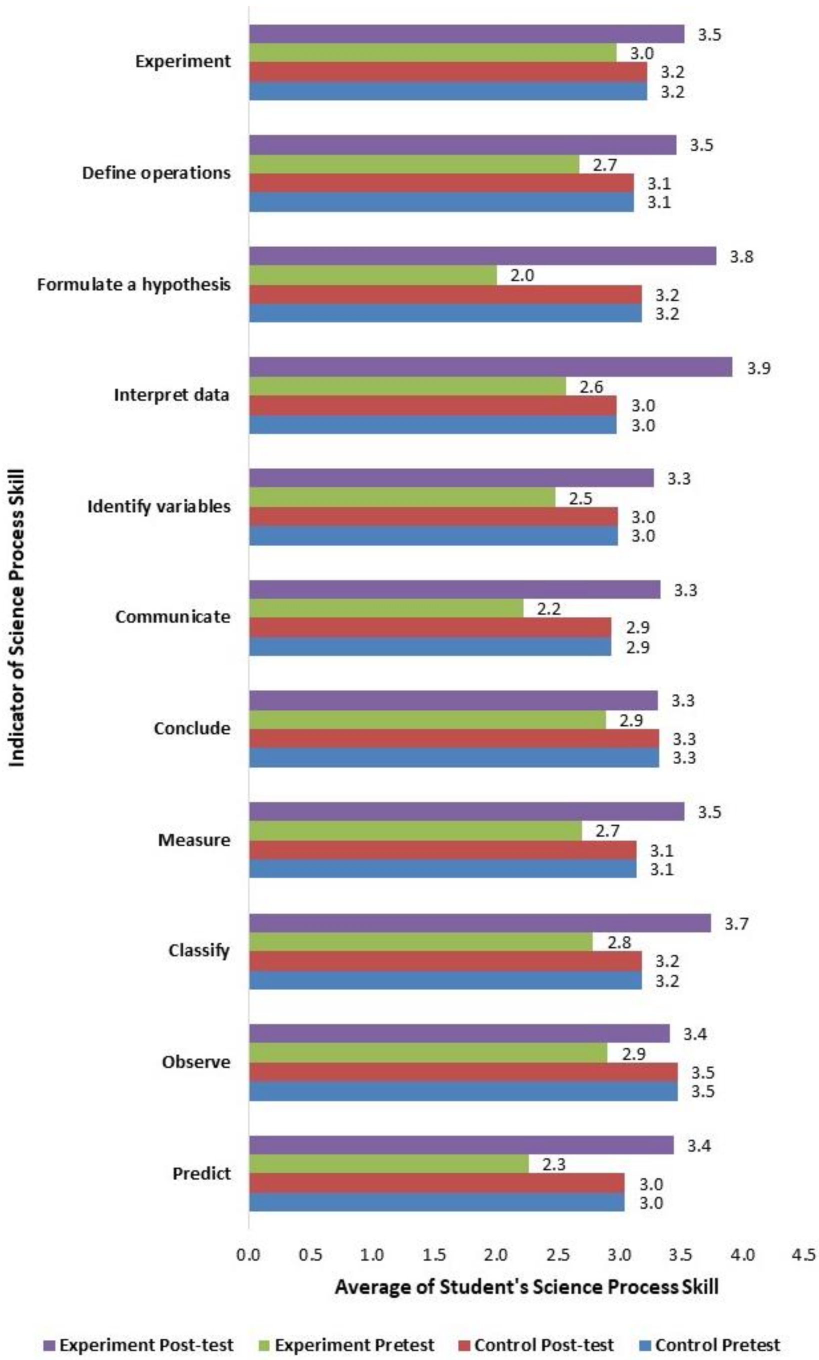

Figure 2. Comparison diagram of science process skills before and after treatment in each indicator

Table 6. Average Science Process Skills Score

Group	Average		
	Pretest	Posttest	Differences
Control	55.27	73.61	18.35
Experiment	54.87	81.30	26.43

Based on the results of the ANCOVA test, it can be seen that the calculated F is 21.512 with a significance of 0.000. The significance value is less than 0.05, so there is a difference in science process skills between students in the experimental and control classes. The experimental class has a corrected mean value higher than the corrected mean value for the control class, summarized in Table 8.

Table 7. ANCOVA Test Results for Differences in Science Process Skills

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1646,53[a]	2	823.266	24.879	.000
Intercept	4411.927	1	4411.927	133.330	.000
Pretest	965.468	1	965.468	29.177	.000
Experiment	711.840	1	711.840	21.512	.000
Error	1422.880	43	33.090		
Total	279047.000	46			
Corrected Total	3069.413	45			

Table 8. Corrected Mean Value of Science Process Skills

Group	N	Corrected mean	Enhancement (%)
Control	46	73.522	10.70
Experiment	46	81.391	

Based on Table 8, it can be seen that the corrected mean in the experimental class is higher than the control class, so it can be concluded that the achievement of science process skills in the experimental class has a value of 10.70% higher than the control class. The Project-based Learning model is believed to potentially improve students' science process skills (Amsikan, 2022; Andriyani et al., 2019). Integrated process skills include identifying variable indicators, interpreting data, formulating hypotheses, operationally defining, and conducting experiments (Sheeba, 2013). Project-based learning provides a problem to be solved by students in groups or individually. Working in groups requires good collaboration and communication skills to build an effective team. Project-based learning provides a collaborative learning environment that can improve students' collaboration and communication skills (Alharbi et al., 2018; Owens & Hite, 2022). When in group conditions, students will learn how to work well with other team members (Hussein, 2021; Sudrajat et al., 2020). In Project-based Learning, students discuss in groups to design solutions to problems given (Guo et al., 2020). The characteristics of problems in project-based learning encourage students to think about solutions to overcome these problems in the form of real products (Maros et al., 2023).

The learning process in Project-based Learning is organized to encourage students to develop their problem-solving skills through implementing projects (Hanney, 2018). Previous research results show that project-based learning improves problem-solving skills (Stoeva & Stoev, 2022; Zabihi et al., 2019). The activities students do to solve problems support them to improve their thinking skills (Diniyyah et al., 2022; Sudrajat et al., 2020). Research activities in Project-based Learning involve students participating in actual work activities to design their final product (Markula & Aksela, 2022). Involving students in real research activities and developing their thinking skills can improve their science process skills (Brotherton & Preece, 1996; García-Carmona et al., 2023).

Learning using an ethnoscience approach is contextual, providing students with a more authentic experience (Fasasi, 2017). Learning with an ethnoscience approach emphasizes achieving an integrated understanding rather than an in-depth one (Zidny et al., 2020). Students learn to connect the material studied in class with the context of their lives and the relationship between science and technology so that learning at school is informative but also practical and valuable. One dimension of studying science is that science learning is intended to obtain a relationship between science, technology, and society (Chiappetta & Koballa, 2006). A deep understanding of a phenomenon and their ability to relate it to scientific phenomena can support improving students' science process skills.

Conclusion

These results indicate that the integrated PjBL module on black soybean ethnoscience meets the valid, practical, and effective criteria. The validity of the module, according to material experts, and the development of teaching materials show very valid criteria. The practicality of module obtained through a questionnaire to field practitioners shows that it is very practical. The effectiveness of the product tested using an experimental design shows that the integrated PjBL module of black soybean ethnoscience is significant in improving science process skills. The results of the analysis of each indicator show that there has been an increase in the value of science process skills in the pretest and posttest. Teachers can use the results of this research as a means of developing students' science process skills. However, larger-scale trials are needed to determine the effectiveness of the product being developed better.

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Conceptualization, methodology, writing—original draft preparation, D.P.A.; formal analysis, writing—review and editing, supervision, A.K.S. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

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