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The Development of Teaching Module Biodiversity of Exotic Fruits Plants of South Kalimantan based on STEM-PjBL for Phase E Students in Senior High School

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Abstract:

The Merdeka curriculum implemented in Indonesian schools allows teachers to create, select and modify teaching modules according to the context and needs of the learners. This research was used to develop a biology teaching module by exploring the potential of plants biodiversity in South Kalimantan, especially exotic fruit plants using the syntax of STEM-Project Based Learning model. The biology teaching module development design was used the ADDIE model (Analysis, Design, Development, Implementation and Evaluation). The results of the development in the form of teaching modules that have three sub-topics namely 1) levels of biodiversity (genes, species, and ecosystems); 2) species diversity of exotic fruit flora of South Kalimantan and 3) Biodiversity conservation efforts. The Teaching Module has complete components consisting of general information, core components and attachments. Validity and feasibility tests involved 3 experts (biology teachers with more than 5 years of teaching experience) and 10 students from SMAN 7 Banjarmasin. Data analysis was done descriptively from validity and feasibility test data. The results showed that the developed product is feasible to use in the learning process of biodiversity of E phase students in class X with excellent and very valid categories.

Keywords:

Exotic Fruit Plants, South Kalimantan, STEM-PjBL, Teaching Module

Introduction

The latest curriculum in Indonesia, named Merdeka Curriculum, has three new teaching tools which include teaching modules, learning objective flows and Pancasila learner profile strengthening projects (Anggraena, Felicia, et al., 2022; Fitri et al., 2022). Teaching modules are used as learning planning documents with components consisting of at least learning objectives, learning steps and assessments needed in one unit/topic based on the learning objectives flow (Kemendikbud-Ristekdikti, 2022). The components of the full version Teaching Module include

1) The general information consists of the identity of the module authors, initial competence, Pancasila learner profile, facilities and infrastructure, target learners and the learning model used; 2) The main components include: learning objectives, assessment, meaningful understanding, triggering questions, learning activities, reflection of learners and educators, and 3) The attachments include: Learner Worksheets (LKPD), enrichment and remedial, reading materials for educators and learners, glossaries and bibliography (Anggraena, Ginanto, et al., 2022).

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The Biology subject in Senior High School has also changed in the Merdeka Curriculum in the Learning Outcomes which are divided into Phase E and Phase F. The subject of Biology in the Merdeka Curriculum is defined as the study of the phenomena of life and living things which include the structure of physiology, morphology, living space, as well as their origin and distribution (Kemdikbud-Ristekdikti, 2022). Biological Sciences are needed for Indonesia to maintain biodiversity, ecosystem sustainability, the well-being of humans and other organisms as well as their populations, also the sustainability of biological resources which owned by Indonesia (Kemdikbud-Ristekdikti, 2022).

This research aim to learn about biodiversity is focused on plants because people tend to ignore plants, even though plants are important in the sustainability of life in the world, which why the term 'Plant Blindness' has emerged (Amprazis et al., 2021; Brownlee et al., 2023; Ny et al., 2022; Pedrera et al., 2023). Plant biodiversity, Indonesia ranks fifth in the world with more than 38,000 species (55% endemic) (Gunawan et al., 2019). Therefore, it is necessary to aware students about recognizing and protecting the plants around them to prevent plant blindness in Indonesia's younger generation.

Biology is a subject that is appropriate to be integrated with local potential, local wisdom and culture, one of them is on the topic of Biodiversity (Adinugraha & Ratnaputri, 2020; Ningrat et al., 2024). The development of a contextual learning material through exploring local potential such as biodiversity needs to be conducted as a learning resource for students in high school that is in accordance with geographical, ethnographic, and regional characteristics (Sukirno et al., 2020). The learning of biodiversity has the same goal as conservation learning so it should be given to students (Navarro-Perez & Tidball, 2012). Learning based on local potential of plants can be implemented through making teaching modules, but in fact teachers have not made and integrated local potential in their teaching module (Mellawen et al., 2024). Based on the literature study also shows that textbooks from Campbell, Mason, Morris and Open Text contain more animal images than plants (Brownlee et al., 2023).

Based on the results of interviews with Biology teachers at SMAN 4 Banjarmasin, SMAN 7 Banjarmasin and SMAN 12 Banjarmasin showed that Biology textbooks and teaching materials have not provided specific material local potential on biodiversity in South Kalimantan. The development of teaching materials in the form of biology teaching modules on Flora biodiversity in South Kalimantan is very necessary to introduce the potential and conservation efforts to students. The results of interviews with students, many

of students do not know and utilize the exotic fruits of South Kalimantan.

South Kalimantan as place for this research has a diversity of local fruit species consisting of the genus *Artocarpus* with a number of 15 species, *Mangifera* with a number of 13 species, *Garcinia* and *Baccaurea* with a number of 12 species and *Durio* with a number of 7 species (Budiharta & Meijaard, 2017). The diversity of South Kalimantan Exotic Fruit Plant Species has the potential to be used as material for the learning process of biodiversity at the high school level. The teaching material of South Kalimantan Exotic Fruit Plant Species Diversity is implemented through the STEM-PjBL learning model. Project-based learning has a positive impact on students' learning of biodiversity (Kendall et al., 2021).

STEM-PjBL is a learning model that involves learners in groups to complete projects, prepare project reports and present their project reports to their classmates (Baran et al., 2021). Science class implemented with STEM-PjBL can encourage learners to think creatively, solve problems, search for answers, and complete practical products during the class project (Chen & Lin, 2019). Indonesian teachers can improve the quality of science learning for Generation Z with one of the alternatives with a STEM approach to train 21st century skills (Ichsan et al., 2023). The STEM-PjBL model provides good cognitive learning outcomes for learners from the project activities that have been carried out (Maulana et al., 2023; Nurtamara et al., 2023).

Based on the literature review and the preliminary study that has been carried out by the researcher, then the objectives of the research conducted are: 1) developing the product Teaching Module Biodiversity of Exotic Fruits Plants South Kalimantan based on STEM-PjBL and 2) testing the feasibility of the product Teaching Module Biodiversity of Exotic Fruits of South Kalimantan based on STEM-PjBL.

Method

The development of the Teachings Module on Biodiversity of Exotic Fruits South Kalimantan based on STEM-PjBL was used the ADDIE development model. The ADDIE development model has the following stages: Analysis, Design, Development, Implementation, and Evaluation (Fitri et al., 2022; Indriani & Astuti, 2023; Nursamsu et al., 2023; Pakaya et al., 2023; Rupa Basu, 2018; Setyaningsih et al., 2022). The stages carried out in this research are to assess the feasibility of the product, so the ADDIE stages used are analysis, design and development (Hasibuan et al., 2023).

The analysis stage is the stage of the need analysis of the development of teaching materials with

the learning objectives, the characteristics of the material and the characteristics of the students. The design stage is designing Teaching Module products from the preparation of material, determining the steps of the appropriate learning model, designing diagnostic, formative and summative assessments and their assessment rubrics. The development stage is the stage of developing the teaching module, so that at this stage there is already a draft teaching module. The draft teaching module will be validated by practitioners from SMAN 7 Banjarmasin, SMAN 4 Banjarmasin and SMAN 12 Banjarmasin with assessment criteria 91-100: very good, 81-90: Good, 71-80: enough and less than 70: lacking. The final development stage is used to test the feasibility of teaching modules conducted by students regarding the practicality of the teaching modules that have been developed. Assessment of the feasibility of teaching modules by students using an assessment rubric from the aspects of display, presentation of material and product benefits. The validity criteria for the feasibility test are as follows:

- 80.1-100% = very valid
- 60.1 - 80% = Valid
- 40.1- 60% = Enough Valid
- 20.1- 40 % = Lack of validity
- 0-20% = Not Valid

(Husna et al., 2021)

Data obtained from expert validators and learners (readability) were analyzed using descriptive quantitative techniques (Husnadi et al., 2024). The expert validators and learners (readability) in the development phase to made product validity criterion and decision of the teaching module in the development teaching module (Setyaningsih et al., 2022). Testing and revision process were important, so that the product already meets the criteria for a good product, is empirically tested and there are no more mistakes (Cahyadi, 2019).

Result and Discussion

A. Teaching Module Product Development

The Teaching Module for Biology of Flora Biodiversity (Exotic Fruits) in South Kalimantan based on STEM-PjBL is prepared based on the in merdeka curriculum and the local potential of gene diversity, species and ecosystems in the South Kalimantan area. The teaching module was developed from observations and biodiversity inventories conducted by researchers. Researchers found ecosystem diversity in the form of swamp land, rivers, rice fields and peatlands. the species diversity of local fruit species, namely Cempedak (*Artocarpus integer* Thunb.); Langsat (*Lansium*

domesticum); akin/Lai (*Durio kutejensis* (Hassk.) Becc); Kapul (*Baccaurea macrocarpa* (Miq.) Mull. Arg); rambai (*Baccaurea motleyana* Müll.Arg.); Balangkasua (*Lepisanthes alata* (Blume) Leenh.); Gandaria (*Bouea macrophylla* Griff.); Mundar (*Garcinia forbesi* King.); Kasturi (*Mangifera casturi* Kosterm) and kuweni (*Mangifera odorata*). South Kalimantan also has an ex-situ conservation area, the Banua Botanical Garden as a garden that conserve the diversity of local plants of South Kalimantan.

Therefore, the Teaching Module developed has a novelty value that is indispensable for learning biology in high school. The novelty of the developed module is the presence of biodiversity material with the diversity of exotic fruit plant species in southern Kalimantan. It is further suggested that the developed module can empower the awareness of preserving biodiversity in the daily lives of students. The results of the development of the Biology Teaching Module are presented in Figure 1 to Figure 7.



Figure 1. Cover of the Teaching Module

I. Identitas Modul Ajar

A. Informasi Umum

B. Informasi Khusus

Dimensi	Elemen	Sifat Elemen
Materi	Identifikasi	Identifikasi
	Identifikasi	Identifikasi
Metode	Identifikasi	Identifikasi
	Identifikasi	Identifikasi
Media	Identifikasi	Identifikasi
	Identifikasi	Identifikasi
Penilaian	Identifikasi	Identifikasi
	Identifikasi	Identifikasi

Figure 2. Identity of the Teaching Module

The module cover displays the title, a picture of the fruit of an exotic plant in South Kalimantan, the author's name and the institution. The module identity consists of general information and specific information. Specific information contains initial competencies, Pancasila learner profile, learning facilities and infrastructure, target learners and the learning model used, namely using the STEM-PjBL model.

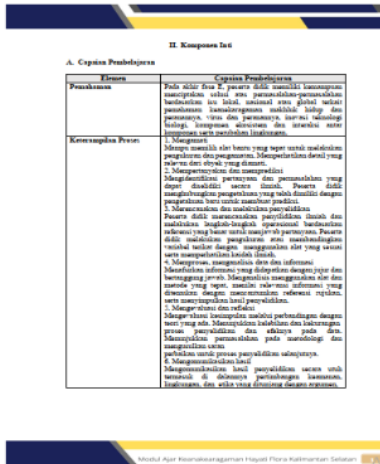


Figure 3. Core Components

The core component consists of learning outcomes (understanding and science process skills), learning objectives, meaningful understanding, triggering questions, learning preparation, learning activities, assessment, and learner and teacher reflection. The learning objectives achieved in the teaching module are that students are able to analyze diversity and conduct science process skills to provide ideas, suggestions or scientific arguments in solving projects/problems of the type of diversity of exotic fruit plant species in South Kalimantan. Science process skills are needed by learners to solve projects. Science process skills are skills that consist of basic skills and integrated skills (Beaumont-Walters & Soyibo, 2001; Brotherton & Preece, 1995). In addition to learning objectives, the core component also contains a learning plan using the STEM-PjBL model. Project-based learning is required to train the 21st century skills of the 6Cs: Character, Creativity, Critical thinking, Citizenship, Communication, and Collaboration (Leasa et al., 2023) and the PjBL model is highly recommended for teachers to use in science learning (Zulyusri et al., 2023). STEM-PjBL learning can be used as a teaching model that trains students' creative, collaborative, and communicative thinking skills (Kurniahtunnisa et al., 2023). The steps in the learning plan of STEM-PjBL are outlined in the Learner Worksheet (LKPD).

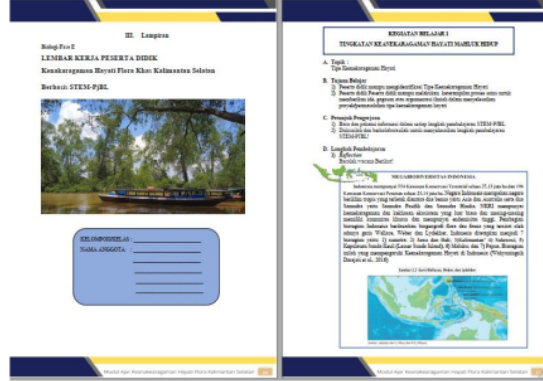


Figure 4. LKPD (Student Worksheets)

LKPD in the Teaching Module consists of three topics namely Levels of Biodiversity of Living Things, Species Diversity of South Kalimantan Exotic Fruit Flora and Conservation Efforts of South Kalimantan Exotic Fruit Flora. LKPD is prepared based on STEM-PjBL learning steps which consist of reflection, research, discovery, application, and communication (Laboy-Rush, 2021). LKPD is used in learning process activities according to the learning model used in order to facilitate students and teachers to achieve learning objectives (Novitha & Suhartini, 2023).

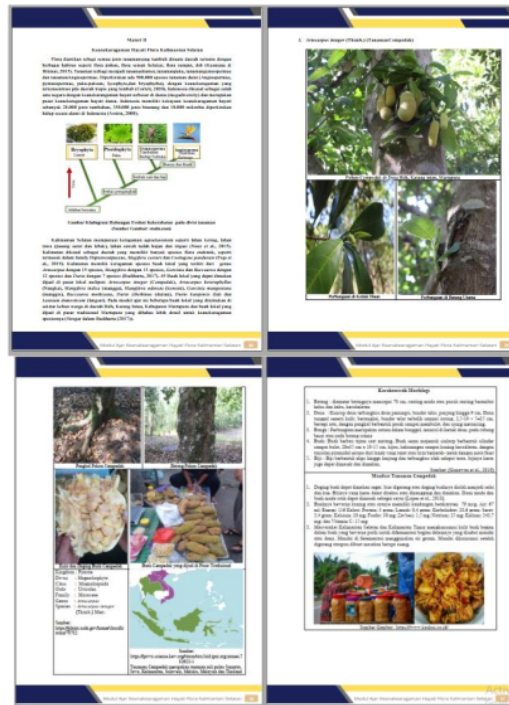


Figure 5. Teaching Materials

Teaching materials adjust to LKPD, so they are useful to help teachers and students find study materials/literature to support learning activities. The advantages of the teaching materials compiled are contextual-based teaching materials by providing topics of biodiversity from the gene, species and ecosystem levels in South Kalimantan and its conservation efforts. South Kalimantan has a special region, namely peatland areas, which are not yet available in existing textbooks at school. Teaching materials that are arranged contextually based on field data from flora inventory research results according to the lives of students can help connect theoretical concepts with real situations which ultimately involve students to solve problems around them (Sukirno et al., 2020).

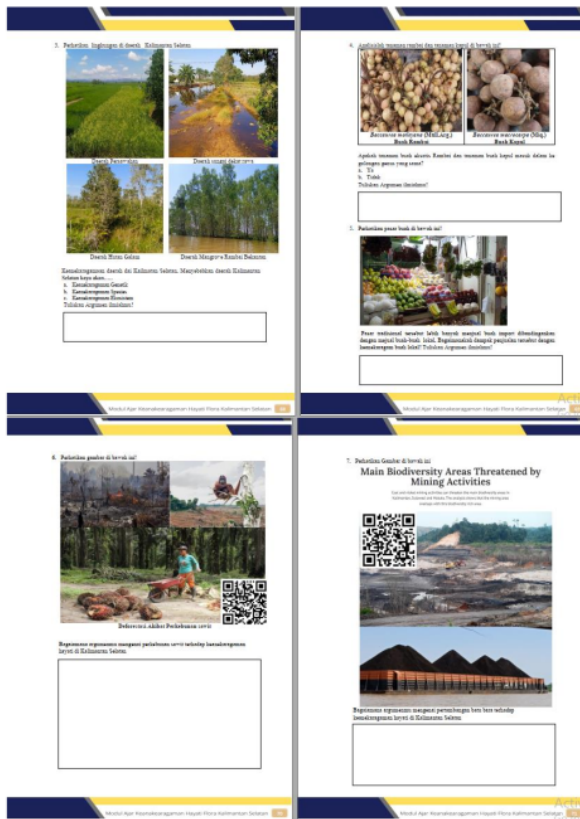


Figure 6. Teaching module assessment

The assessment in the Merdeka Curriculum uses three assessments, namely diagnostic assessment, formative assessment and summative assessment. Diagnostic assessment is given to assess students' learning preparedness in learning the topic of biodiversity. Formative assessment is given to assess the learning process by assessing knowledge, skills and

attitudes. Formative assessment is assessed from the LKPD that has been done with differentiated assessment the results of projects carried out by students. Summative assessment is given at the end of learning to assess the achievement of learning objectives regarding the level of biodiversity, species diversity of exotic fruit flora in South Kalimantan and conservation efforts of exotic fruit flora in South Kalimantan.

Summative assessment emphasizes the assessment of students' argumentation skills. Argumentation skills in science education are very important (Wang & Buck, 2016). The question exercises presented in the module provide opportunities for students to analyze cases related to biodiversity in South Kalimantan and its conservation efforts, then ask students to develop arguments that contain solutions to the case analysis. Science learning in senior high school can encourage students to use argumentation to solve ill-structured in science issue (Sadler & Donnelly, 2006). Summative assessment that contains argumentation, formative assessment in LKPD and diagnostic assessment using rubric guidelines.

Figure 7. Rubric of Assessment

The rubrics compiled include 1) diagnostic assessment rubrics; 2) summative assessment rubrics consisting of 10 questions with argumentation assessment rubrics; 3) LKPD assessment rubrics, 4) project assessment rubrics (Developing projects, carrying out projects, products, project reports, and communication), and 5) Pancasila learner profile assessment rubrics. The assessment rubric is prepared to assess and evaluate the quality of students' performance achievements as outlined in the form of criteria or dimensions that will be graded from lack to excellent (Anggraena, Ginanto, et al., 2022).

B. Feasibility Test for Teaching Module

The feasibility test of teaching modules is carried out by assessing teaching modules from experts. Experts who assess biology teaching modules specialize in the field of biology and teachers who have experience teaching biology for five years or more, experts play a role in assessing what is presented in the teaching module (Cruz & Rivera, 2022). The expert evaluators of the biology teaching module Biodiversity of Flora Exotic Fruit Plants South Kalimantan consisted of 3 teachers from SMAN 7 Banjarmasin, SMAN 12 Banjarmasin and SMAN 4 Banjarmasin. One of the teachers is also a facilitator of teacher activators (Namely Guru Penggerak) in Banjarr³⁰in. The result of experts assessment is presented in Table 1.

Table 1. Results of Expert Assessment of Teaching Modules

Aspect	Indicator	Val. 1	Val. 2	Val. 3
Identity of Teaching Modul	Completed	6	6	6
Prior competencies	Prior competencies in accordance with learning outcomes	3	3	3
Pancasila learner profile	Contains the Pancasila learner profile according to the Learning Outcomes and outlines the objectives.	3	3	3
Facilities and infrastructure for learning	Facilities are available and suitable	3	3	3
Learners' targets	Learners' targets are already varied	3	3	3
The learning model	The learning model used is appropriate and fulfills the needs of the students.	3	3	3
Learning objectives	Learning objectives contain understanding and science process skills	3	3	3
Meaningful understanding	Meaningful understanding ¹⁴ is available in accordance with the Learning Outcomes	3	3	3
Triggering questions	Triggering questions ¹⁴ available in accordance with the Learning Outcomes	3	3	3

Preparation for learning	Facilities are available and explained in detail	3	3	3
Learning activities	Learning activities are available consisting of introduction, core activities, closing; leads to the Pancasila learner profile and learning objectives; and already refers to learning to differentiate.	3	3	3
Assessments	There are three assessments: diagnostic, formative and summative	2	3	3
Learning reflections	Learning reflections available for students and teachers		3	3
LKPD	LKPD are available and complete	3	3	3
Reading Materials	Teacher and learner reading materials are varied	3	2	2
Glossary	The glossary is complete	3	3	3
Bibliography	Bibliography that includes more than one	3	3	3
Essential	Concept understanding of each subject is through experiential and interdisciplinary learning.	3	3	3
Engaging, meaningful and challenging	Teaching modules fulfill the principles of interesting, meaningful and challenging	3	3	3
Relevant and contextual	Teaching modules fulfill the principles of relevance and contextualization	3	3	3
Continuous	Teaching modules fulfill the principle of continuously	3	3	3
Total score		65/66	65/66	65/66
Percentage (%)		98.4	98.4	98.4

Val: Validator

Based on Table 1. The results of the validation / assessment score from the expert show a value of 98.4 which means very good, so that the teaching module product can be used for students. Based on the teaching module validation form conducted by the expert, it shows that the teaching module has all the complete components of the general information component, core components and attachments. Teaching modules have also fulfilled the principles of teaching modules which include essential, interesting and challenging, relevant and contextual, and sustainable (Maulinda, 2022).

After revising the suggestions and improvements in the Teaching module, the next step was to conduct a feasibility test on a small group of 10 students at SMAN 7 Banjarmasin. The results of the feasibility assessment by students are presented in Table 2.

Table 2. Small Group Feasibility Test Result

Aspect	Score	Criteria
Display	88.38	very valid
Material Presentation	81.91	very valid
benefits of usage	80.81	very valid

Based on table 2, it is known that the teaching module feasibility test in small groups has an average score of 83.69, which means that the teaching module is very valid and no revision is needed. The validity value of the teaching module indicates that the teaching module is practical to use in learning biology using the STEM-PjBL model. The practicality test is needed to obtain clear information about the impressions and possibilities that occur in learning using the developed product (Dharmono et al., 2022). Further research that can be done is to test the effectiveness of the Biology Teaching Module of Flora Biodiversity (Exotic Fruit) in South Kalimantan based on STEM-PjBL can be applied in biology learning in class X SMA / MA. Modules that have completed the development stage by obtaining expert validation, further research is implemented in the learning classroom setting (Cruz & Rivera, 2022). The implementation of STEM-PjBL-based learning from the module developed from this research is supposed to provide a collaborative and cooperative classroom for students in exploring plants. Collaborative and cooperative learning is needed to motivate learners to recognize plants and their functions, nurture plants, cultivate plants, name the plants and identify plants to increase students' understanding of the importance of plants in the environment (Fančovičová & Prokop, 2011).

Conclusion

The Teaching Module Biodiversity of Exotic Fruits Plants of South Kalimantan based on STEM-PjBL can be developed by exploring the potential of local fruits in South Kalimantan. The Teaching Module has complete components consisting of general information, core components and attachments. The results of expert validation show an average value of 98.4% which means very good, so the Teaching Module can be implemented. The results of the feasibility test in small groups showed an average value of 83.69 which means very valid. The decision of this research showed that the Teaching Module for Biology of Biodiversity Exotic Fruit Plants in South Kalimantan based on STEM-PjBL is suitable for use to determine its effectiveness in achieving biology learning objectives in the Merdeka Curriculum for further research.

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Author Contributions

The first author contributed to the writing of teaching modules, the inventory of exotic fruit flora species diversity of South Kalimantan and journal writing. The second author and the third author play a role in plant experts and supervision of teaching modules developed.

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Conflicts of Interest

The authors declare no conflict of interest.

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