RESEARCH ARTICLE

Fostering students' problem-solving skills through biology learning model integrated with *Kurikulum Merdeka*

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Abstract: *Kurikulum Merdeka* is a learning experience framework that offers flexibility and focuses on essential content, character development, and students' competencies. Teachers had the discretion to develop their modules to choose, design, and organize the learning contents for students, based on their needs. By using that module, there is more flexibility and independence either for teachers and students, while enhancing the relevance, interactivity, and effectiveness of learning. This research aims to develop problem-based teaching modules on biology based on *Kurikulum Merdeka* as a reference in the learning process. This research and development, referring to Borg and Gall's model, consists of (1) research and information collection, (2) planning, (3) developing a preliminary form of the product, (4) preliminary field testing, and (5) main product revision. The participants in this development research are teachers as learning experts and students of a senior high school in one of the districts of East Lombok as a subject in limited trials. Data collection used closed questionnaires to determine the feasibility and ideality of the instrument. Data analysis using quantitative descriptive analysis involves analyzing the results of instrument feasibility and ideality from experts and students. The results show that the developed module was included in the very feasible and ideal learning resources. The readability test of the worksheet after limited trials was included in the good category for the biodiversity content, and quite good for the virus and ecosystem content. Therefore, the problem-based teaching module on biology content in phase E of grade XI of senior high school is considered feasible.

Keywords: Biology teaching module; *Kurikulum Merdeka*; problem-based learning; problem-solving

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Introduction

The curriculum consists of carefully designed and selected problems, requiring students to be proficient in high-level thinking, independence, and collaborative (Munawaroh, 2020). The current curriculum can vary based on the country and type of educational institution. However, many countries have frameworks that regulate basic curricula for formal education, such as primary and secondary schools. For instance, Indonesia currently implements the *Kurikulum Merdeka*. This curriculum offers concept introduced in Indonesia as part of educational reform. It aims to provide more flexibility and freedom to schools in designing their own curriculum according to local needs and conditions, as well as adapting to global developments. Kumar and Radcliffe (2017) state that the development of a curriculum in a country begins with the introduction and assimilation of advances in disciplines.

The *Kurikulum Merdeka* has several main objectives to improve the education quality in Indonesia. One of the crucial that emphasizes the importance of building critical thinking, creativity, collaboration, and communication skills. The goal is to prepare students to face the challenges and opportunities in the ever-changing global society and economy. Carter et al (2017); Özreçberoğlu and Çağanağa (2018); Ozturk and Guven (2016) state that the main variable of the current curriculum is to train problem-solving skills, which are components of the high-level thinking needed today. It has become a goal in the education system to develop individuals to have these skills and to think and process knowledge acquired from the learning process. These skills are important assets for students to face rapid changes in the world of knowledge (Ritter & Mostert, 2017). To achieve these goals, learning processes are conducted. According to Susilawati et al (2022), contributions can be made to the development of students' potential, personalities, intelligence, and character through the learning process.

Studying science, especially biology, cannot be separated from environmental and health problems that require exploration by students, thereby encouraging students' higher-level thinking abilities Ariza et al (2024); Kaya and Elster (2018); and Wechsler et al (2018) emphasize the need for changes in science education that focus on exploring processes and arguments in current science education trends. Luo et al (2020) and Yulindar et al (2018) stated that building conceptual knowledge, increasing literacy, and developing problem-solving, reasoning, and analysis skills are part of science learning outcomes. Valdez and Bungihan (2019) and Wong et al (2021) suggests that to optimize student progress, knowledge and skills about important topics in science learning need to be provided. However, the patterns commonly used in class are lectures, discussions, and group work, thus influencing the quality of students in problem-solving, whereas in science learning there need to be observation and research activities that utilize the school environment which has an impact on the way students learn (Wong et al., 2021). One of the principles and approaches contained in independent curriculum learning is problem-based learning. This kind of approach is believed to help students develop thinking skills, and creativity and foster social attitudes. Marthaliakirana et al (2022) and Wong et al., (2021) suggest that teachers consider and reorganize to organize classes using problem-based learning and integrate it into critical literacy practices.

Anshori (2021) stated that the application of the problem-based learning model often encounters obstacles, such as incompatibility with learning objectives. Apart from that, Sahyar et al (2017) and Shishigu et al (2018) found that students' problem-solving abilities were low and they were still passive in the learning process and were unable to increase students' conceptual knowledge. Anazifa and Djukri (2017); Argaw et al (2017); Chia and Goh (2016); Gao and Wang (2016); Li et al (2020); Thomas and Strunk (2017) show that science teaching has no significant relationship between problem-solving abilities, critical thinking, and students' learning motivation and problem-based learning practices. Alfares (2021) and Caires-Hurley et al (2020) found that students still have difficulty developing knowledge and face many challenges when solving problems. Apart from the lack of suitability between the learning model and the material being taught, the availability of learning resources is also one of the factors in low student learning outcomes. Fatmawati et al (2023) and Kristanti et al (2018) found that in several schools the use of learning tools did not show constructivist-based learning, and did not emphasize problem-solving skills, tending to focus on concepts, such as the use of worksheets. Asma et al (2020) and Astutik et al (2020) need to design and develop more interactive learning tools at all school levels. (Prahani et al., 2022), students need teaching methods that are more interesting, and innovative, utilize learning sources and media, and provide interesting visualizations of the content being taught. One of the causes is the lack of availability of teaching materials so the material taught is not delivered during class hours (Khairini et al., 2021).

Some researchers also suggest that teachers need to use problem-based learning, they need to consider socio-scientific problems in real life (Lubis et al., 2022; Nguyen, 2020; Rehmat & Hartley, 2020). This is indicated to maximize students' social skills such as communication, interpersonal relationships, student retention skills, creative thinking, thought organization, analytical skills, and students' metacognitive awareness (Arifin et al., 2020; Scheepers et al., 2018; Wardoyo et al., 2021), student character development (Bahri et al., 2021), student performance in achieving problem-solving (Magaji, 2021). Apart from considering general skills in implementing problem-based learning, it is also necessary to carry out content analysis and appropriate assessment instruments, as stated by several previous researchers. Bayrak and Gürses (2020); Suhirman et al (2021) also stated that this was done to avoid student boredom. Lapuz and Fulgencio (2020); Thorndahl and Stentoft (2020) suggest using instruments that can measure critical thinking and validate the data obtained. Kloeg (2023) hopes to develop problem-based learning research as a meaningful action.

Biology learning aims to understand concepts, and facts, find solutions to problems, train high-level thinking, integrate skills, and instill a scientific attitude to prepare students for the future. Arbia et al (2020) and Gholami et al (2019) require teaching materials with constructivist strategies that contain elements of high-level thinking such as critical, creative, collaborative, and communicative abilities. Therefore, teachers need learning tools to help them achieve science learning goals, especially constructivist-based learning tools. Based on this description, this development research aims to develop biology learning modules and provide guidance to schools that have not fully implemented the independent curriculum.

Method

The focus of this research is to develop a teaching module for biology subjects in phase E, which is biology for tenth grade in secondary schools. The research design used is development research which refers to the theory of Gall et al (2003) which consists of ten stages, consist of (1) research and information collection, (2) planning, (3) initial product form development, (4) initial field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing, (9) final product revision, and (10) deployment and implementation. However, in this study, only five stages were carried out, because this step is preliminary research to find out what is biology module that will be used on a wider scale can be used (Figure 1).

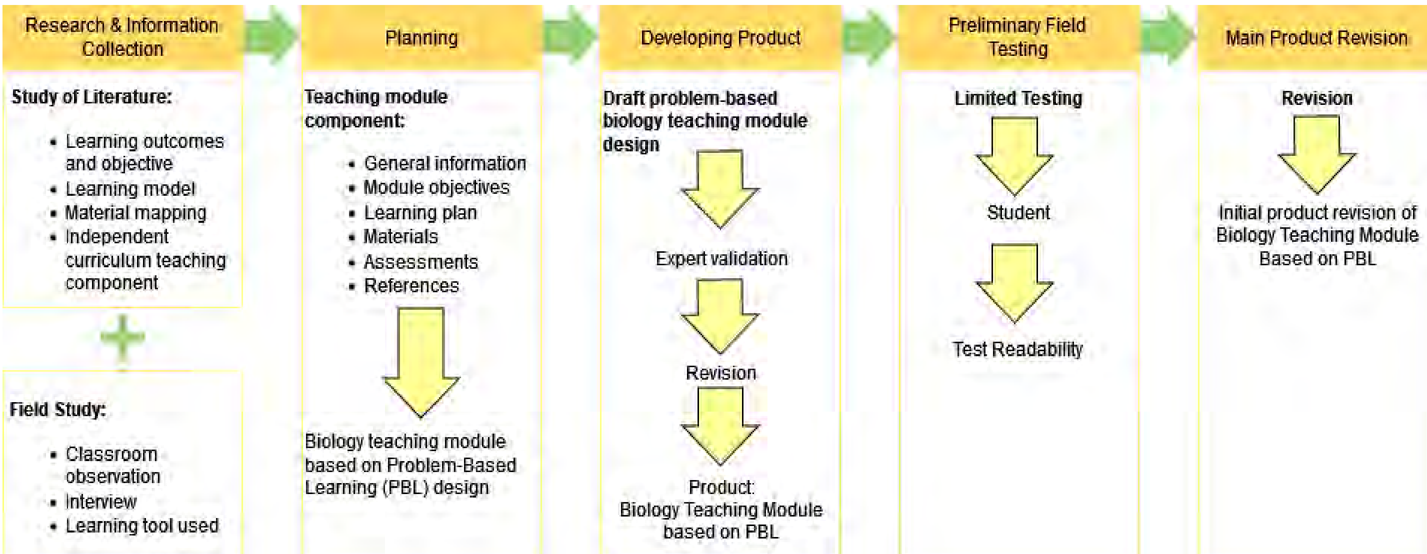

Figure 1. Research flow for developing problem-based biology teaching modules

This research involved 14 students from a one high school in East Lombok as test subjects for a limited learning module. Research data collection uses a questionnaire to determine the feasibility and ideality of the product being made as well as readability tests. The biological content in the problem-based learning biology module is the content for eleventh grade (Phase F) which consists of biodiversity, viruses, and ecosystems. Meanwhile, learning syntax refers to Arends (2012), including student orientation to problems, organizing students to learn, helping group independence and investigation, developing and presenting artifacts and exhibitions, as well as analyzing and evaluating the problem-solving process. Worksheet indicators in the teaching module include identifying problems, stating the cause of the problem, proposing solutions, and concluding. Quantitative descriptive data analysis, i.e. analyzing of product feasibility, ideality, and readability based on predetermined formulas. The results of the feasibility and ideal assessments from experts who act as validators are used as a reference for revising the product to produce a product that is feasible (Table 1). Assessment by calculating the average value of the components on the instrument in terms of the feasibility and ideality of the biology learning module (Formula 1).

$$\text{Score} = \frac{\text{score obtained}}{\text{score max}} x\ 100\% \quad (1)$$

Table 1. Criteria of instrument feasibility

Percentage (%)	Category
81 – 100	Very feasible
61 – 80	Feasible
41 – 60	Quite feasible
21 – 40	Not feasible
<21	Very unworthy

The ideal module adopts the Formula 2 proposed by Widoyoko (2009) and is grouped into intervals regarding the criteria as explained in Table 2.

$$\bar{x} = \frac{\sum x}{n} \quad (2)$$

Note:
$\bar{x}$: average score for each assessment component
∑x: total score for each assessment component
n : number of validators

Table 2. Category of ideality module

Scores	Category
$\bar{x} > 3.4$	Very good
$2.8 < X \leq 3.4$	Good
$2.2 < X \leq 2.8$	Less
$1.6 < X \leq 2.2$	Not good
$\bar{x} \leq 1.6$	Very less

Readability test was carried out by distributing trial instruments to 14 students, to measure whether the instrument was easy to understand or not. The readability test results were analyzed using the following Formula 3 and converted to percentage intervals as follows regarding to Table 3.

$$\% \text{ Problem based learning} = \frac{X}{N} \times 100\% \quad (3)$$

Note:
% Problem based learning : mastery of *Problem Based Learning*
X : total score of students who answered correctly
N : total score

Table 3. Percentage assessment scale

Percentage (%)	Criteria
86 - 100	Very good
76 - 85	Good
60 - 75	Fair
55 - 59	Not good
≤55	Very less

Results and Discussion

Teaching modules in the context of the *Kurikulum Merdeka* are almost the same as learning instructional that are completely designed to carry out learning activities. In teaching modules, learning outcomes (LO) and the flow of learning objectives must be considered (Minarti et al., 2022; Suriswo et al., 2023). Learning outcomes are competencies that students are expected to achieve at the end of the learning phase, while the flow of learning objectives is a series of learning objectives that are arranged systematically and logically in the learning phase by referring to three aspects of competency, i.e. knowledge, skills, and attitudes (Suriswo et al., 2023). Several things need to be considered in preparing teaching modules so that they are effective and follow the educational principles promoted, such as having clear and measurable learning objectives, diverse learning approaches, and active student involvement (Sari et al., 2019; Weinberger & Shonfeld, 2018).

Problem-based teaching modules are important because they can optimize student-centered learning and holistic character development. The development of teaching modules aims to provide teaching tools that can guide teachers in carrying out learning in implementing the *Kurikulum Merdeka*. The following are the stages of developing problem-based learning modules that have been implemented at high school (Phase E). The literature study carried out at the initial stage of this research mapped the learning objectives to be achieved in one phase. Furthermore, we also analyzed the recommended learning models, content mapping, and teaching module components that refer to the implementation of the *Kurikulum Merdeka*. We elaborated the results of our literature study using interviews with related parties to assess how the curriculum was implemented, the learning tools used in teaching and learning activities, and observations of learning in the classroom.

The results of the field study showed that the school still used the 2013 curriculum in learning activities, learning instructional used existing textbooks, learning methods in class were still monotonous including classical lectures and discussions, and students' worksheets were not a problem instead of questions. Students' worksheets are like those in general and less directed at problem-solving, the cognitive level is classified as low (within C1 and C2) according to Bloom Taxonomy (Anderson et al., 2001). Fatmawati et al (2023) state that teachers only gave assignments in textbooks and asked students to carry out these assignments by discussing, apart from that teachers were still unable to make their biology teaching instructional.

The initial design of the problem-based biology module includes the required crucial components. The minimum components in the teaching module are following the learning and assessment guidelines, namely learning objectives, initial and final assessment of learning, learning steps, and learning media. General components contained in teaching modules such as general information, module objectives, usage plans, content, assessment, and references follow the provisions issued by the Ministry of Education and Culture in 2022. Scan the following QR code (Code 1) to access the module before expert validation.

(1)

Furthermore, the initial product design developed was validated by two experts. The first validator, as the assessment expert, assessed that in terms of suitability of content presentation, suitability of learning syntax, suitability of discussion content, and suitability of language it was quite good but needed improvement in several parts. For instance, in the ecosystem module, it is necessary to adjust the image to the problem orientation because it does not match the content of the questions presented. In terms of content suitability, all three need further development, such as adjusting the use of images that are relevant to the context of the problem being studied.

Worksheet feasibility is also an area of improvement that needs attention. Validators suggest that the presentation of video links about biodiversity, viruses, and ecosystem content be replaced by presenting contextual problems and adding narration to strengthen the video context. Furthermore, for instructions on answering questions in the content of the discussion, a space column should be provided to answer questions. The results of module improvements based on expert input can be seen in QR Code (2). Figure 2 shows the results of expert assessments showing that content, learning syntax, worksheets, and language get a score range of 3 to 4 (very good).

(2)

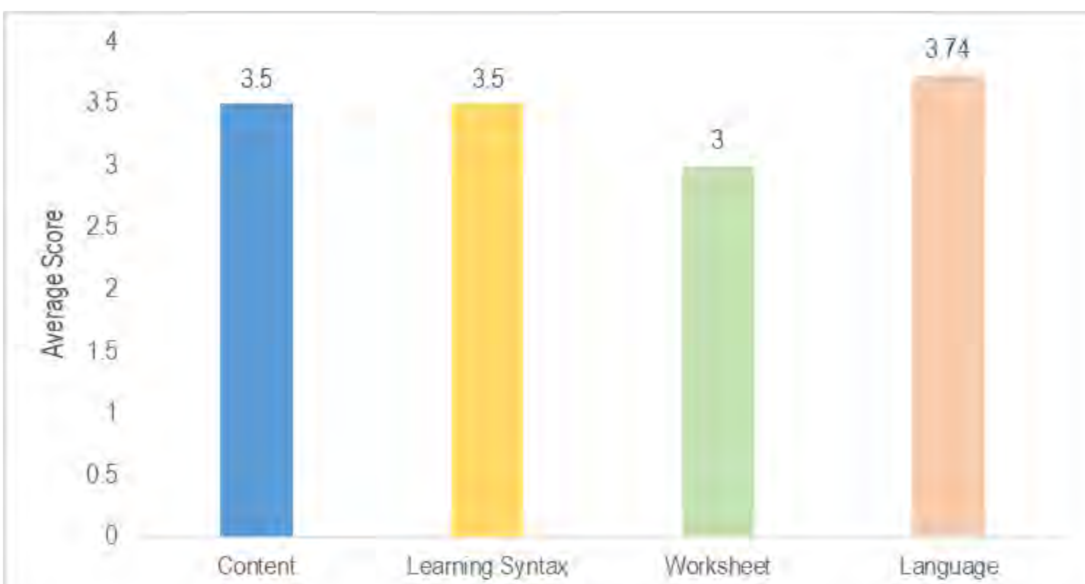

Figure 2. Average value of ideality product

In line with the results of measuring the ideality of the module, feasibility measurements by experts also show a similar trend (Figure 3). Of the four validated variables, three variables received very decent validation (>80%), i.e. content, learning syntax, and language, while the worksheet received low validation (75%). It shows that required to improve and improvise student learning activities in the module to optimize their thinking abilities.

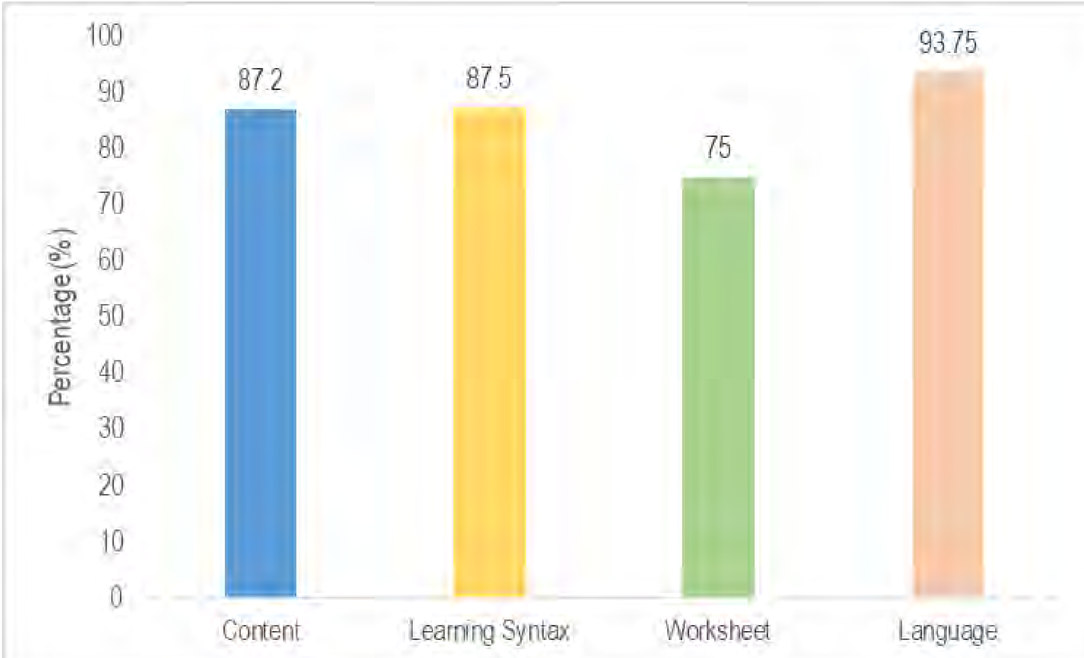

Figure 3. Percentage of product feasibility.

Limited field trials with students provide an overview of the readability of the biology module by users. Readability tests were carried out to determine students' understanding of using the problem-based learning biology module. The test results show that two contents have a good readability level, namely biodiversity and viruses with percentages of 76% and 71% respectively. Meanwhile, ecosystem material only got a 68% readability score. More assessment results are presented in Figure 4.

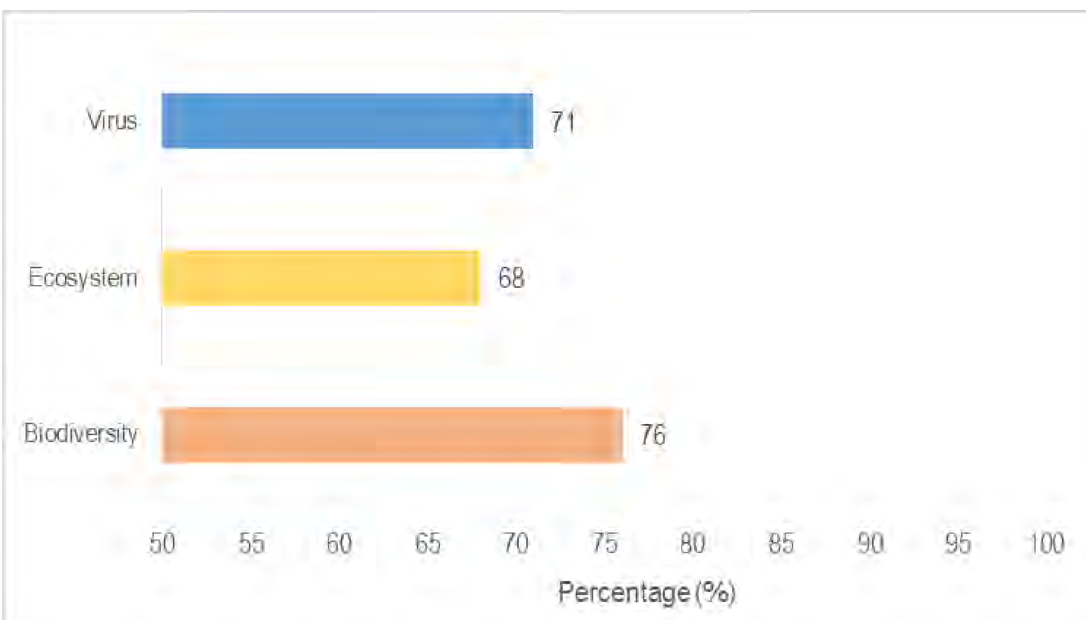

Figure 4. Percentage of student understanding of the content contained in biology module

The characteristics of biology subjects in high school are the study of life phenomena and living things, and the application of phase E content leads to the study of personal, local, and global issues. Furthermore, at the end of phase E, students can create solutions to problems based on local, national, or global issues related to understanding the diversity of living things and their roles, viruses and their roles, biological technological innovation, ecosystem components, and interactions between components and environmental changes. This is following the elements listed in the learning outcomes for biology subjects (Phase E and F) that have been determined by the Educational Standards, Curriculum, and Assessment Agency - Ministry of Education, Culture, Research and Technology of the Republic of Indonesia in 2022.

Teachers, in teaching science concepts, should recognize and map students' ways of thinking to make it easier to design learning plans and the assistance needed to optimize students' learning experiences. In the end, optimal facilitation is expected to increase students' level of knowledge and skills through quality learning.

Science learning emphasizes direct experience to understand the content accurately. That is the spirit and main value of the Kurikulum Merdeka which is implemented in the development of the biology module. Lee and Grapin (2022) explains that in studying science it is highly recommended to link scientific phenomena, understanding, and interpreting data, in the activities of designing and evaluating scientific investigations. OECD (2019),in the PISA report, underlines that studying science is one way to train students' basic skills in solving problems related to critical, logical, and systematic thinking. However, theoretical learning alone is not enough to help students apply it in real life. Several other researchers also stated that science learning is also a space to develop students' potential in making predictions based on data, drawing conclusions, and ultimately creating strategies for solving a problem so that students can be creative productively by involving communicative abilities (Bahtiyar & Can, 2016; Susilo et al., 2019; Vong & Kaewurai, 2017).

Watanabe (2009) states that by training and developing the right skills in terms of observation, reasoning, and analysis, students can become good problem solvers. More than that, to optimize students' mastery of content, optimal strategies are needed and constructivist learning is one approach to support learning activities that can train basic skills, one of which is using problem-based learning. Problem-based learning starts from contextual, challenging, and relevant problems (Balim et al., 2016; Chia & Goh, 2016; Setyawan et al., 2020). Problem-based learning can be interpreted as scenarios of daily life problems that function as a basis for getting students used to solving problems (Braßler, 2016; Groessl & Vandenhouten, 2019; Jamal et al., 2019; Major & Mulvihill, 2018; Nair et al., 2020; Şenyiğit, 2021). It is believed that these learning scenarios with everyday problems will ultimately contribute to students' ability to understand the context of the problem, improve abstract thinking, hone higher thinking skills, and actively participate in problem-solving efforts (Maas et al., 2018; Sung & Black, 2020). Apart from that, problem-based learning is also more effective than non-problem learning (Valdez & Bungihan, 2019).

Problem-based learning activities begin with student orientation toward contextual problems. The relevance of the problem context to reality and everyday life must be the main requirement that teachers need to consider. Therefore, teachers must prepare appropriate learning resources and references for students in searching for and proposing appropriate problem-solving solutions. More than that, the design of learning activities that provide space for collaboration between fellow students is expected to optimize student communication. One of the efforts made is to ensure the heterogeneity of group members to foster personal responsibility within the group.

In practice, problem-based learning involves various types of problems, then groups of students are asked to analyze the problem by including evidence and strong reasons as a basis for solving the problem during the cooperative investigation process in groups (Garmendia et al., 2022; Golightly, 2021; Ørngreen et al., 2021; Suntusia et al., 2019). Furthermore, to improve problem-solving abilities, Kadir et al (2016); Laksmi et al (2021); and Scholkmann et al (2023) suggest that problem-based learning is an effective guide and instructional learning in the classroom and can improve scientific explanation skills.

On the other hand, in implementing teaching modules, teachers can modify teaching modules that have been provided by the government and/or develop their teaching modules according to student characteristics. Teachers in educational units can design learning strategies based on the results of the initial assessment that has been carried out at the beginning so that later there will be differentiated learning. In designing teaching modules, the principles and procedures for developing teaching modules also need to be analyzed so that they are easy to understand and implement collectively. The principles of developing teaching modules include that learning is designed by considering the stage of development of students, the learning process is appropriate to the context, environment, and culture of students, and is oriented toward a sustainable future. Meanwhile, the procedures for developing teaching modules include identifying learning objectives and outcomes, conducting an initial assessment, determining learning assessment techniques and instruments, determining the number of learning hours, and creating learning scenarios.

Conclusion

In implementing a *Kurikulum Merdeka*, problem-based teaching modules are important because they can help optimize learning and holistic character development so that in the end it can be achieved. The research results show that the module developed has important components with an emphasis on selecting contextual problems and student-centered learning design.

With the right teaching modules, students can more actively learn content and develop skills that are relevant to the 21st century, develop students' character, and improve students' cognitive abilities and high-level thinking abilities. From the results of the development of the problem-based biology learning module which has been carried out through a series of research and development stages, it can be stated that the problem-based biology learning module is suitable for use as a reference for teachers in learning in Phase E.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

B. Fatmawati: writing original draft preparation, methodology and analyse data; **M. Marzuki:** editing; **F. Roshayanti:** review paper; and **P. K.** Suprapto; review paper.

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