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# Integrating Problem-Based Learning into E-Modules : A Development Study with Validation and Student Response Analysis

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**Abstract:** This study aims to develop an e-module integrated Problem-Based Learning (PBL), validate the feasibility of the developed e-module, and analyze student responses to its use in learning. The research was conducted at two schools in Riau Province, namely SMA Negeri 2 Siak Hulu and SMA Negeri 3 Siak Hulu, employing the ADDIE development model, which was focused up to the development stage. Validation was carried out by five experts consisting of subject matter, media, and instructional experts. The instruments employed in this study were a validation sheet and a student response questionnaire. Data analysis was conducted by calculating the results of the validation test and the students' responses. The validation results indicated a very high level of validity, with an average score of 97% from media experts, 97% from subject matter experts, and 98% from instructional experts. Furthermore, the student response to the e-module usage yielded an average score of 94%, categorized as very good. This e-module was specifically designed for the cell topic in biology, featuring an interactive interface accessible both offline and online. The integration of the PBL model into the e-module was implemented through stages of problem orientation, learning organization, investigation, product development, and analysis and evaluation. Therefore, this study recommends the use of the e-module integrated PBL as an innovative alternative teaching material to improve student learning outcomes and serve as a reference for technology-based instructional material developers.

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## Introduction

Technology development represents progress and innovation in scientific, technical, and digital fields, transforming how we interact with the world. Technological advancements in the era of globalization have had a profound impact, permeating almost every aspect of life, including politics, economics, culture, the arts, and education (Sancho-Garcia & Ivorra Alemañy, 2022; Sharma, 2023). Education is integral to achieving the Sustainable Development Goals, as it supports other objectives by fostering the skills and knowledge necessary for sustainable development. Both teachers and students must be equipped with meaningful nationalist character values in the learning process as a proactive measure against the strong influence of globalization (Robertson, 2022). Alongside technological advancements, numerous challenges inevitably arise in education (Borenstein & Howard, 2021; Selwyn, 2021).

Challenges in learning refer to factors that may hinder the learning process. By understanding these challenges and developing effective strategies for designing instructional materials, teachers can enhance the quality of education and prepare students to become independent, creative, and problem-solving-oriented learners (Asmida et al., 2024). Additionally, teachers must be able to select appropriate teaching methods or models that

align with students' needs (Joyce & Calhoun, 2024). One interactive learning model that fosters active student participation is Problem-Based Learning (PBL), which encourages critical thinking and problem-solving skills (Lee, 2025).

The Problem-Based Learning (PBL) concept is a teaching approach that utilizes real-world problems as a context for students to develop critical thinking and problem-analysis skills while acquiring essential knowledge and concepts from the subject matter (Anggraeni et al., 2023; Yu et al., 2015). Integrating Problem-Based Learning (PBL) into education can be applied across all levels of study. Implementing PBL-based e-modules in learning encourages students to actively engage in group discussions to find solutions to given problems, thereby enhancing their critical thinking skills (Shimizu et al., 2019). PBL fosters active student participation and collaboration**,** which is further strengthened when combined with digital tools (Wang, 2023).

The advantages of using e-modules include enhancing student motivation, providing evaluation mechanisms that allow teachers and students to identify areas of mastery and those requiring improvement. Additionally, e-modules are structured according to academic levels, offering a more interactive and dynamic learning experience than traditional printed modules, which tend to be more static (Lubis et al., 2023). However, e-modules also have limitations**,** such as inadequate learning devices for accessing them and rigid or monotonous designs, which may fail to capture students' interest. Therefore, further development of e-modules is necessary to validate both their advantages and limitations (Prabu Kumar et al., 2023).

The development of e-modules aligns with the challenges of the disruption era, ensuring that the modules created can be effectively utilized in the learning process (Sidiq & Najuah, 2020). Technology integration can significantly enhance student engagement and motivation by providing interactive and immersive learning experiences. Similarly, digital tools in language learning promote active participation and help reduce students' speaking anxiety (Bhatia & Hesse, 2023). The development of e-modules involves designing, creating, and structuring interactive digital learning materials. To prevent student fatigue and disengagement, these modules are integrated into electronic formats (Khomaria & Puspasari, 2022). The e-module development process also includes validation stages to ensure the production of high-quality learning materials.

The validation of teaching materials is crucial to ensure their effectiveness, reliability, and suitability for educational purposes. A gap in the existing research lies in the insufficient implementation of comprehensive validation processes for instructional materials, resulting in many learning materials that have not been tested for their validity or alignment with educational goals. The validation of PBL-based e-modules is a critical stage in the development process, carried out by validators to assess whether the designed module is suitable for use as a learning tool (Aisyah & Suryana, 2023)After the validation process, the next step in e-module development is to assess student responses to its implementation.

Student response refers to students' impressions or reactions after experiencing sensory activities, which shape either a positive or negative attitude. Student responses to e-modules include ease of use, active engagement, content clarity, alignment with learning needs, satisfaction, motivation, and impact on learning outcomes (Mardianto et al., 2022). In the learning process, student responses can indicate the effectiveness of the developed e-module. Additionally, student-generated instructional materials, where students create learning objects for their peers, promote independence, self-reliance, and a deeper understanding of the content. This approach fosters a sense of ownership and empowerment among students (Grieger & Leontyev, 2020).

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Referring to the background description, this study aims to develop an e-module that integrates the PBL model, validate the developed e-module, and analyze students' responses to its use in the learning process. The expected outcome of this research is the creation of a practical and interactive PBL-based e-module that enhances student engagement in learning and contributes to developing more innovative teaching methods that align with students' needs in the digital era. Additionally, the findings of this study are expected to provide valuable insights for educators and instructional developers in designing more engaging and technology-driven learning materials relevant to the evolving educational landscape.

## Research Method

This study was conducted at two schools, namely SMA Negeri 2 Siak Hulu and SMA Negeri 3 Siak Hulu, Kampar, Riau Province. The selection of this location takes into considers the variation in learning environments to obtain more representative data. Additionally, accessibility and collaboration with the school administration facilitated the smooth execution of the study, while the relevance of the issues in both schools ensures that the findings can make a significant contribution to the development of teaching and learning. The research employed a development approach based on the ADDIE (Analyze, Design, Development, Implementation, Evaluation) model. However, this study was conducted only up to the Development stage due to financial and human resource constraints.

The data collection technique used in this study involved validation sheets and student response questionnaires. The expert validation sheet was provided to five experts: one subject matter expert, one media expert, and three instructional experts, including one lecturer and two biology teachers. The subject matter expert validation sheet includes two assessment aspects: content feasibility and learning model. The media expert validation sheet consists of two assessment aspects, namely visual design, and programming, each with different indicators. The learning expert validation sheet consists of three assessment aspects with different indicators: visual structure, learning model, language, and readability (Saputri et al., 2023). Furthermore, the student response questionnaire also includes several assessment aspects regarding using the developed e-module. This evaluation covers aspects ranging from visual design to the presented content (Cahaya et al., 2024).

Data analysis techniques refer to methods used to analyze data obtained from data collection instruments after these instruments have been tested. The data analysis technique employed in this study involves calculating the results of the administered questionnaire. Subject matter, media, and learning experts conduct the validation assessment rubric. The formula for analyzing the level of validity descriptively, based on (Saputri et al., 2023), is as follows:

$$V = \frac{Tse}{Tsh} \times 100$$

**Description**
V : Validity
Tse : Total Validity Score from Validators
Tsh : Maximum Expected Total Score

After obtaining results from the validators, the overall conclusions can be adjusted according to validity criteria, each of which ranges from "Not Valid" to "Highly Valid." The validity criteria are as follows: (1) A range of $0\% < V \leq 20\%$ is categorized as Not Valid; (2) A range of $20\% < V \leq 40\%$ is categorized as Less Valid; (3) A range of $40\% < V \leq 60\%$ is categorized as Fairly Valid; (4) A range of $60\% < V \leq 80\%$ is categorized as Valid; and (5) A range of $80\% < V \leq 100\%$ is categorized as Highly Valid. Meanwhile, for the response analysis, the percentage calculation of statements is conducted using a formula proposed by Rahman et al. (2022), which has been modified by the researcher as follows:

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$$P = (\Sigma R)/n \times 100\%$$

**Description**

P : Percentage of Respondents
∑R : Total score of respondents' answers
N : Total ideal score for a single criterion item

The same procedure was applied in the response test, where the data were analyzed, and conclusions were drawn based on the predetermined response criteria. The student response criteria encompass a range of classifications, varying from "Poor" to "Very Good."

## Results and Discussion

This study resulted in the development of an e-modul integrated PBL designed explicitly for the topic of Cells. The research employed the ADDIE development model up to the development stage, where each phase plays a crucial role in ensuring the quality of the e-module. During the analysis stage, a literature review and field study were conducted to identify issues through observations and interviews with teachers and students. The findings revealed that teachers had never used or developed e-modules as teaching materials, and students still relied on printed textbooks based on the revised curriculum edition, with a limited number of copies available (Figure 2).

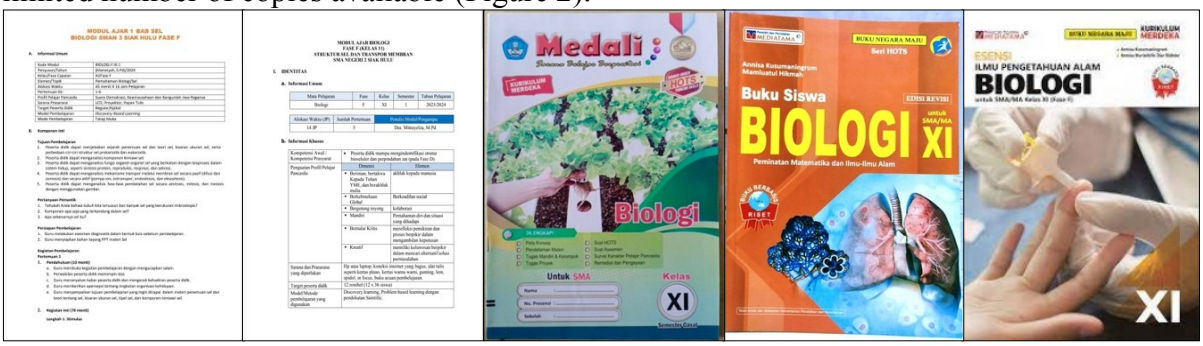


**Figure 1. Example of the Use of Teaching Modules and Books by Schools**

We also conducted a field study during this initial stage to analyze the curriculum, needs, learning materials, and students. The findings from the field study were as follows: (1) The implemented curriculum follows the Merdeka curriculum; (2) Both students and teachers require comprehensive, efficient teaching materials that can also be used for independent learning at home; (3) The most challenging topic identified was Cell Biology; (4) Observations during classroom learning showed that students were highly enthusiastic and cooperative despite the limitations in teaching materials. Students demonstrated strong learning enthusiasm in class, likely due to their intrinsic motivation. Intrinsic motivation is an internal state that drives individuals to engage in activities for their own sake, leading to self-satisfaction without external rewards (Szulc-Kurpaska, 2023; Vilca & Yucra, 2025). It plays a crucial role in enhancing students' engagement, perseverance, and deeper information processing, ultimately leading to more effective learning (Szulc-Kurpaska, 2023; Vilca & Yucra, 2025)

The second stage, namely the design phase, involved using the Canva application to create the visual layout of the e-module. The selected fonts included Abundant Harvest, Aeroflame, Baloo Thambi, Cooper BT, Glacial Indifference, Amber Kai, and Times New Roman. The PBL-integrated e-module was designed with an appropriate and non-distracting color combination, primarily featuring a deep-sea blue theme harmonized with complementary shades. The font sizes varied between 15 and 30 (Canva units), ensuring readability. The final e-module can be accessed by students and teachers on smartphones and desktops in an offline PDF format. At the same time, the online version is available as a

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flipbook using Flip PDF Professional software, accessible through a dedicated website. The e-module design at this stage is presented in Figure 3.

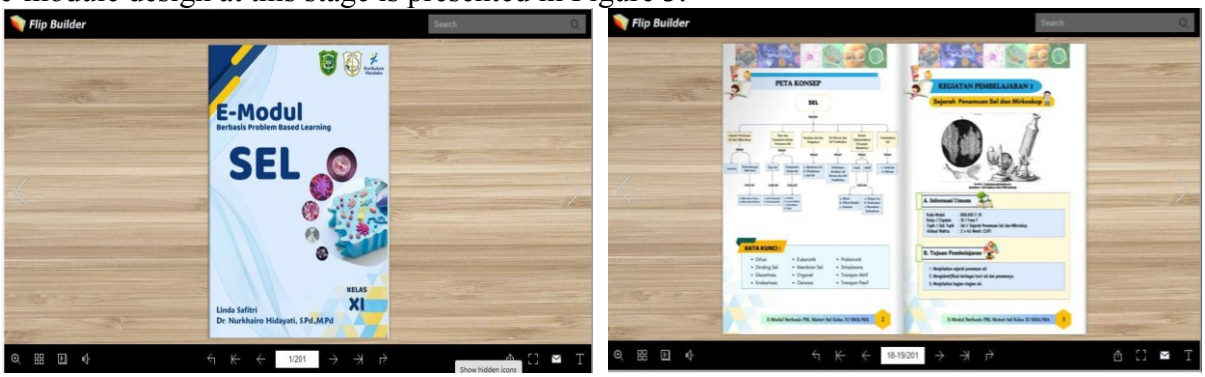


**Figure 2. E-Module Display in Flip PDF Professional Software**

The components included in the e-module align with the predetermined framework, consisting of the cover, table of contents, preface, learning objectives, Pancasila Student Profile, material explanations, learning activities structured according to the PBL model syntax, reflection, evaluation with answer keys, self-assessment, glossary, and a bibliography. This PBL-integrated e-module is designed in Indonesian, and its content is structured by the current Merdeka curriculum. The developed e-module product is presented in Figure 4.

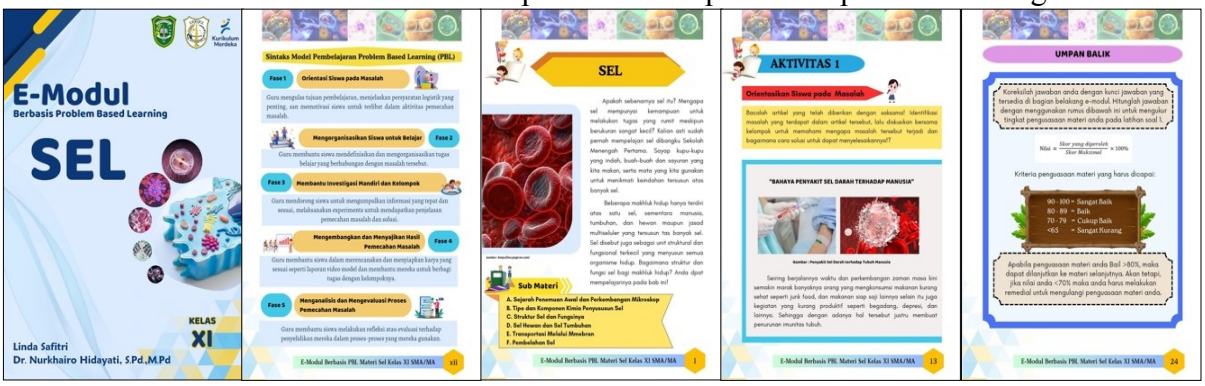


**Figure 3. Display of Several E-Module Layouts**

At the development stage, the researchers integrated the PBL model into the e-module, ensuring that the PBL syntax was embedded within its structure. The e-module was systematically designed for each session, aligning with the teaching module, learning objectives, and expected learning outcomes. Several studies have concluded that increasing students' learning interests can be achieved through the use of innovative, varied, engaging, contextual teaching materials and learning models that align with students' needs (Fahmi et al., 2021; Rahim et al., 2022). Using hands-on learning modules that students find meaningful and useful can trigger and sustain situational interest. Therefore, the designed e-module, which aligns with the teacher's teaching module and subtopics on cells, is more accessible and practical for both teachers and students.

The integration of PBL into the e-module is reflected in each activity presented within the module (Figure 5). The initial stage of PBL is problem orientation. This stage aims to stimulate curiosity, enhance motivation, and encourage students to identify and analyze problems. By providing structured guidance, fostering a mastery-approach orientation, and integrating collaborative, educators can enhance the effectiveness of PBL and support student success in problem-solving tasks (Chung, 2019; Nitisiri et al., 2023). The display of the e-module in the organizing student phase of the syntax illustrates the step where the teacher provides instructions or guidance for group formation, allowing students to work either

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individually or collaboratively. In this phase, students are tasked with understanding and analyzing the problem presented in the "problem orientation" phase of the syntax, followed by formulating the problem based on their analysis. The objective is to enable students to collaborate effectively, share responsibilities, and design systematic strategies to solve the problem independently and critically.

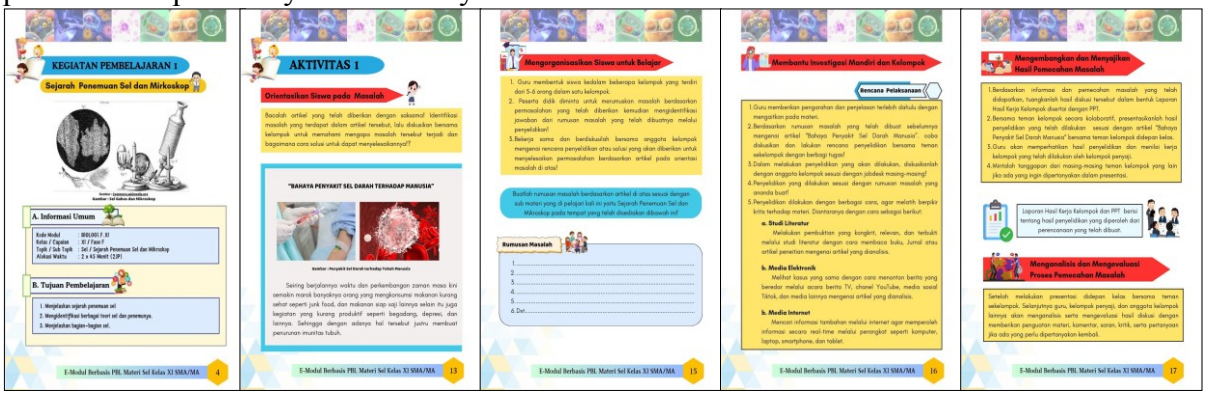


**Figure 4. Display of the PBL-Integrated E-Module**

The next syntax of supporting independent and group investigations. This stage aims to collect relevant data and information to solve the identified problems, with students taking an active role in determining the problem statement. At this stage, students are encouraged to design systematic problem-solving strategies. This aligns with the findings of (Dualom, 2021), who stated that planning and conducting investigations require reliable reference sources supporting group inquiries' success. The appearance of the e-module in the syntax of developing and presenting work results reflects the investigative process that has been conducted, with the results documented in group work reports and presented. The e-module not only hones critical and collaborative thinking skills but also deepens students' understanding through evaluation and collective reflection (Kamaluddin et al., 2024)

The last syntax is *analyzing and evaluating* which reflects the final stage of the inquiry process, where students assess and reflect on the results they have obtained. The instructions guide them in evaluating the investigative process while fostering discussions and feedback between teachers and students. This interaction not only enhances classroom engagement but also strengthens students' understanding and involvement in the learning process. Evaluating and reflecting at the end of a learning process are crucial for improving teaching and learning outcomes. Reflection has been shown to positively impact academic performance, as prompting students to reflect can lead to deeper engagement and enhanced performance in writing and other academic tasks (Mills et al., 2020).

The developed PBL-integrated e-module was further evaluated through validity testing and response analysis. Expert validation ensured the appropriateness of the content, design, and PBL syntax, while the response test assessed the e-module's comprehensibility and usability for students. The results of the validation conducted by media experts are presented in Table 1.

**Table 1. Media Expert Validation Results**

| No | Aspects | Validity Results (%) | Description |
|---|---|---|---|
| 1 | Cover Design | 100 | Highly Valid |
| 2 | Text Readability | 100 | Highly Valid |
| 3 | Attractiveness | 100 | Highly Valid |
| 4 | Clarity | 100 | Highly Valid |
| 5 | Interactivity | 100 | Highly Valid |
| 6 | Maintainability | 100 | Highly Valid |

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| | | | |
|---|---|---|---|
| 7 | Usability | 100 | Highly Valid |
| 8 | Compatibility | 100 | Highly Valid |
| 9 | Reusability | 75 | Valid |
| **Average (%)** | | **97** | **Highly Valid** |

Based on Table 1, the media expert validation results indicate that the e-module demonstrates high quality, with an average validity score of 97%, categorized as highly valid. All key aspects, including cover design, text readability, attractiveness, text clarity, interactivity, maintainability, usability, and compatibility, received a perfect score of 100%. However, the reusability aspect scored 75%, indicating certain limitations in the e-module, particularly in its inability to be edited once published or used by teachers and students in the learning process. Overall, the developed e-module is engaging and interactive, as evidenced by the 97% average validation score from media experts, confirming its effectiveness as an interactive teaching material**.** This finding aligns with the statement by (Elsoraya & Yerimadesi,2022), which emphasizes that students' interest in engaging learning materials serves as a benchmark for the success of the learning process. Engaged students are more likely to participate actively, invest effort, and persevere through challenges, leading to better academic outcomes (Bai et al., 2023; Hirsch et al., 2018).

The validation test by subject matter experts is also a crucial aspect of the development of the PBL-integrated e-module, as it addresses students' needs in understanding the subject matter, particularly the cell topic. The results of the subject matter expert validation can be seen in Table 2.

**Table 2. Results of Subject Matter Expert Validation**

| No | Aspects | Validation I (%) | Description (%) | Validation II (%) | Description (%) |
|---|---|---|---|---|---|
| 1 | Coherence | 100 | Higly Valid | 100 | Highly Valid |
| 2 | Complexity of Material | 75 | Valid | 100 | Highly Valid |
| 3 | Relevance | 100 | Higly Valid | 100 | Highly Valid |
| 4 | Relevance of Material to the PBL | 100 | Higly Valid | 100 | Highly Valid |
| **Average** | | **97 (Higly Valid)** | | | |

Table 2 illustrates that the validation process was conducted twice to refine the content of the e-module. In the first validation process, the subject matter expert assessed aspects such as coherence, content relevance, and alignment with the PBL model, all of which were deemed complete and highly appropriate (100%). The depth of the material received a score of 75% (Valid) but was considered less complex. Although the module was deemed suitable for use, the validator recommended adding more content to enrich students' knowledge and enhance the overall quality of the e-module. Multiple validation tests were carried out to ensure that the developed e-module met the required standards of quality. This aligns with the statement by (Waruwu, 2024) that a product is considered valid if it meets the validation criteria through a structured assessment instrument. After revisions, the final average score reached 97%, categorizing it as highly valid. Validation helps in assessing the quality of educational products, such as modules and multimedia tools, ensuring they are practical and effective for student use (Bayu & Fauzan, 2023; Pilendia & Amalia, 2020).

Validation was also conducted by learning experts, serving as a crucial step in ensuring that the e-module is not only of high quality but also effectively integrates PBL. This aligns with the findings of (Meldrawati et al., 2021), who stated that the validity of an e-module's feasibility, as assessed by multiple experts, is determined by its compliance with specific criteria. By focusing on its usability in the learning process, this validation ensures that the PBL strategy is optimally implemented, enabling the e-module to support a more

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interactive and meaningful learning experience. The results of the learning expert validation are presented in Table 3.

**Table 3. Results of Learning Expert Validation**

| No. | Aspects | Validator 1 (%) | Validator 2 (%) | Validator 3 (%) | Description |
|---|---|---|---|---|---|
| 1 | Display | 100 | 100 | 100 | Higly Valid |
| 2 | Clarity of Objectives | 100 | 100 | 100 | Higly Valid |
| 3 | Relevance of Objectives | 100 | 100 | 100 | Higly Valid |
| 4 | Content Appropriateness | 100 | 100 | 100 | Higly Valid |
| 5 | Alignment with PBL Syntax 1 | 75 | 100 | 100 | Higly Valid |
| 6 | Alignment with PBL Syntax 2 | 100 | 100 | 100 | Higly Valid |
| 7 | Alignment with PBL Syntax 3 | 100 | 100 | 100 | Higly Valid |
| 8 | Alignment with PBL Syntax 4 | 100 | 75 | 100 | Higly Valid |
| 9 | Alignment with PBL Syntax 5 | 100 | 100 | 100 | Higly Valid |
| 10 | Systematic Logical Flow | 100 | 100 | 100 | Higly Valid |
| 11 | Language | 75 | 100 | 100 | Higly Valid |
| 12 | Readability | 100 | 100 | 100 | Higly Valid |
| 13 | Comprehensibility | 100 | 100 | 100 | Higly Valid |
| **Average (%)** | | **98 (Higly Valid)** | | | |

Referring to Table 3, the three validators provided highly positive evaluations, with an average score of 98%, indicating that the e-module is considered highly valid from a learning perspective. In terms of appearance, clarity and relevance of objectives, content suitability, and logical flow, the e-module received a perfect score (100%) from all validators, demonstrating that its design and content meet optimal quality standards. Similarly, in the linguistic aspect, while one validator assigned a score of 75%, indicating a slight variation in assessment, the overall evaluation remains within the highly valid category.The integration of the PBL model into the e-module by presenting problems that are relevant and closely related to students' daily lives can enhance their ability to think objectively and rationally. This aligns with the view of Babo et al., (2024), who stated that the goal of PBL is to improve students' transferable skills, including communication, collaboration, critical thinking, and self-directed learning. Since the validation results from learning experts have confirmed its validity, this supports the statement by Fitria et al., (2024), which discusses the development of e-modules integrating the PBL model, emphasizing that such materials are suitable for use once they meet the required assessment criteria. In addition to conducting validation with experts, we also gathered student responses after using the PBL-integrated e-module. In practice, students accessed the developed e-module using their smartphones (Figure 6).

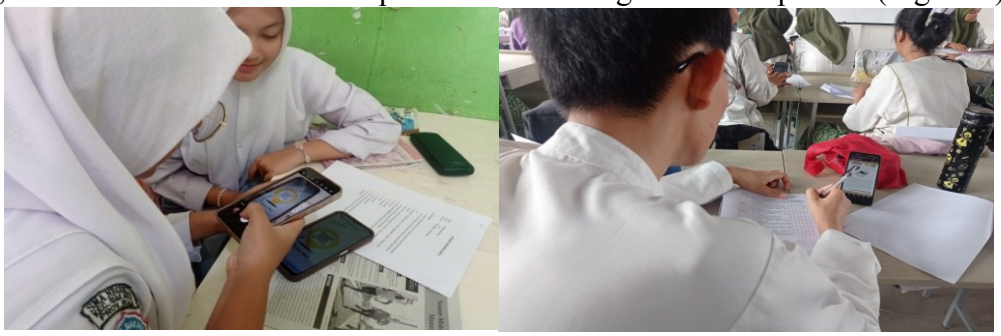

**Figure 5. Student Use of the E-Module**

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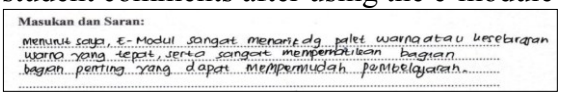
After reading the e-module, we asked students to complete a questionnaire. The processed results of the questionnaire filled out by students after using the e-module can be seen in Table 4.

**Table 4. Student Response Test Result**

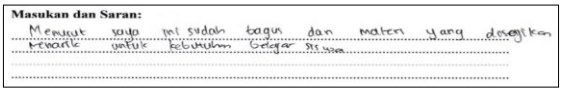
| No | Aspect | Test Result Response (%) | Deescription |
|---|---|---|---|
| 1 | Display Design | 93 | Verry Good |
| 2 | Text Readability | 93 | Verry Good |
| 3 | Image Display Clarity | 92 | Verry Good |
| 4 | Font Usage | 94 | Verry Good |
| 5 | Language Usage | 94 | Verry Good |
| 6 | Coherence | 95 | Verry Good |
| 7 | Material Presentation | 96 | Verry Good |
| 8 | Motivation | 93 | Verry Good |
| 9 | Suitability with PBL Learning Model | 94 | Verry Good |
| **Average (%)** | | **94** | **Verry Good** |

Table 4 provides information regarding students' responses after experiencing the use of the developed e-module. The average student response test result was 94%, indicating that students provided a very positive response. This is evidenced by the high scores in each aspect, reflecting the success of designing an effective and engaging e-module. Furthermore, the average results demonstrate that this e-module is highly appealing, particularly in terms of layout design, background, paragraph structuring, image selection, the inclusion of barcodes, and its availability in both PDF format and Flip PDF Professional, allowing pages to be flipped interactively. These features enhance students' usability, making the e-module more interactive and user-friendly. Additionally, careful selection of colors and design elements was considered to motivate students and increase their interest in learning.

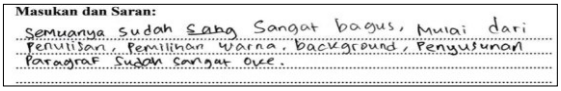
Furthermore, the developed e-module aligns with students' needs, particularly in addressing topics that are perceived as difficult to understand, such as cell material. Some student comments after using the e-module are presented in Figure 7.




In my opinion, the e-module is very interesting with the right color palette or color harmony, and really




I think this is good and desirable material. Interesting for students' learning needs.




Everything is very good, starting from the writing, choosing colors, background, paragraph arrangement


This module is easy to understand and interesting. And also very helpful in learning

**Figure 7. Excerpt of Comments and Suggestions from Student**

The students' comments reflect positive responses toward the developed e-module, encompassing aspects such as design, content, and its alignment with the Problem-Based Learning (PBL) model. Regarding design, Mocanu et al.,(2024) state that an engaging layout in module development can enhance students' interest. Furthermore, an e-module is a form of self-learning material systematically structured into the smallest learning units to achieve specific learning objectives and presented in an electronic format (Manalastas & De Leon,

2021). The inclusion of barcodes in the e-module can further support students' skills in achieving digital competence (Pratiwi & Indana, 2022).

Independent learning activities, whether at school or at home, require instructional materials that can effectively capture students' interest (Manalastas & De Leon, 2021). Teaching using e-modules has proven to be more effective, as teachers can facilitate multiple discussion groups with students supported by the e-modules (Rukmana et al., 2024). Consequently, the integration of the PBL-based e-module in each session not only benefits students but also simplifies the teaching process for educators (Lastri, 2023). The use of e-modules gradually familiarizes both students and teachers with technology in the learning process. This not only enhances learning effectiveness but also helps them adapt to the rapid technological advancements in today's digital era.

The findings of this study have both conceptual and practical implications for teaching and learning. Conceptually, the PBL-based e-module supports constructivist theory by encouraging active student engagement through exploration and problem-solving. Practically, the use of the e-module, as demonstrated in the photographic documentation, highlights its ease of access, interactivity, and enhanced student engagement. Furthermore, this e-module assists teachers in presenting material in a more systematic and engaging manner, thereby improving the effectiveness of classroom instruction.

## Conclusion

This study has successfully developed an e-module integrated PBL on cell material that has gone through a validation process by media, material, and learning experts. The validation results showed a very high level of feasibility with an average score of 97% from media experts, 97% from material experts, and 98% from learning experts. In addition, the student response test showed a very good level of satisfaction with an average score of 94%, which reflects the ease of use, clarity of the material, and the attractiveness of the e-module display. The integration of the PBL model in this e-module is applied through the stages of problem orientation, organizing learning, investigation, product development, and analysis and evaluation, which effectively encourage active student involvement in learning.

## Recommendation

This study recommends the use of e-module integrated PBL for teachers to enhance student engagement in the learning process. The optimization of e-modules should also be aligned with appropriate instructional strategies. For future researchers, further studies are needed to assess their effectiveness in various contexts and to develop more innovative technological features to improve the quality of digital learning. Additionally, this e-module can also be developed for other subjects.

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