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Development of Case Based Learning Based E-Modules For Improving Junior High School Science Problem-Solving Skills

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Abstract

The 21st century requires students to have problem-solving skills as the ability to solve problems from previous activities to obtain new, more meaningful knowledge. PISA results in 2022 show Indonesia's science skills are low, especially in solving problems. The low problem solving ability is also experienced by SMPN 3 Mertoyudan students as evidenced by the analysis of ASAS 2023 results and interview results. The purpose of the research is to develop Case Based Learning-based e-modules that are valid, effective and practical to improve the KPM of junior high school students. This research method uses the Research and Development method with the ADDIE development model. The results of the research on the validity of the e-module showed an average assessment of 4.43 very valid with a feasibility percentage of 88.5% in the very feasible category. The effectiveness of e-modules based on the results of the t-test obtained sig 0.000, namely there is a significant difference and the magnitude of the increase in pretest and posttest results is high with a value of 0.70 in the N-Gain test. The practicality of e-modules is in the feasible category with a percentage of 81%. The conclusion of this study is that e-modules based on Case Based Learning are valid, effective and practical in improving problem solving skills. Suggestions from this study are expected to develop better e-modules with more complete, detailed material and clarity of instructions on e-modules.

Keywords: *E-module, Case Based Learning, Problem Solving*

Pengembangan E-Modul Berbasis *Case Based Learning* untuk Meningkatkan Kemampuan Pemecahan Masalah IPA Tingkat SMP

Abstrak

Abad-21 menuntut peserta didik untuk memiliki kemampuan pemecahan masalah sebagai kemampuan untuk menyelesaikan permasalahan dari kegiatan sebelumnya untuk memperoleh pengetahuan baru yang lebih bermakna. Hasil PISA tahun 2022 menunjukkan kemampuan sains Indonesia rendah terutama dalam memecahkan masalah. Rendahnya kemampuan pemecahan masalah juga dialami oleh peserta didik SMP yang dibuktikan berdasarkan analisis hasil ASAS 2023 dan hasil wawancara. Tujuan penelitian yaitu untuk mengembangkan e-modul berbasis *Case Based Learning* yang valid, efektif dan praktis untuk meningkatkan KPM peserta didik SMP. Metode penelitian ini menggunakan metode *Research and Development* dengan model pengembangan ADDIE. Hasil penelitian pada kevalidan e-modul menunjukkan rata-rata penilaian 4,43 sangat valid dengan persentase

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kelayakan 88,5% pada kategori sangat layak. Kefektifan e-modul berdasarkan hasil uji *t-test* memperoleh sig 0.000 yaitu terdapat perbedaan yang signifikan dan besar peningkatan hasil *pretest* dan *posttest* tinggi dengan nilai 0,70 pada uji N-Gain. Kepraktisan e-modul dalam kategori layak dengan persentase 81%. Kesimpulan dari penelitian ini yaitu e-modul berbasis *Case Based Learning* valid, efektif dan praktis dalam meningkatkan kemampuan pemecahan masalah. Saran dari penelitian ini diharapkan adanya pengembangan e-modul yang lebih baik lagi dengan materi yang lebih lengkap, terperinci serta kejelasan intruksi pada e-modul.

Kata kunci: *E-modul, Case Base Learning, Pemecahan Masalah*

INTRODUCTION

The 21st century is marked by rapid advancements in science and technology, requiring students to continuously adapt and respond to emerging developments (Junedi et al., 2020). Mastery of 21st-century skills—including innovation, creativity, collaboration, communication, critical thinking, and problem-solving—is essential for preparing students to face global challenges. Among these, problem-solving skills (KPM) represent a core competency, defined as the ability to apply prior knowledge and experience to resolve new situations (Dewi et al., 2020). Such skills foster creativity, critical analysis, and independent learning (Nurfatah et al., 2018).

However, international assessments reveal that Indonesian students' scientific problem-solving abilities remain relatively low. Results from the 2022 Programme for International Student Assessment (PISA) show that Indonesia ranked 67th out of 81 participating countries, with a science score of 383(OECD, 2023). Similarly, findings from TIMSS indicate weaknesses in students' creative and analytical thinking skills (Irmita, 2018). Only 34% of Indonesian students reached level 2 proficiency in science far below the OECD average of 76% suggesting that while students can recognize familiar scientific phenomena, they struggle with higher-order problem-solving tasks (OECD, 2023).

Observations conducted during the School Field Introduction II (PLP II) program at SMP Negeri 3 Mertoyudan revealed similar challenges. When given problem-solving questions, many students were confused, unable to identify key issues, and struggled to generate appropriate solutions. The 2023 Odd Semester Summative Assessment (ASAS) results also confirmed that student performance on problem-solving indicators, based on

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Polya's (2014) framework, remained below 50%. Interviews with science teachers further indicated that classroom instruction predominantly relied on textbooks and traditional teacher-centered methods, which limited student engagement and motivation. According to (Wulandari et al., 2020), the absence of real-world contextualization in learning activities inhibits students' ability to practice and develop problem-solving skills.

This condition highlights the need for improvement. Rohmah and Sutiarso (2018) argue that monotonous and unvaried teaching approaches contribute to student boredom and fail to nurture their reasoning skills. To address this, appropriate instructional materials that cater to students' characteristics and learning needs are necessary (Ulvah & Afriansyah, 2016). One effective solution is the use of electronic modules (e-modules) systematically designed digital learning materials presented in simple, accessible language (Ningtyas et al., 2019). According to Munir (2013), e-modules can foster a more engaging learning atmosphere and enhance student motivation. At SMP Negeri 3 Mertoyudan, e-modules have not yet been utilized as instructional resources, and students have not received sufficient training in problem-solving skills. Therefore, this study proposes the development of a Case-Based Learning (CBL)-based e-module as an innovative teaching material. CBL is a learning model that engages students in solving real-world cases, enabling them to think critically, explore multiple solutions, and construct deeper conceptual understanding (Arianto & Fauziah, 2020; Syarafina et al., 2017).

The novelty of this research lies in integrating e-module development with the CBL approach to enhance junior high school students' scientific problem-solving abilities. While previous studies have explored the use of e-modules in improving learning outcomes and motivation, few have combined them with CBL, which emphasizes contextual learning, critical thinking, and higher-order problem-solving. Thus, this study aims to contribute a new pedagogical innovation in digital science education—developing e-modules that are not only engaging and accessible but also capable of systematically cultivating students' problem-solving competence through real-world cases (Nazara et al., 2022). Developed an electronic module based on Problem-Based Learning for the human circulatory system concept; however, their study primarily emphasized students' responses and interests rather than their problem-solving abilities (Waluya &

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Sukestiyarno, 2025).

Implemented a Case-Based Learning model to improve science process skills and information technology abilities in ecosystem topics, yet this research did not combine CBL with the development of an interactive digital e-module that is accessible and practical for classroom use. In addition, (Winangun et al., 2024). Designed a case-based e-module grounded in local wisdom for basic science concepts. Although innovative, the study mainly focused on conceptual understanding and cultural context rather than strengthening scientific problem-solving competencies. Furthermore, (Patunah & Herman, 2025) and (Son & Fatimah, 2020) demonstrated that problem-based learning models could enhance mathematical communication and problem-solving skills; however, they did not explore the application of similar strategies within the context of junior high school science learning in a contextual and applied manner. From these findings, it is evident that most prior research primarily focused on evaluating the effectiveness of learning models or students' motivation, with limited attention to the integration of digital e-module development with the CBL approach designed to train higher-order thinking skills (HOTS) and scientific problem-solving abilities in junior high school students. Therefore, this study aims to fill the identified research gap by developing a Case-Based Learning (CBL)-based e-module that is not only visually appealing and interactive but also validated, effective, and practical in enhancing students' problem-solving skills in science learning. This approach is expected to provide a new innovation in the development of digital learning materials that are contextual, engaging, and aligned with the demands of 21st-century skills.

RESEARCH METHODS

The research design used is the research and development method which is often referred to as Research and Development (R&D) with the ADDIE model. The ADDIE development model was chosen because it has simple, structured, systematic and easy-to-implement development stages. The stages of ADDIE model development research consist of 5 stages including: analysis, design, development, implementation and evaluations (Mulyatiningsih, 2019).

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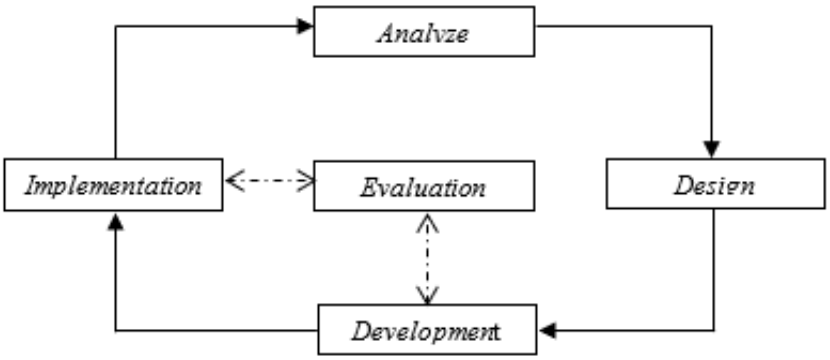

Figure 1**.** ADDIE Development Model Scheme

The development process of the e-module followed the ADDIE model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The analysis stage involved examining the curriculum, identifying students' characteristics, assessing learning needs, and reviewing relevant literature to ensure that the e-module aligns with the educational context and learning objectives. The design stage focused on preparing the e-module framework, drafting the teaching module, and constructing research instruments such as validation sheets and questionnaires.

In the development stage, the e-module was created using digital tools Canva and Book Creator to enhance its visual appeal and interactivity. The implementation stage followed, during which the developed e-module was tested on Grade VII students at SMP Negeri 3 Mertoyudan. The evaluation stage occurred at multiple points of the ADDIE process, particularly during the development and implementation phases, while the analysis and design stages did not include formal evaluation. The study's data sources consisted of interviews, expert validation assessments (from teachers and lecturers), pre-test and post-test results, and student response questionnaires measuring the practicality of the e-module. The research participants included 32 students from Class VII B of SMP Negeri 3 Mertoyudan as product trial subjects, and expert validators who assessed the validity and feasibility of the developed e-module.

The research instruments consisted of (1) validation questionnaires to determine the e-module's validity using expert evaluation sheets, (2) pre-test and post-test questions designed in accordance with Polya's (2014) problem-solving indicators to measure effectiveness, and (3) student response questionnaires to assess the e-module's practicality. For data analysis, both qualitative and quantitative descriptive methods were

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employed. Qualitative data included expert feedback, comments, and suggestions for improvement, while quantitative data were analyzed statistically to determine the module's validity, practicality, and effectiveness. The validity analysis was conducted by expert validators using a 5-point Likert scale, and the average score for each criterion was computed to determine the e-module's level of feasibility.

$$\bar{X} = \frac{\Sigma X}{n}$$

The analysis stage of the effectiveness of e-modules in improving students' KPM is based on the *pretest* and *posttest values* where the question instruments have been tested for normality and reliability first. To determine the effectiveness of e-modules in improving KPM, it is proven by the T test and the N-Gain test. The N-Gain test is calculated using the formula $\text{g} = \frac{\text{postest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$. The T test criteria are There is a difference in students' problem-solving abilities if the sig value $< 0{,}05$ with the N-Gain category can be seen in Table 3.

Table 1. N-Gain Value Categories

Interpertation	Normalized Gain Category
Tall	$0{,}70 \leq g \leq 1{,}00$
Currently	$0{,}30 \leq g < 0{,}70$
Low	$0{,}00 < g < 0{,}30$
There was no increase	$g = 0{,}00$

Analysis of the practicality of the e-module based on the questionnaire responses filled out by students using the Likert scale guidelines. The final percentage obtained was calculated using the formula:

$$\text{final percentage} = \frac{\text{total score obtained}}{\text{maximum score}} \text{ x } 100\%.$$

RESULT AND DISCUSSION

The development process of the Case-Based Learning (CBL)-based e-module followed three main stages: validity, practicality, and effectiveness. The validity stage aims to determine the feasibility level of the developed e-module based on expert judgments, including aspects of content, presentation, language, and graphics, as suggested by the principles of material validation stated by Widoyoko (2016) and the development standards set by BNSP (2016). The practicality stage is conducted to assess

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the usability of the e-module by teachers and students, as well as to evaluate users' responses to its design and content, in line with the criteria for practical learning media proposed by Daryanto (2013). Furthermore, the effectiveness stage aims to examine the extent to which the CBL-based e-module improves students' problem-solving skills through pretest–posttest analysis, paired t-test, and N-Gain calculations as recommended by Susilo et al. (2021) in evaluating instructional products.

The development of the e-module not only focuses on content feasibility but also ensures that the resulting product is user-friendly and effective in enhancing students' thinking and problem-solving abilities. The design of the CBL-based e-module on ecology and biodiversity material was carried out by referring to the standards established by BNSP (2016), which include feasibility of content, language, presentation, and graphics. The developed e-module was evaluated for validity by expert validators consisting of two Science Education lecturers and three Science teachers. This validation aligns with recommendations by Arikunto (2010), who emphasized the importance of expert judgment in assessing instructional media feasibility. The primary purpose of this validation is to determine the level of validity and feasibility of the CBL-based e-module in improving the problem-solving abilities of junior high school students, consistent with previous studies on e-module development and its role in strengthening higher-order thinking skills (Nazara et al., 2022; Suarsana & Mahayukti, 2013). The results of the feasibility assessment are presented in Table 2.

Table 2. Analysis of E-module Feasibility Assessment

No	Rated aspect	Average Score
1	Content Eligibility	4,4
2	Presentation Eligibility	4,3
3	Language Eligibility	4,3
4	Graphic Eligibility	4,7
Total Average		4.43 (Very Valid)
Eligibility Percentage		88.5%

Table 2. Shows the total average score obtained, which is 4.43, then the validity of the CBL-based e-module by the expert validator is interpreted into the validity criteria according to Widyoko (2016) which is in the very valid category. Furthermore, the results of the validity analysis are entered into the feasibility scale according to Arikunto (2010)

obtaining the feasibility criteria in the category of very feasible to use in learning activities. The lowest results of the e-module validation assessment are in the feasibility aspect of presentation and language with an average score of 4.3.

The less than optimal assessment of the feasibility aspect of presentation is because in making the e-module the selection of fonts and language is not perfect. According to BNSP (2016), good learning presentation is the presentation of material that has an interactive and participatory nature with the presentation of concepts presented sequentially from simple to complex forms so that students can more easily understand the material presented. Things that can be done to maximize the presentation in the e-module are the selection of the type of writing and writing color that attracts students so that it can provide clear communication in the presentation of material in the e-module.

In terms of language feasibility, it received a less than optimal score because there were several words in the e-module that did not comply with the correct writing rules and there were typos. In this case, the language in the e-module needs to be considered. According to Wati et al (2017), language is a means of communication between humans and language needs to be adjusted to the development of the reader so that students are interested and find it easy to understand the reading. The aspect of content feasibility received a less than perfect score with a score of 4.4. The lack of validator assessment in the aspect of content feasibility was due to the discovery of an inappropriate sub-chapter classification of the material. Based on BNSP (2016), what can be done to maximize the feasibility of the e-module content is to compile the material appropriately so that there is no misunderstanding of student knowledge in the learning process. The graphic aspect obtained the highest score of 4.7 with a maximum score of 5. In the graphic aspect, the layout of the e-module components is appropriate and attractive. This is supported by Ginanjar's statement (2022) that a good e-module must meet the principle of attractiveness so that students are motivated to study the material and pay attention to the writing on the e-module display.

The second objective of the research activity is to determine the effectiveness of e-modules based on Case Based Learning (CBL) in improving problem-solving skills. The results of the implementation of the development of e-modules based on CBL at SMPN 3 Mertoyudan were carried out in class VII B with 32 students as respondents. The

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learning process was carried out in 5 meetings. The results of the e-module effectiveness test were analyzed based on the difference in average scores between the pretest and posttest scores in classes using e-modules based on CBL. Susilo (2021) said that to test the effectiveness of a product, it can be done by giving pretest and posttest questions to students during learning activities. The pretest and posttest questions consist of 3 questions in the form of each question containing 4 sub-questions that have been adjusted to the problem-solving indicators according to Polya. The questions have previously been tested for validity and reliability. The average score of students' problem-solving abilities can be seen in Table 3.

Table 3. Result of Student Pretest and Postest Scores

Mark	Average	Highest	Lowest
Pretest	51,84	58	44
Posttest	85,81	97	78

Table 3 shows an increase in the average KPM value of students from 51.84 to 85.81. This improvement occurred because the developed e-module integrates structured problem-solving activities supported by case-based syntax, which is known to strengthen students' analytical and reasoning skills (Syarafina et al., 2017; Arianto & Fauziyah, 2020). The effectiveness of the e-module is further examined through the results of the T-test and N-Gain test derived from the pretest and posttest data. The T-test was used to determine whether there was a significant difference between students' pretest and posttest scores following the implementation of the e-module, as recommended by Susilo et al. (2021) in evaluating the effectiveness of instructional materials.

Table 4. Paired t-test Result

Data	Average	Standard Deviation	Sig(2- *tailed*)	Criteria
Pretest	51,84	4,213	0,000	There is a significant difference

The results of the paired sample t-test are presented in table 4 shows the results of the paired sample t-test conducted on the pretest and posttest scores, indicating a sig value (2-tailed) of 0.000, which is lower than 0.05. This finding demonstrates that there is a significant difference between students' pretest scores before using the e-module and

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their posttest scores after learning with the CBL-based e-module. The use of a paired t-test is appropriate for measuring the effectiveness of instructional interventions, as also recommended by Susilo et al. (2021). Following the t-test analysis, the N-Gain test was conducted to determine the magnitude of improvement in students' problem-solving abilities after using the e-module, as suggested in prior studies evaluating learning media effectiveness (Permana et al., 2021; Pramana et al., 2020).

Table 5. N-Gain Test of Pretest and Posttest Result Data

Troubleshooting Indicators	Average score		N-Gain	Information
	Pretest	Posttest		
Understanding the Problem	5,16	8,5	0,85	Tall
Developing a Settlement Plan	5,19	8,1	0,75	Tall
Implementing the Settlement Plan	4	7,47	0,68	Currently
Check Back	3,44	6,88	0,60	Currently
Average total N-Gain			0,70	Tall

The results of the N-Gain analysis are presented in Table 5, Shows the average N-Gain score of 4 problem-solving indicators, namely 0.70 in the high category. The increase was caused by the e-module being developed based on cases so that students can more easily learn and understand existing problems. Case-based learning (CBL) presents a case that gives students the opportunity to practice KPM. This is supported by the opinion of Syarafina (2017) who stated that cases are closely related to problems so that students are able to improve their problem-solving skills with the help of cases. The N-Gain value obtained from the pretest and posttest data in class VII B according to the KPM indicator can be seen in Figure 2.

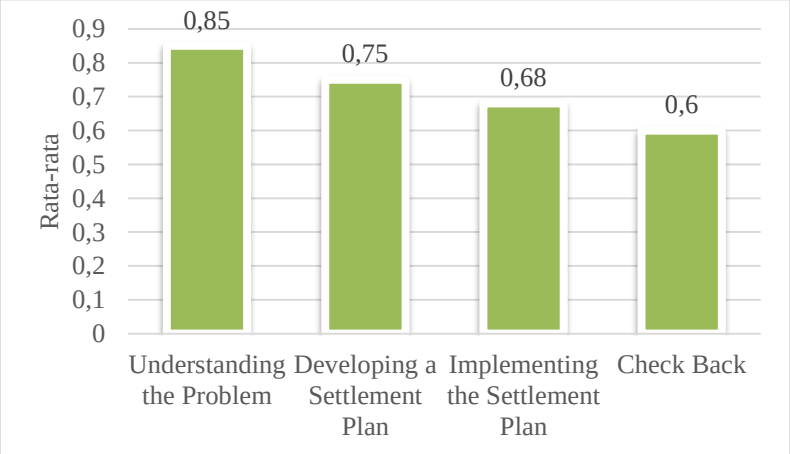

Figure 2. N-Gain value graph for each indicator

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Figure 2 illustrates the improvement in students' problem-solving abilities (KPM) across each indicator. The first indicator, understanding the problem, achieved the highest N-Gain score of 0.85, categorized as high. This demonstrates that students were able to identify the orientation of the problem and recognize key aspects of the issues presented. This indicator aligns with the Case-Based Learning (CBL) syntax embedded in the e-module, particularly at the stages of case identification and case analysis. During the case identification stage, students collaboratively discuss the presented problem, while in the case analysis stage, they describe the causes and effects of the identified issues. The defining characteristic of a CBL-based e-module is the use of contextual cases that are closely related to students' real-life environments, enabling them to apply their knowledge meaningfully. As stated by Shoimin (2014), case-based learning grounded in real-life contexts requires students to master effective problem-solving strategies.

The second indicator, developing a solution plan, obtained an N-Gain score of 0.75, also within the high category. At this stage, students were able to formulate structured plans to solve the cases provided. This indicator corresponds to the CBL syntax involving case analysis and independent information gathering. Students were required to identify relevant theories or concepts related to the issue and formulate systematic steps toward an appropriate solution. According to Nazara (2022), effective e-modules should include activities that encourage students to collaboratively analyze and discuss cases, thereby strengthening their problem-solving strategies.

The third and fourth indicators, implementing the solution plan and reviewing the results (rechecking), achieved N-Gain scores of 0.68 and 0.60, respectively, both categorized as moderate. In the implementation phase, students collaborated to answer case-related questions by utilizing the information previously gathered. However, their performance was not yet optimal due to limited understanding of the instructions, leading to incomplete responses and insufficient evaluation of the strengths and weaknesses of their proposed solutions. This aligns with the view of Wulandari et al. (2020), who argue that students often struggle to apply problem-solving steps when instructional guidance is unclear. At this stage, the teacher's role as a facilitator is crucial in guiding students through each step of the problem-solving process and providing additional clarification when needed, as emphasized by Hosnan (2014) regarding the teacher's responsibility in

supporting learners' higher-order thinking activities.

The rechecking indicator showed that many students did not review or verify the steps they had completed. Most assumed their answers were already correct, a tendency that has been noted in previous studies where students frequently skip solution verification due to overconfidence in their initial reasoning (Inayah, 2018). Nevertheless, this indicator remains consistent with the concluding stage of the Case-Based Learning (CBL) syntax, in which teachers are expected to prompt students to reflect on their findings, reassess their reasoning, and summarize conclusions collaboratively, supporting the principles of CBL described by Arianto and Fauziyah (2020).

Based on the overall N-Gain score of 0.70, categorized as high, it can be concluded that students' problem-solving abilities significantly improved after using the Case-Based Learning (CBL)-based e-module. This finding reinforces that the e-module effectively enhances students' critical and analytical thinking skills, consistent with prior research demonstrating that case-based digital modules support deeper cognitive engagement (Suarsana & Mahayukti, 2013; Nazara et al., 2022). The next phase of this research involves evaluating the practicality of the developed e-module in supporting students' problem-solving abilities, assessed through student response questionnaires administered to 32 participants from Class VII B.

Table 6. Recapitulation of Student Respondes

No	Aspect	Percentage	Category
1	Contents	80%	Practical
2	Presentation	82%	Very Practical
3	Linguistics	80%	Practical
	Average	81%	Very Pratical

The questionnaire contained three main aspects content, presentation, and language and the results are summarized in table 6, indicates that the developed e-module received positive responses from students, achieving an average practicality score of 81%, which is categorized as very practical, particularly in enhancing students' problem-solving skills. The content aspect scored 80%, falling within the practical category. This demonstrates that students found the e-module helpful in facilitating their understanding of the learning materials. The practicality of the content aspect is closely related to the

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interactive nature of the case-based learning (CBL) approach embedded in the e-module, which emphasizes student-centered learning activities. Through the CBL stages, students are encouraged to take an active role and engage meaningfully in classroom discussions. This finding is consistent with Jogiyanto (2019), who asserts that case-based learning fosters active student participation in the classroom learning process.

The validation stage of this study aimed to evaluate the e-module's feasibility in terms of content, presentation, language, and graphic quality, as assessed by expert validators. This process aligns with the criteria established by BNSP (2016) and the evaluation framework proposed by Widoyoko (2016), ensuring that the final product met the standards for high-quality digital learning materials. The practicality stage involved limited field testing with students to determine the e-module's usability, attractiveness, and effectiveness in supporting conceptual understanding, consistent with Daryanto's (2013) view that teaching materials must be practical and user-friendly to support independent learning. Meanwhile, the effectiveness stage focused on measuring students' improvement in problem-solving skills by comparing pre-test and post-test scores through statistical analysis, following the recommendations of Susilo et al. (2021) in evaluating learning media effectiveness.

Figure 3. E-module before and after revision

Prior to revision, the initial form of the e-module (shown in Figure 3) displayed an early layout with several design shortcomings, such as inconsistent color combinations, misaligned text, and unclear instructional directions. As seen in Figure 3, the left panel

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represents the "before" version of the module, while the right panel illustrates the improved "after" version refined through expert and student feedback. These deficiencies highlight the relevance of visual design principles discussed by Ginanjar et al. (2022), who state that well-organized and visually appealing digital learning materials increase student motivation and readability. Based on the validation results and user input, the module's appearance was redesigned to become more attractive, communicative, and user-friendly.

The improved version enhances both visual aesthetics and functional usability, resulting in a better learning experience. This finding is aligned with the work of Hapsari and Zulherman (2021), who reported that visually rich digital media positively influence student engagement and understanding. The present study's outcomes also correspond with findings by Faqih, Adriyani, and Muna (2023), who developed differentiated learning tools intended to foster learner autonomy. Their research and development project produced multiple instructional components such as syllabi, lesson plans, authentic assessments, and learning-style inventories that experts rated as highly feasible, and whose classroom implementation revealed statistically significant effectiveness. Similarly, the e-module developed in this study incorporates the principles of differentiated learning. Its student-centered interface and flexible navigation mirror the characteristics of the tools proposed by Faqih and colleagues, helping to strengthen learner independence and self-regulation.

The presentation of findings outlines each phase of the development process from expert validation and practicality assessments to effectiveness testing and demonstrates that the Case-Based Learning (CBL) e-module meets the standards of validity, practicality, and effectiveness for classroom use. This developmental sequence follows the systematic nature of the ADDIE model, which emphasizes ongoing evaluation and refinement to ensure high-quality instructional products (Mulyatiningsih et al., 2023; Arikunto, 2010).

The revised e-module, depicted in Figure 2, exhibits substantial improvements in interface and layout that reflect expert recommendations and student trial feedback. The updated design adopts a more contemporary and intuitive visual layout, balanced color schemes, proportionate text organization, and clearer navigation cues elements shown to

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increase comfort and engagement in digital learning environments (Ginanjar et al., 2022). These enhancements were implemented to optimize usability and interactivity, reinforcing the findings of Hapsari and Zulherman (2021), who highlight the importance of appealing visual design for improving motivation and comprehension. One key innovation in this version is the integration of Quick Response (QR) codes that link directly to supplemental resources such as instructional videos, interactive simulations, and scientific references. This enables learners to explore content independently and access multimodal materials that enrich their conceptual understanding.

Such multimedia integration is consistent with the expectations of 21st-century learning, which calls for digital tools that encourage autonomy, accessibility, and flexibility (Pelangi et al., 2020; Munir, 2013). The inclusion of interactive digital components in this study also corresponds with the findings of Haka, Sari, Masya, and Rakhmawati (2024), who showed that web-based virtual learning media foster scientific attitudes effectively. Their research characterized by high validity scores (87.5–94%) and positive teacher responses (85.33%) provides strong empirical support for the use of digital platforms to cultivate inquiry skills and scientific thinking. Their reported medium N-gain scores and significant differences between experimental and control groups indicate that interactive, web-based tools can meaningfully enhance student engagement and reasoning. In parallel, the QR-based multimedia features in the CBL e-module developed in this study offer opportunities for deeper exploration and reflective learning, underscoring the pedagogical value of integrating interactive digital resources into science education.

Moreover, the implementation of the CBL approach was reinforced by the inclusion of real-world cases structured systematically. Each case guided students through stages such as understanding the context, examining trigger questions, conducting analysis, and engaging in reflection—steps that align with CBL principles emphasizing contextualized learning and the development of higher-order thinking (Arianto & Fauziyah, 2020; Jogiyanto, 2019). Additional visual supports such as images, videos, and case-based exercises helped bridge theoretical concepts with practical applications, consistent with Hapsari and Zulherman's (2021) findings that multimedia elements enhance student engagement and comprehension. Consequently, the revised e-module provides a more

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interactive and meaningful learning experience that effectively fosters critical thinking and problem-solving through contextual digital learning, aligning with Suarsana and Mahayukti's (2013) view that problem-oriented digital modules strengthen analytical and reasoning skills.

The practicality of the CBL e-module was assessed using a student response questionnaire following classroom implementation. The questionnaire evaluated three aspects content, presentation, and language using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The data were analyzed descriptively by calculating the mean of each aspect and converting it into percentage form according to the criteria of Riduwan (2013). The results indicated that the presentation aspect received the highest score at 82%, placing it in the very practical category. This demonstrates that the module's visual design, color harmony, and multimedia integration fostered an engaging learning environment, improved comprehension, and reduced fatigue. This aligns with Gita et al. (2018), who argue that attractively designed e-modules enhance interest, deepen understanding, and alleviate boredom.

The language aspect scored 80%, categorized as practical. Students responded positively to the module's simple, clear, and communicative language. The concise sentences and familiar terminology enabled students to grasp the material independently, consistent with Prastowo (2015), who emphasizes that instructional materials should use language appropriate to learners' developmental levels to ensure clarity and meaningful understanding. Overall, the findings suggest that the developed e-module is practical and supportive of learning, particularly in strengthening students' understanding of ecology and biodiversity concepts. It additionally supports the development of problem-solving abilities through individual and collaborative learning tasks. Nonetheless, a minor limitation was identified: certain instructional instructions lacked clarity, occasionally causing difficulty in interpreting directions. Future revisions should therefore refine instructional guidance to ensure smoother navigation and improved learner comprehension.

The practicality of the developed Case-Based Learning (CBL) e-module was assessed through a student response questionnaire administered after the learning implementation. This evaluation aimed to determine how practical, accessible, and user-

friendly the e-module was in real classroom settings. The questionnaire covered several indicators—including content, presentation, and language—rated using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The collected data were analyzed descriptively by calculating the mean score of each aspect and converting it into percentage form. Referring to the criteria of Riduwan (2013), a score above 80% is classified as very practical. The results showed that the presentation aspect achieved the highest score at 82%, placing it in the very practical category. Students responded positively to the module's visual layout, interactive features, and integration of multimedia elements such as videos and illustrative images. The harmonious combination of text, color, and visuals created a more engaging learning environment, supported understanding, and helped reduce feelings of monotony. These findings are consistent with Gita et al. (2018), who highlight that visually appealing digital modules can enhance student motivation and deepen comprehension.

The language aspect obtained an 80% practicality score, categorized as practical. Students appreciated the clear, concise, and communicative language used throughout the module, which aligned with their cognitive level. The straightforward wording and familiar terminology enabled learners to understand the material independently. This aligns with Prastowo (2015), who emphasizes that instructional materials should employ language appropriate for students' developmental stages to ensure clarity and meaningful learning. Additional literature further reinforces the practicality of well-designed digital learning media. Roslina, Samsudin, and Liliawati (2022) found that STEM-integrated Project-Based Learning (STEM-PJBL) effectively enhances conceptual understanding, problem-solving skills, and creativity.

Their systematic review shows that combining scientific, technological, engineering, and mathematical elements in structured project activities encourages active exploration and engagement with real-world contexts. These characteristics mirror the strengths of the CBL e-module, where structured tasks, coherent visuals, and meaningful contexts contribute to its overall practicality. Similarly, Hotimah and Ramadani (2021) demonstrated that a Problem-Based Learning model enriched with reading activities and concept mapping significantly improves students' critical thinking and reading interest. Concept maps help students organize information logically, while reading activities

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strengthen initial understanding before problem-solving. This suggests that practical instructional media should support systematic thinking processes through clear structuring, guided steps, and visual aids. These attributes are also evident in the CBL e-module developed in this study, making it more effective and user-friendly from the students' perspective. The study conducted by Dewi, Habiddin, Dasna, and Rahayu (2022) demonstrates that the application of Case-Based Learning (CBL) in chemistry education has expanded significantly over the past decade. Through a systematic review of 93 articles indexed in Scopus, the authors identified that CBL is commonly implemented through four essential stages: case orientation, peer discussion, case-related literature review, and final evaluation.

The cases used in chemistry learning are generally presented as factual narratives connected to real-world contexts. In addition, CBL is frequently integrated with other active learning approaches such as Inquiry-Based Learning, Problem-Based Learning, and Project-Based Learning. Meanwhile, the pilot study by Hassoulas et al. (2025) examined the effectiveness of technology-enhanced Case-Based Learning (TEL-CBL) among medical students. This approach incorporates a variety of digital tools, including immersive learning spaces, virtual reality devices, 3D anatomy applications, emergency simulations, and generative AI-based virtual patient platforms. The findings revealed that students in the TEL-CBL group achieved higher formative assessment scores, showed stronger engagement, and reported increased confidence in clinical and communication skills. However, some students noted that certain technologies, such as VR headsets or AI interactions, were not always optimal and could occasionally feel repetitive. Overall, both studies highlight that CBL whether implemented traditionally or supported with technology is effective in improving conceptual understanding, critical thinking skills, and student engagement. Enhancing CBL with technological tools can enrich the learning experience, although its implementation must consider user comfort and the quality of digital interactions.

CONCLUSION

Based on the results and discussion presented earlier, several conclusions can be drawn. (1) The Case-Based Learning (CBL)-based e-module was found to be valid and

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feasible for implementation, obtaining an average validation score of 4.43 (very valid) and a feasibility percentage of 88.5%, which falls into the very feasible category. (2) The e-module proved to be effective in enhancing students' problem-solving skills, as indicated by the T-test result (sig = 0.000 < 0.05), showing a significant difference between pre-test and post-test scores. The N-Gain score of 0.70 further confirmed a high level of improvement in students' problem-solving performance. (3) In terms of practicality, the e-module received a score of 81%, categorized as very practical, demonstrating that it can be easily used in classroom learning activities.

It is recommended that future development efforts focus on refining the e-module by adding more comprehensive and detailed content, as well as clearer instructional guidance to facilitate students' understanding. Furthermore, the inclusion of progressively structured case examples, beginning with simple and contextually relevant phenomena from students' daily lives, is suggested to strengthen the learning process and engagement.

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