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Evaluating the Validity of a Phenomenon-Based Learning E-Module on Acid-Base Topics Using the Articulate Storyline Application

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ABSTRACT

This research aims to assess the validity and effectiveness of an e-module based on Phenomenon-Based Learning (PBL) for teaching acid-base solutions, developed using the ADDIE model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. The development method is well-suited for creating educational materials. In this study, the e-module was validated by experts in chemistry content and media design. The validation results indicated that the e-module was highly valid across various aspects, including content, presentation, language, graphics, PBL characteristics, appearance, and software utilization, with validity percentages of 96.00%, 96.66%, 100.00%, 92.00%, 96.36%, and 96.66%, respectively. Additionally, an e-module trial was conducted with feedback from two chemistry teachers and 20 students. The responses were overwhelmingly positive, with effectiveness ratings of 96.66% and 98.76%. Based on these findings, it can be concluded that the e-module developed with the Articulate Storyline application for acid-base solution materials is both valid and effective for use in the learning process.

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1. INTRODUCTION

Chemistry plays a significant role in everyday life, and one of the key topics in high school chemistry that is deeply connected to daily experiences is the study of acids and bases. As fundamental concepts in chemistry, acids and bases must be thoroughly understood, as they serve as the foundation for more advanced chemical principles (Abdullah, 2020). To make the study of acids and bases more meaningful, it is essential to link the content to students' experiences, such as demonstrating the use of acid-base indicators. Utilizing the right teaching models can greatly enhance students' success in mastering chemistry concepts. One such model that is particularly effective for teaching acids and bases is Phenomenon-Based Learning (Phenobl), which connects learning with real-world phenomena. Phenobl encourages students to engage with phenomena, organize their investigations, and analyze the results, making learning more relevant and interactive. As stated by Rise (2019), Phenobl integrates inquiry-based, problem-based, and project-based learning, emphasizing a learner-driven, skill-centered, and

authentic learning process. In this approach, students actively build their own knowledge by exploring real-life phenomena.

The use of the Phenobl learning model not only enhances students' understanding of academic content but also fosters the development of essential 21st-century skills. In today's knowledge-based era, individuals must possess the ability to think critically, collaborate, communicate, and solve problems effectively. These skills, often referred to as the 4Cs—critical thinking, creativity, collaboration, and communication—are crucial for students to succeed and thrive in a rapidly changing world. By integrating Phenobl into the classroom, educators can better prepare students for the challenges of the 21st century.

Learning in the 21st century focuses on equipping students with the ability to adapt to technological, media, and informational advancements (Dani & Fajriati, 2022). Essential skills for 21st-century learning include critical thinking, communication, creativity, and collaboration, collectively referred to as the 4C skills (Rosnaeni, 2021). Learning involves the organization and management of the learning environment to foster students' engagement in the educational process (Pane & Darwis Dasopang, 2017). The process is marked by behavioral changes in students as they interact with their surroundings. This learning process significantly contributes to the development of students' intellectual, moral, and various skill sets. Teachers play a crucial role in facilitating this process by providing appropriate teaching materials (Hairani & Amini, 2023). They are expected to address students' learning challenges by selecting, developing, and utilizing suitable materials.

To achieve effective learning outcomes, appropriate learning resources are essential. These resources encompass both written and unwritten materials used by teachers in the learning process (R & Susanti, 2019). In the past, teachers relied on printed teaching materials; however, with advancements in science and technology, it is now crucial to transition to computer-based learning methods. One such resource, the e-module, offers an interactive learning experience that aligns with contemporary educational approaches. E-modules, particularly those designed around phenomenon-based learning, can help foster critical thinking, creative thinking, communication, and collaboration skills. These e-modules empower students to construct their own knowledge (student-centred learning) by exploring content, explaining phenomena, and solving problems related to acid-base chemistry.

E-modules used as learning resources must possess distinctive features that capture students' interest and encourage their engagement. One such tool is Articulate Storyline, a software designed to achieve this goal. According to Yulistya et al. (2022), Articulate Storyline is an effective application for learning because it offers an engaging and enjoyable user interface. This is supported by Burhannudin (2021), who highlights that the Articulate Storyline application is advantageous due to its ability to incorporate interactive elements such as text, sound, video, animation, and images. The resulting files can be shared as application files or websites, which are compatible with laptops and smartphones. E-modules designed for educational use often follow a problem-based approach, which focuses students' attention on specific problems, organizes their learning activities, encourages both individual and group study, and facilitates the development and evaluation of academic performance, while also analyzing and assessing the overall learning process (Zhafirah et al., 2020).

Acids and bases are a representation of chemistry, studying chemical facts, concepts and principles. Chemistry studies processes, products and attitudes. Chemistry, from a process perspective, includes the ability to observe, measure, group, ask questions, formulate hypotheses, conduct experiments, and draw conclusions. From the attitude aspect of chemistry, it includes caring for the environment, being curious, tenacious, honest, patient, critical, diligent, disciplined, careful, paying attention to work safety, and working together. Some of these skills are process skills, and aspects of attitude which are often referred to as scientific attitudes (Wati Sukmawati, 2019).

Understanding concepts is essential for mastering chemistry, as the subject is inherently abstract and complex. Due to its abstract nature, a comprehensive approach is required to study chemistry effectively. According to Coll (2008), understanding complex and abstract concepts necessitates three levels of representation: macroscopic, submicroscopic, and symbolic. The macroscopic level focuses on observable

phenomena in everyday life, while the submicroscopic level explains these events from a microscopic perspective. The symbolic level, on the other hand, represents real-world phenomena through symbols or images. The Phenobl learning model enhances chemistry comprehension by aligning with these three levels of representation. Chemical phenomena can be integrated into e-modules using the Articulate Storyline application, presented through videos, animations, or interactive images, making the learning process more engaging and effective.

The development of e-modules based on phenomenon-based learning has been explored by several researchers. For instance, Maisarmah (2022) conducted a study titled "Development of a Chemistry Learning E-Module Based on Phenomenon-Based Learning to Direct Students' Critical Thinking Skills," which yielded positive results. The feasibility of the e-module was rated at 75% for the material aspect (Good/Feasible), 83.27% for the media aspect (Very Good/Decent), 90% for teacher response (Very Good), and 81% for student response (Very Good). These findings indicate that the Phenomenon-Based Learning chemistry e-module is suitable for use as a learning resource. In a similar vein, Arman Cahyanto et al. (2022) developed an interactive e-module based on Articulate Storyline 3 to enhance critical thinking skills on the subject of sound waves. Their research revealed an average feasibility score of 85.78% from three validators, a medium N-gain of 68%, and an 81% student questionnaire response. Based on these results, the e-module was deemed valid, effective, and applicable in educational settings.

However, there has yet to be research focused on developing a phenomenon-based e-module for acid-base content. Acid-base concepts, studied in high school chemistry (Grade XI), are closely related to everyday life and can be effectively explained using common phenomena encountered by students. Misconceptions, particularly regarding the determination and calculation of pH, often arise in this subject. The use of appropriate learning resources and models can help address these misconceptions and enhance student achievement.

Given the importance of improving learning resources, it is crucial to develop a phenomenon-based e-module using Articulate Storyline for teaching acid-base material to class XI SMA/MA students. This research aims to create an e-module based on phenomenon-based learning for acid-base concepts, assessing its validity through content suitability, presentation quality, linguistic accuracy, graphic design, adherence to Phenobl characteristics, visual appeal, and software usability. Once a valid e-module is developed, it will be evaluated for its effectiveness through user responses (teachers and students) during the learning process. The ultimate goal of this research is to produce a valid, engaging, and innovative e-module for acid-base chemistry that can serve as an alternative teaching tool and an independent learning resource for students. Such an e-module will help make chemistry more accessible and enjoyable for students.

2. METHODS

This research adopts a Research and Development (R&D) approach, following the stages outlined in the ADDIE model. The ADDIE model comprises five stages: Analysis, Design, Development, Implementation, and Evaluation (Sugihartini & Yudiana, 2018). The study was conducted within the Chemistry Education Program at FKIP, Riau University, and the developed e-module was tested at a high school in Pekanbaru, focusing on students who had previously studied acid-base material.

The developed e-module was validated by experts in chemistry education and learning media, assessing several aspects: content suitability, presentation quality, linguistic accuracy, graphic design, adherence to the characteristics of phenomenon-based learning, visual appeal, and the utilization of software and media. After validation, the e-module was tested with students, and feedback was collected from teachers. One-on-one trials were conducted with three students representing varying levels of ability (high, medium, and low), to gather information on the time taken to complete the modules and exercises. A small group trial was conducted with 20 students, also representing different ability levels, to assess the ease of use, perceived benefits, presentation attractiveness, and overall user experience. Additionally, feedback from two chemistry teachers who used the module in their lessons, was collected. The teacher

response test aimed to assess the module's suitability for the teaching process. Teachers provided feedback via a questionnaire that included 25 statement items covering aspects of content appropriateness, characteristics of the Phenomenon-Based Learning model, practical usability, and visual appeal.

Suggestions and comments from both experts and users (teachers and students) were used to refine and improve the e-module. Data collection instruments included validation sheets and user response questionnaires. Both instruments utilized a Likert scale, ranging from 1 to 5, with specific criteria for each score, as outlined in Table 1.

Table 1. Likert scale assessment criteria

Criteria	Score
Strongly Agree (SS)	5
Agree (S)	4
Disagree (KS)	3
Disagree (TS)	2
Strongly Disagree (STS)	1

(Sugiyono, 2015)

The validation score is calculated using the equation:

$$\text{Percentage (\%)} = \text{x } 100\%\frac{\text{Validator score}}{\text{the highest score}}$$

(Heni Vidia Sari & Hay Suswanto, 2017)

Feasibility assessment or product assessment criteria can be seen in Table 2 below. This table outlines the various aspects considered during the evaluation process, providing clear criteria for assessing the quality and effectiveness of the developed e-module. Each aspect is carefully examined based on established standards to ensure the e-module meets the necessary educational requirements and is suitable for use in a classroom setting. The assessment criteria also help identify areas for improvement, guiding the refinement of the e-module based on expert feedback and user responses. The results from these assessments serve as the foundation for determining the overall feasibility and effectiveness of the e-module in supporting student learning outcomes.

Table 2. Table of validity assessment criteria

Percentage Score (%)	Interpretation
P > 84%	Very Interesting/Very Valid
68 < P ≤ 84%	Interesting/Valid
52% < P ≤ 68%	Interesting enough/Valid enough
36 < P ≤ 52%	Less interesting/less valid
P ≤ 36%	Very Less Interesting/Very Invalid

(Diana et al., 2018)

The teacher's response to the appropriateness of the content, the characteristics of phenomenon-based learning, ease of use, benefits of use, and the attractiveness of the presentation are analyzed as follows: These aspects were carefully assessed to gauge how well the e-module aligns with educational objectives and how effectively it supports the teaching process. Feedback on the content's relevance ensures that the material meets the learning needs of students, while the evaluation of phenomenon-based learning characteristics helps determine if the e-module encourages active engagement and critical thinking. The ease of use is examined to ensure that the module is accessible and intuitive for both teachers and students. Additionally, the benefits of use focus on the module's ability to enhance learning outcomes, and the attractiveness of the presentation is assessed to determine whether the visual elements of the module engage students and contribute to a positive learning experience. These analyses provide valuable insights into the e-module's effectiveness and areas for further enhancement.

$$\text{Percentage (\%)} = \text{x } 100\% \frac{\text{total score}}{\text{the highest score}}$$

(Safira et al., 2021)

Before presenting the table, it is important to note that the teacher response categories are based on a set of established criteria aimed at evaluating the various aspects of the e-module. These categories cover key factors such as content appropriateness, the characteristics of phenomenon-based learning, usability, and the overall presentation of the module. The following table outlines the eligibility criteria for analyzing the percentage of responses collected from the teacher questionnaires. This table provides a clear framework for assessing how well the e-module meets the teachers' expectations and its effectiveness in a real classroom setting.

Table 3. Table of eligibility criteria for percentage analysis for teacher response questionnaires

Percentage Score (%)	Interpretation
81% - 100 %	Very Good/Very Interesting
61 % - 80 %	Good/Interesting
41% - 60%	Fairly Good/Fairly Interesting
21% - 40 %	Not Good/Less Attractive
< 21%	Very Poor/Very Unattractive

(Ernawati, 2017)

Student response questionnaires are used to obtain data on ease of use, benefits of use, and attractiveness of presentation. Data was obtained from student questionnaires using the Guttman scalewith a score of 0 to 1 in the form of a checklist (◆) as in table 4 below:

Table 4. Guttman Scale

Position Statement	Score
Agree	1
Don't agree	0

(Sugiyono, 2015)

User response data is then analyzed using the formula:

$$\text{Percentage (\%)} = \text{x } 100\% \frac{\text{Total Score}}{\text{The highest score}}$$

(Safira et al., 2021)

The next step is to categorize the percentage results according to table 3.

3. FINDINGS AND DISCUSSION

The teaching material developed is an electronic module on acid-base material. The e-module created has gone through the recommended instructional principles, starting from conducting an instructional analysis, syllabus, to becoming a teaching material. With the ease of using the teaching materials created, it shows a positive impact on teachers, namely that they will have more time to guide students in the learning process, help students to acquire new knowledge from various sources or references used in teaching materials, and the role of the teacher as one -the only source of knowledge is reduced. This teaching material is made in the form of a module for the concept of independent

learning for students because in essence students have the ability to work independently and are more responsible for their actions. The following is a cover image of the e-module being developed.



Figure 1: E-module cover

This acid-base material e-module is divided into 4 sub-lessons. In each sub-learning, students will be oriented to phenomena that will later be linked to learning. In its application, several phenomena that are integrated into this learning are as follows:

a. Learning activity 1: Use of floor cleaning fluid and use of stomach medicine in everyday life
b. Learning activity 2: Description of foods and drinks that contain acids and bases
c. Learning activity 3: Use of vinegar when eating pickles
d. Learning activity 4: Use of pH in measuring soil acidity levels

Each learning activity within the module incorporates phenomena that are directly related to the material being discussed, aiming to enhance students' critical thinking skills. This section provides opportunities for group discussions and sharing of opinions, fostering the development of students' collaboration and communication abilities. At the conclusion of the module, exercises are designed to challenge and strengthen students' higher-order thinking (HOT) skills. The module ends with a summary and evaluation questions to assess students' HOTs capabilities and ensure they have grasped the key concepts.

3.1 Validity of E-module

The validity of the developed e-module was assessed by a panel of experts, with each aspect of the e-module carefully evaluated to ensure its quality and effectiveness in supporting student learning. The following table presents the results of the e-module feasibility validation, highlighting the average values provided by the validators for each aspect. The criteria used for evaluation indicate the level of validity for each component, which confirms the e-module's appropriateness for use in the classroom.

Table 5. E-Module feasibility validation results

No	E-Module Feasibility Aspects	Average Value of Validators	Criteria
1	Feasibility Aspects of E-Module Content	96.00%	Very Valid
2	Linguistic Aspect	96.66%	Very Valid
3	Aspects of E-Module Presentation	96.00%	Very Valid
4	Graphic Aspects	100.00%	Very Valid
5	Characteristic Aspects of Phenomenon-Based Learning	92.00%	Very Valid
6	Display Aspects	96.36%	Very Valid
7	Aspects of Software Utilization	96.66%	Very Valid

The assessment of the content suitability aspect of the e-module, based on phenomenon-based learning and utilizing the Articulate Storyline application for mastering 21st-century skills in the acid-

base solution material for class XI SMA/MA equivalent, was conducted using four assessment indicators, which included five statements. These indicators focused on evaluating the alignment of the e-module with the basic competencies and learning indicators for acid-base solution material, its relevance to the subject matter, its appropriateness to students' needs, and its overall usefulness in the learning process. The average validation score for this aspect was 96.00%, which falls under the "very valid" category, indicating that the content is highly suitable and aligned with educational standards.

The linguistic aspect was evaluated based on two indicators containing five statements, aimed at assessing the accuracy and correctness of grammar used in the e-module. The validation results for this aspect exceeded 84%, meeting the "very valid" criteria, which confirms the high quality and clarity of the language in the module, ensuring that it is accessible and understandable to students.

For the presentation aspect, five indicators containing six statements were used to assess the clarity, completeness, motivational elements, and the effectiveness of communication within the e-module. The validation results for this aspect were found to be "very valid," indicating that the presentation is clear, engaging, and communicative, facilitating effective learning experiences for students.

The graphic aspect assessment, which included two indicators and five statements, focused on the design elements such as typography and overall layout. The validation results for this aspect were also rated as "very valid," reflecting that the e-module's visual design is both appealing and functional, contributing to an optimal learning environment.

The assessment of the characteristic aspects of phenomenon-based learning involved five indicators, including orienting the phenomenon to students, organizing student learning, supporting individual or group investigations, presenting the results of these investigations, and analyzing and evaluating the phenomena. This aspect received an average validation score of 92%, also classified as "very valid." This suggests that the e-module effectively incorporates key features of phenomenon-based learning, fostering active engagement and critical thinking.

The appearance aspect was evaluated through seven indicators that examined the functionality and design of navigation buttons, typography, images, colors, videos, cover pages, and layout within the e-module. The validation results for this aspect were highly positive, with an average score of 96.36%, categorizing it as "very valid." This indicates that the e-module's appearance is visually appealing and user-friendly, enhancing its usability.

The software utilization aspect was assessed based on two indicators, focusing on the interactivity and supporting software within the e-module. With an average validation score of 96.66%, this aspect also received a "very valid" rating, demonstrating that the e-module's use of interactive elements and software enhances the learning experience.

Overall, the average percentage for all validated aspects was above 84%, which is classified as "very valid." These results indicate that the e-module meets the necessary criteria for effectiveness and quality, confirming its suitability for further trials and use in educational settings. This validation process ensures that the e-module is well-developed, meets educational goals, and can be successfully implemented in the learning environment.

3.2 Product development trial results

3.2.1 Teacher Response

The average teacher responses regarding the content appropriateness, the characteristics of the Phenomenon-Based Learning model, the practicality of the e-module, and its appearance were collected and analyzed. The results of these teacher responses are presented in the table below:

Table 6. Percentage of teacher responses to E-Module

Teacher	Percentage	Criteria
G-01	97%	Very good
G-02	96%	Very good
Total	96.50%	Very good

The use of e-modules based on phenomenon-based learning using the articulate storyline application for mastering 21st century skills in acid-base solution material for class XI SMA/MA equivalent benefits teachers because it can streamline learning time. According to the teacher at SMAN 4 Pekanbaru, the e-module developed has fulfilled all aspects and is proven by the response results of 96.50% with very good criteria.

3.2.2 Student Response

One-on-one trials were conducted to gather detailed insights into user reactions to the material and the messages conveyed through the e-module. These trials provided valuable feedback on how students interacted with the content, how effectively they engaged with the material, and the time spent completing the tasks. The data collected from these trials, including the time taken by students to work on the questions and their overall experience using the e-module, are presented in Table 7. This information is crucial for assessing the usability and effectiveness of the e-module, ensuring that it meets the intended educational goals and is accessible to students of varying abilities.

Table 7. Average score for completing exercises per learning activity and time for completing e-modules per learning activity

Learners	Average value of exercise completion per learning activity	Average e-module processing time per learning activity (minutes)
PD-01	95	85.50
PD-02	85	87.00
PD-03	80	89.50

PD = Students

Before presenting the table, it is important to note that small group trials were conducted to further assess the effectiveness of the e-module from the students' perspective. In these trials, feedback was collected from a group of students to evaluate aspects such as the ease of use, the perceived benefits of using the module, and the attractiveness of its presentation. The average response scores from the students in the small group trials provide valuable insights into the overall user experience and the module's effectiveness in engaging and supporting student learning. The results of these trials are summarized in Table 8 below.

Table 8. Average student response scores in small group trials

No	Assessment aspect	% Average student response score	Criteria
1	Ease of Use Aspect	94.38	Very good
2	Aspects of Benefits of Use	94.06	Very good
3	Aspects of Presentation Attractiveness	93.75	Very good
Average score		94.06	Very good

Discussion

The research findings demonstrate that the e-module based on phenomenon-based learning, developed using the Articulate Storyline application for teaching acid-base solution material to class XI

SMA/MA equivalent, is highly suitable for use as a teaching resource. The e-modules developed can be accessed by both teachers and students through links provided by the developer, and they are accessible for use beyond school hours on smartphones or laptops, offering flexibility in learning.

The assessment of the content suitability aspect evaluates how well the e-module aligns with the basic competencies and learning indicators for acid-base solution material, the relevance of the material, its suitability for students' needs, and its overall usefulness. The e-module received a validation score of 96.00%, which places it in the "very valid" category. This suggests that the content is well aligned with the curriculum, and the use of phenomena in the e-module encourages active student participation, helping students achieve Core and Basic Competencies. The alignment of teaching materials with the curriculum is essential for preventing conceptual misunderstandings and ensuring that students learn effectively (Nisa, 2020; Herawati & Muhtadi, 2018).

The linguistic aspect of the e-module, which assesses the accuracy and coherence of the language used, received a validation score of 96.00%, indicating that the language is clear and correct. Using good and proper language in educational materials makes learning easier for students, eliminating confusion and ensuring that the content is easily comprehended (Rahman et al., 2019; Puspitasari, 2019).

In terms of the presentation aspect, the e-module received a validation score of 96.66%, signaling that the material is presented clearly and comprehensively, with motivational elements and communicative aspects included. This enhances students' engagement and interest in the learning process, fostering a more effective educational experience (Nathalia Angelina et al., 2021).

The graphic aspects of the e-module, which assess the design, typography, images, and videos used, achieved a perfect validation score of 100.00%. This indicates that the e-module's design is both aesthetically appealing and well-organized, ensuring that the material is presented in a clear, visually engaging manner. The use of attractive colors and images is essential for keeping students' attention and enhancing their motivation to learn (Permana et al., 2021; Octaviara & Pahlevi, 2019).

Regarding the characteristic aspects of phenomenon-based learning, the e-module scored 92.00%, demonstrating that it effectively incorporates key features of this learning model. This includes helping students explore and understand acid-base concepts through real-life phenomena. Such an approach encourages critical thinking and helps students actively engage with the content, as they investigate problems in everyday life. This method of learning aligns with the theory that using natural phenomena in the classroom fosters the development of critical thinking skills (Pujianto & Maryanto, 2009; Pareken et al., 2015).

The display aspects, which assess the e-module's navigation buttons, typography, spacing, layout, and overall design, received a validation score of 96.36%. This indicates that the e-module is easy to navigate, with clear and user-friendly features that enhance its accessibility.

The software utilization aspect, which evaluates the interactivity and ease of use of the e-module, scored 96.66%. This suggests that the e-module is highly interactive and responsive, making it easy for students to find information and engage with the content during their learning process (Ricu Sidiq & Najuah, 2020).

Overall, the e-module developed for teaching acid-base solutions based on phenomenon-based learning, using the Articulate Storyline application, was validated as "very valid" across all assessed aspects. Teacher and student responses further confirm the e-module's effectiveness and suitability for use in the classroom. Teachers reported that the e-module helped students engage in independent learning while allowing for easy monitoring and individual guidance. Student feedback was overwhelmingly positive, with a 98.76% response rate indicating that the e-module is not only easy to use but also highly engaging. This finding aligns with previous studies that highlight the positive impact of appropriate teaching materials on creating an enjoyable and effective learning environment (Marpaung & Pongkendek, 2021; Maisarmah, 2022; Arman Cahyanto et al., 2022).

4. CONCLUSION

In conclusion, the research demonstrated that the e-module developed using the Articulate Storyline application for teaching acid-base solution material to class XI SMA/MA students is highly suitable for use as a teaching resource. The validation results showed very positive outcomes across various aspects, including content suitability (96%), linguistic accuracy (96%), presentation quality (96%), graphic design (100%), adherence to phenomenon-based learning characteristics (92%), appearance (96%), and software utilization (100%). These results indicate that the e-module is effective in delivering the material in a clear, engaging, and interactive manner. The trial results further support its effectiveness, with teacher feedback rating the e-module very positively (96.5%) and student responses also being highly favorable (94.06%). This suggests that the e-module significantly enhances the acid-base learning process.

However, the research does have certain limitations. For instance, it was conducted in a specific geographic location with a limited sample size, which may affect the generalizability of the findings. Additionally, the study focused solely on the acid-base solution material, and further research could explore the applicability of this e-module for other chemistry topics. Future studies should consider expanding the sample size and testing the e-module in different educational settings to assess its broader applicability. Moreover, future research could explore the integration of more advanced interactive features and evaluate the long-term impact of e-modules on student learning outcomes.

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