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Development of a Heyzine E-Module Integrating Cassava Fermentation Ethnoscience for Acid-Base Chemistry

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ABSTRACT
Understanding acid-base concepts remains challenging for many students because these concepts are abstract and often disconnected from everyday experiences. This study aimed to develop and evaluate a Heyzine Flipbook-assisted e-module integrating cassava fermentation ethnoscience to support acid-base chemistry learning. The study employed a Research and Development (R&D) approach based on the Borg and Gall model. The developed e-module integrated interactive digital features, ethnoscience-based contexts, and multimedia elements to promote meaningful learning experiences. The product was validated by material and media experts, while its practicality and effectiveness were evaluated through teacher responses, student responses, and pretest-posttest assessments. The validation results indicated that the e-module was highly valid, with average scores of 92.51% from material experts and 91.88% from media experts. The practicality evaluation showed very positive responses from teachers (91.88%) and students (89.64%). Furthermore, students' learning outcomes improved significantly, as reflected by the increase in the mean score from 41.39 on the pretest to 73.33 on the posttest. The normalized gain (N-gain) score was 0.54, indicating a moderate level of effectiveness in improving students' understanding of acid-base concepts. These findings suggest that integrating ethnoscience and digital learning technology through a Heyzine Flipbook-assisted e-module provides an innovative, contextual, and effective learning resource for chemistry education.

Keywords: acid-base chemistry, cassava fermentation ethnoscience, e-module, Heyzine Flipbook, learning outcomes.

1. INTRODUCTION

Chemistry plays an important role in developing scientific literacy, critical thinking, and problem-solving skills. However, many students perceive chemistry as a difficult subject because it involves abstract concepts that require understanding of macroscopic, submicroscopic, and symbolic representations. Acid-base chemistry is one of the topics that frequently causes misconceptions and low conceptual understanding among students.

The implementation of the Merdeka Curriculum encourages the use of technology-based and contextual learning resources. One promising digital learning resource is the electronic module (e-module), which provides flexible access to learning materials and supports multimedia integration. Previous studies have reported that digital learning media can enhance students' engagement, motivation, and learning outcomes (Alifa et al., 2025). Among various digital platforms, Heyzine

Flipbook enables the development of interactive learning materials with attractive visual features that support independent learning (Putra & Nurlina, 2025).

Besides technological innovation, contextual learning is essential for meaningful science education. Ethnoscience integrates local cultural knowledge with scientific concepts, allowing students to connect classroom learning with real-life experiences (Sudrajat et al., 2021). One example is cassava fermentation, a traditional Indonesian process involving biochemical reactions that produce organic acids and influence pH levels, making it relevant to acid-base chemistry concepts (Utami et al., 2023).

Several studies have developed ethnoscience-based learning materials and digital chemistry modules. Previous findings indicate that ethnoscience integration can improve students' conceptual understanding, scientific process skills, and appreciation of local culture. For instance, Sunyono et al. (2023) reported that chemistry learning based on Pelangiran ethnoscience effectively improved students' scientific process skills in electrolyte and non-electrolyte solution topics. In addition, Fadhilah and Yerimadesi (2025) found that ethnoscience-integrated digital learning materials enhanced students' engagement and understanding of chemistry concepts. Other studies have also demonstrated that digital modules provide flexible and interactive learning experiences that support students' learning outcomes. However, studies that combine ethnoscience, interactive e-modules, and Heyzine Flipbook technology in acid-base chemistry learning remain limited. Furthermore, the integration of cassava fermentation ethnoscience into a Heyzine Flipbook-assisted e-module has not been widely explored. Therefore, this study addresses this gap by developing and evaluating a Heyzine Flipbook-assisted e-module integrating cassava fermentation ethnoscience for acid–base chemistry learning.

A preliminary needs analysis revealed that chemistry learning materials were still dominated by conventional textbooks and lacked interactive features as well as contextual integration of local culture. Therefore, this study aimed to develop a Heyzine Flipbook-assisted e-module integrating cassava fermentation ethnoscience and to evaluate its validity, practicality, and effectiveness in supporting acid-base chemistry learning among senior high school students.

2. RESEARCH METHOD

Research Design

This study employed a Research and Development (R&D) approach aimed at developing and evaluating an instructional product in the form of an e-module assisted by Heyzine Flipbook and integrating cassava tape ethnoscience for acid-base chemistry learning. The research adopted the Borg and Gall development model because this model provides systematic procedures for producing educational products and evaluating their feasibility before implementation (Borg & Gall, 1993).

The development process This research reached the fifth of ten stages: research and information gathering, planning, product draft development, field trials, and revision of the initial product. At the problem identification stage, observations and preliminary analysis were conducted to identify challenges in chemistry learning, particularly in acid–base materials. The information gathering stage involved collecting supporting references related to e-module development, digital learning media, ethnoscience approaches, and curriculum requirements.

After obtaining preliminary information, the product design stage was conducted by developing learning content, integrating ethnoscience contexts related to cassava tape fermentation, and designing interactive features using the Heyzine Flipbook platform and HTML5 Package. The developed product was then evaluated through expert validation and revised according to suggestions before being implemented in a limited trial. To evaluate its effectiveness, a One Group Pretest-Posttest Design was implemented by comparing students' learning outcomes before and after the use of the developed e-module.

Table 1. Research design

Pretest	Treatment	Posttest
O_1	X	O_2

Description:
O_1 = Pretest
X = Learning using Heyzine Flipbook
O_2 = Posttest

Participants

The participants involved in this study consisted of several groups to support product evaluation comprehensively. The validation process involved media experts and subject matter experts who assessed the feasibility of the developed e-module in terms of instructional design, content accuracy, presentation quality, and media appearance. Practicality evaluation involved chemistry teachers and eleventh-grade students at the senior high school level.

Table 2. Participants

No	Participants	Total
1	Material expert	2 people
2	Media expert	2 people
3	Chemistry teacher	3 people
4	Students of class XI IPA	36 students

Data Collection

Data collection was conducted using both non-test and test instruments. Non-test instruments included validation questionnaires, teacher response questionnaires, and student response questionnaires. Validation questionnaires were administered to experts to assess product feasibility before implementation. Teacher and student questionnaires were This study adopted a Research and Development (R&D) methodology following the Borg and Gall development model. The developed product was a Heyzine Flipbook-assisted e-module integrating cassava tape ethnoscience for acid–base chemistry learning.

Validation Technique

Media validation was conducted by material experts and media experts using validation sheets. Material validation included content and language aspects, while media validation included display and usability aspects.
The validation data were analyzed using the following formula:
$P = (\Sigma X / \Sigma Xi) \times 100$

Table 3. Validation Criteria

Percentage	Category
81–100%	Very Valid
61–80%	Valid
41–60%	Fairly Valid
21–40%	Less Valid
0–20%	Invalid

Data Analysis

The effectiveness of the developed e-module was analyzed through students' learning outcomes using pretest and posttest scores. To determine the improvement in students'

understanding after using the learning media, normalized gain (N-gain) analysis was applied using the following formula:

$$N\text{-}gain = \frac{Posttest - Pretest}{100 - Pretest}$$

The obtained N-gain scores were interpreted into three categories. A score greater than 0.70 indicated high improvement, a score between 0.30 and 0.70 indicated moderate improvement, and a score below 0.30 indicated low improvement. This analysis was conducted to determine the effectiveness of the developed e-module in improving students' understanding of acid–base chemistry concepts.

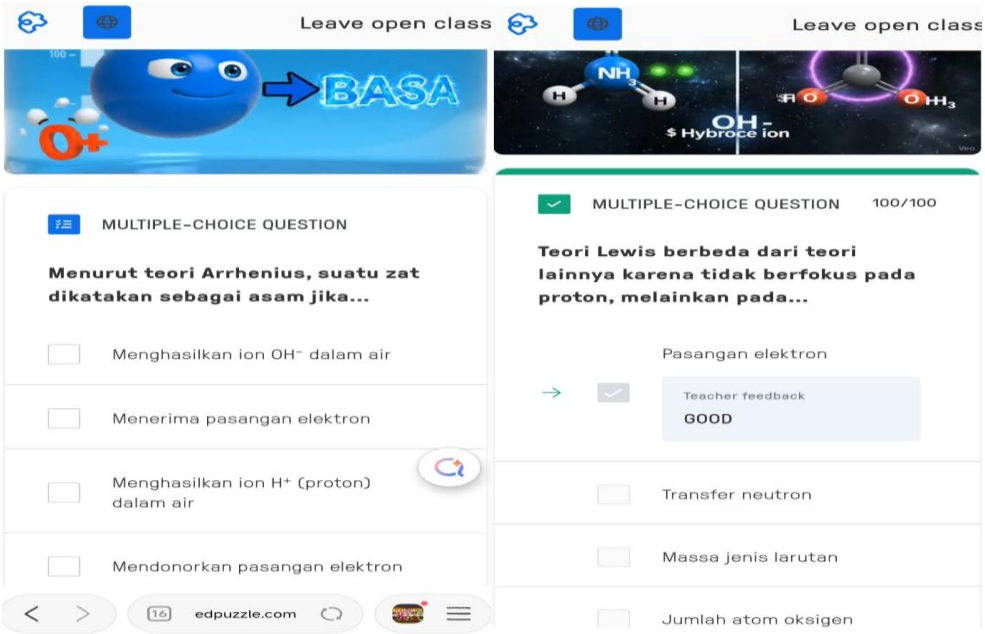
Table 4. N-Gain Categories

N-Gain Value	Category
g > 0.7	High
0.3 ≤ g ≤ 0.7	Medium
g < 0.3	Low

3. RESULTS AND ANALYSIS

This section describes the results obtained during the development, validation, and implementation stages of the Heyzine Flipbook-assisted e-module integrating cassava tape ethnoscience on acid-base material. The findings are presented quantitatively and qualitatively to provide a comprehensive evaluation of the developed product. Quantitative data were obtained from expert validation sheets, teacher and student response questionnaires, and pretest-posttest assessments. Meanwhile, qualitative data were derived from suggestions and comments provided by validators and users during the revision process. The discussion focuses on the validity, practicality, and effectiveness of the developed e-module in supporting students' understanding of acid-base concepts through contextual learning experiences that integrate local cultural knowledge and digital technology.

Product Development Results



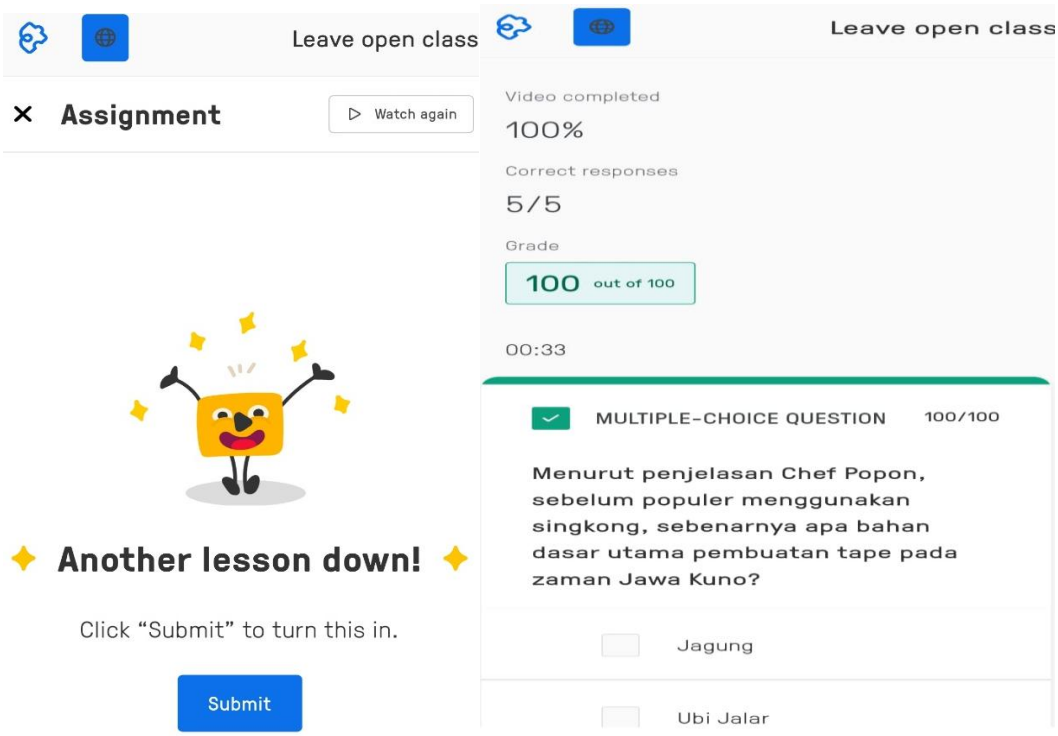


Figure 1. Product Development

3.1. Validation Results

Product validity was evaluated by one material expert and one media expert. The assessment covered aspects of content suitability, presentation, language, graphical design, and media functionality. The validation results are presented in Table 5.

Table 5. Material Expert Validation Results

Aspect	Average Score	Category
Content Feasibility	92,857%	Very Valid
Presentation Feasibility	93,236%	Very Valid
Language	91,425%	Very Valid
Average	**92,506%**	**Very Valid**

Based on Table 5, the material expert validation results indicate that the developed e-module achieved an average score of 92,506%, which falls into the very valid category. The content feasibility aspect obtained a high score, indicating that the learning materials were aligned with the learning objectives, curriculum requirements, and acid–base concepts. The presentation aspect demonstrated that the organization of the material, illustrations, and learning activities supported students' understanding. Furthermore, the language aspect showed that the e-module used clear, communicative, and grammatically appropriate language, making the content easy for students to understand.

Based on the media expert validation results, the developed e-module was evaluated in terms of media display, media operation, typography, and usefulness. These aspects were assessed to ensure that the e-module met the criteria for an effective and user-friendly learning medium. The results of the media validation are presented in Table 6.

Table 6. Media Expert Validation Results

Aspect	Average Score	Category
Media Display	92,857%	Very Valid
Media Operation	93,236%,	Very Valid
Typography	90%	Very Valid
Usefulness	91,425%	Very Valid
Average	**91,879%**	**Very Valid**

Based on Table 6, all aspects of media validation obtained very high scores, indicating that the developed e-module was highly feasible for implementation in chemistry learning. The validators considered the visual appearance attractive, the navigation system easy to operate, the typography readable, and the overall media beneficial for supporting students' learning activities.

3.2. Practicality Test Results

Based on the results of the student response questionnaire, the percentage for each aspect is presented as follows.

Table 7. Percentage of Student Responses

Aspect	Percentage	Category
Ease of Use	90.12%	Very Practical
Presentation	88.45%	Very Practical
Attractiveness	91.36%	Very Practical
Usefulness	88.62%	Very Practical
Average	**89.64%**	**Very Practical**

The data indicate that students' responses toward the developed e-module were categorized as very practical. The attractiveness aspect obtained the highest percentage score of 91.36%, indicating that students were highly interested in the visual appearance, interactive features, and ethnoscience integration presented in the e-module. Meanwhile, the presentation aspect obtained the lowest percentage score of 88.45%; however, it still fell within the very practical category. Overall, the average percentage score of 89.64% demonstrates that the developed Heyzine Flipbook-assisted e-module was practical, easy to use, and well accepted by students as a learning resource for acid-base chemistry.

3.3 Comparison of Pretest and Posttest Scores

To determine the improvement in students' understanding of the learning material, a preliminary test (pretest) and a final test (posttest) were conducted. The scores obtained by the students were then compared to identify changes in learning outcomes after the learning process was carried out.

Table 8. Descriptive Statistics of Pretest and Posttest Scores

Test	Highest Score	Average Score	Lowest Score
Pretest	60	41.39	25
Posttest	90	73.33	58

Based on the data presented in Table 8, students' learning outcomes improved after the implementation of the Heyzine Flipbook-assisted e-module integrating cassava tape ethnoscience. Before using the e-module, the average pretest score was 41.39, indicating that students had limited understanding of acid–base concepts. The highest pretest score was 60, while the lowest score was 25. After the learning process, the average posttest score increased to 73.33, with the highest score

reaching 90 and the lowest score increasing to 58. These results indicate a significant improvement in students' understanding of the learning material.

The increase in students' learning outcomes suggests that the developed e-module effectively supported the learning process. The integration of multimedia features through Heyzine Flipbook and the contextual presentation of acid-base concepts using cassava tape ethnoscience helped students understand the material more easily and meaningfully. Furthermore, the interactive activities provided within the e-module encouraged active participation and independent learning. Overall, the comparison between pretest and posttest scores demonstrates that the developed e-module contributed positively to improving students' understanding of acid-base chemistry concepts.

3.4 N-Gain Analysis

Based on the pretest and posttest data, the effectiveness of the developed e-module was evaluated using the normalized gain (N-gain) test. This analysis was employed to measure the improvement in students' learning outcomes and conceptual understanding of acid–base chemistry after the implementation of the Heyzine Flipbook-assisted e-module integrating cassava tape ethnoscience. The N-gain value was calculated using the following formula:

$$g = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

The obtained N-gain score was 0.54, which falls into the moderate category. This result indicates that the developed Heyzine Flipbook-assisted e-module integrating cassava tape ethnoscience was sufficiently effective in improving students' understanding of acid–base concepts. The moderate improvement demonstrates that the e-module successfully facilitated students in connecting theoretical concepts with real-life phenomena through interactive and contextual learning experiences.

The increase in students' learning outcomes may be attributed to the integration of multimedia features, interactive learning activities, and ethnoscience content within the e-module. The use of cassava tape fermentation as a contextual example helped students relate acid–base concepts to familiar cultural practices, making the learning process more meaningful. This finding is consistent with previous studies reporting that ethnoscience-based learning can improve students' conceptual understanding by connecting scientific concepts with local cultural knowledge (Sudrajat et al., 2021). In addition, digital learning media have been shown to enhance students' engagement, motivation, and learning outcomes through interactive and flexible learning experiences (Alifa et al., 2025). The interactive features provided through the Heyzine Flipbook platform also encouraged active participation and independent learning, supporting findings by Putra and Nurlina (2025), who reported that Heyzine Flipbook-based learning media improved students' learning interest and accessibility to learning materials. Therefore, the N-gain result of 0.54 indicates that the developed e-module contributed positively to enhancing students' conceptual understanding and learning outcomes in acid–base chemistry.

4. CONCLUSION

This study developed a Heyzine Flipbook-assisted e-module integrating cassava fermentation ethnoscience for acid-base chemistry learning using the Borg and Gall R&D model. The developed e-module demonstrated high validity based on expert evaluations and high practicality based on positive responses from teachers (91.88%) and students (89.64%). Its effectiveness was indicated by the improvement in students' learning outcomes, with the mean score increasing from 41.39 to 73.33 and an N-gain score of 0.54 (moderate category). Therefore, the e-module is considered a valid, practical, and effective learning resource for supporting acid-base chemistry learning.

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