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Development of an E-Module Based on Multiple Representation Integrated with Islamic Education to Improve Scientific Literacy and Learning Independence of Students on Buffer Solution Material

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ABSTRACT
This study aims to develop a multiple-representations-based e-module to enhance students' scientific literacy and learning autonomy in the topic of buffer solutions. The research employed a Research and Development (R&D) methodology using the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. Expert validation and limited trials involving teachers and students from three senior high schools in Pekanbaru were conducted to assess the e-module. The results indicate that the e-module is valid, practical, and effective in improving both conceptual understanding and learners' autonomy. Beyond enhancing academic performance, the integration of multiple representations enables students to interrelate macroscopic, submicroscopic, and symbolic levels of chemical concepts. Moreover, the e-module incorporates Islamic educational values, emphasizing the integration of scientific knowledge with spiritual and ethical dimensions to foster holistic learning. These findings suggest that representation-based digital learning tools can serve as an effective strategy for promoting scientific literacy and self-regulated learning in chemistry education.

Keywords: *e-module, multiple representation, scientific literacy, learning independence, buffer solutions, islamic education.*

INTRODUCTION

Educational challenges remain a significant concern for educators, particularly for in-service teachers and prospective teaching professionals. To effectively address these challenges, educators must continuously enhance their competencies to meet the learning needs of millennial students. One of the critical aspects in addressing 21st-century educational demands is the emphasis on scientific literacy as a transferable outcome in science education (Suyidno, 2022). Data from the Programme for International Student Assessment (PISA) reveal that Indonesian students still lag behind their international peers in scientific literacy, indicating the urgent need to improve these competencies (Fuadi et al., 2020). In recent years, Indonesia has consistently ranked below other countries, reflecting the low level of scientific literacy among students compared to global standards.

The 21st-century educational landscape requires both pre-service and in-service educators to strengthen their professional competencies continuously to accommodate the diverse learning needs of millennial students. Among these competencies, scientific literacy is crucial as it equips learners with the ability to think critically, solve problems, and make evidence-based decisions in daily life (Suyidno, 2022; OECD, 2023). However, data from PISA consistently demonstrate that Indonesian students' performance in scientific literacy remains below the global average, placing the nation among the lowest-ranked participants (OECD, 2023). This situation represents a pressing national educational concern, necessitating immediate action to enhance the quality of science learning and foster a culture of inquiry-based education (Fuadi et al., 2020; Sari & Prasetyo, 2022). Consequently, this study seeks to contribute to the improvement of students' scientific literacy by developing learning strategies that align with 21st-century educational demands.

The low scientific literacy of Indonesian students is largely attributed to learning practices that have not been oriented toward developing these competencies (Ardianto, 2016). This assertion is supported by interviews conducted with three chemistry teachers from State Islamic Senior High School 1 Pekanbaru, State Islamic Senior High School 3 Pekanbaru, and State Senior High School 14 Pekanbaru. The interviews revealed that students exhibit low interest in learning, limited reading and analytical skills, and insufficient ability to apply concepts in problem-solving. As a result, learning often relies solely on content memorization. This phenomenon is likely linked to traditional science education approaches, which emphasize rote memorization over the development of higher-order thinking skills. Furthermore, several theoretical perspectives suggest that low scientific literacy arises from conventional learning habits that neglect analytical skills and the integration of reading and writing competencies in science (Fuadi et al., 2020).

Achieving scientific literacy necessitates the development of supporting abilities, among which learning independence is particularly critical. Independent learning refers to students' capacity to master knowledge consciously and apply it to problem-solving without reliance on others. Learning independence is vital, as it cultivates disciplined study habits, high learning motivation, and the ability to regulate one's behavior, enabling students to complete tasks autonomously. Key indicators of learning independence include responsibility, motivation, initiative, discipline, and self-confidence. Nevertheless, previous studies have identified challenges in the learning process, such as the underutilization of technology, which limits the effectiveness of learning activities (Aji et al., 2020). Many students face difficulties accessing high-quality chemistry learning resources, particularly materials involving calculations, reactions, and complex topics.

Preliminary studies conducted through interviews with chemistry teachers and questionnaires distributed to students across three schools—State Islamic Senior High School 1 Pekanbaru, State Islamic Senior High School 3 Pekanbaru, and State Senior High School 14 Pekanbaru—revealed several limitations in existing teaching materials. Teachers reported that available resources, such as textbooks, e-modules, PowerPoint presentations, and PDF e-modules, inadequately addressed aspects of scientific literacy, lacked focus on specific skills, and did not sufficiently promote independent learning. Additionally, self-assessment components were often missing, and content organization was primarily based on basic competencies rather than aligning with the 2013 curriculum. Teaching materials predominantly consisted of text and images, resulting in monotonous and less engaging learning experiences. Consequently, the absence of scientific literacy integration in both the learning process and instructional materials limits students' learning independence, lowers motivation, impairs decision-making, and negatively affects learning outcomes (Fitriana, 2023). Implementing teaching materials that integrate scientific content, processes, and application contexts can facilitate students' independent learning. The findings also indicate that teachers have not fully leveraged technology in chemistry instruction, thereby limiting efforts to meet the challenges of the 4.0 Industrial Revolution and 21st-century learning demands.

From the perspective of Islamic Education, the development of scientific literacy and learning independence should be grounded in values that balance intellectual, spiritual, and moral dimensions. In Islam, science is regarded as a means to recognize the signs of Allah's creation (ayat kauniyyah), guiding learners to develop both analytical reasoning and spiritual awareness (Nasr, 2021; Al-Attas, 2018). Integrating Islamic values into digital learning media, such as e-modules, allows students to perceive chemistry concepts not merely as abstract theories but as manifestations of divine order, fostering curiosity, ethical reasoning, and environmental responsibility (Yuliana et al., 2022). This integrative approach supports the holistic development of students as insan kamil—individuals who are intellectually competent and spiritually conscious—aligning with the vision of Islamic education that harmoniously integrates knowledge ('ilm) and faith (iman) (Rahman, 2020).

Various strategies can be employed to enhance students' learning independence and scientific literacy, one of which is the development of tailored teaching materials. Modules, in particular, serve as planned learning units designed to help individual students achieve their learning objectives, facilitating independent learning with or without teacher guidance. Modules typically include learning instructions, competencies to be achieved, content material, supporting information, practice exercises, evaluation components, and feedback on results (Sukiman, 2011).

In practice, chemistry learning in schools has predominantly focused on memorizing chemical concepts rather than understanding their underlying meaning (Fatmawati, 2013). Chemistry, as defined, is a science that explains reaction mechanisms and natural phenomena scientifically, with matter and substances as its primary objects (Akaygun, 2016; Utami et al., 2017; Johnstone, 1993). Preliminary interviews with chemistry teachers also revealed that students often perceive chemistry as a difficult and uninteresting subject. This perception is exacerbated by instructional practices that fail to engage all three levels of chemical representation—macroscopic, submicroscopic, and symbolic—focusing instead on the macroscopic and symbolic levels only (Sunyono et al., 2013). Existing teaching materials minimally connect these three levels (Julia et al., 2016), highlighting the need for resources that effectively visualize chemistry content (Puspita Sari, 2023). Buffer solution material, in particular, encompasses all three levels of representation and represents an essential topic in class chemistry instruction (Devi et al., 2018; Nurusshobah et al., 2018).

To enhance students' scientific literacy and learning independence, it is necessary to provide electronic modules that learners can access independently, anytime and anywhere. The integration of multiple representations within e-modules is particularly beneficial, as previous studies have shown that such modules can improve students' independence, motivation, and learning outcomes by making learning more engaging, practical, and efficient (Harefa & Silalahi, 2019; Linda et al., 2021; Febriana & Sakti, 2021). Based on these considerations, this study focuses on the development of Multiple Representations (MR)-based e-modules for chemistry, specifically buffer solution material, integrated with Islamic Education values to promote the unity of scientific understanding and moral-spiritual insight among students.

METHODOLOGY

This study employed the Research and Development (R&D) method using the ADDIE model, which comprises five stages: analysis, design, development, implementation, and evaluation. Data were collected using interviews, student questionnaires, validation sheets, and teacher and student response questionnaires. Validation of the e-module was conducted by four experts, including three material experts and one media expert. Small-scale trials employed two approaches: one-on-one tests and user response assessments. The one-on-one tests involved three students representing high, medium, and low ability levels. User response assessments included three teachers and 30 students from State Islamic Senior High School 1 Pekanbaru, State Islamic Senior High School 3 Pekanbaru, and State Senior High School 14 Pekanbaru. The teacher response

questionnaires were administered directly to chemistry teachers of class XI in May 2023 to obtain feedback on the implementation of the e-module in the chemistry learning process. Similarly, student response questionnaires were distributed directly to 30 students from the same schools during the same period.

Responses from both teachers and students, as well as data from the expert validation sheets, were quantified using a Likert scale ranging from 1 to 4. This scaling method facilitated the evaluation of the validity and practicality of the Multiple Representations (MR)-based e-module. Moreover, the development process of the e-module incorporated principles of Islamic Education by integrating values such as responsibility, discipline, honesty, and reflection on Allah's creation throughout the learning content and activities. This integration ensures that the e-module not only enhances students' conceptual understanding and learning independence but also cultivates their moral and spiritual awareness in alignment with Islamic educational objectives.

Table 1. Rating Category Likert Scale

Scale	Information
4	Very good
3	Fine
2	Enough
1	Not good

(Sugiyono, 2017)

From the Likert scale rating category, the average percentage of each component will be calculated using equation (1).

$$P = \frac{\sum x}{\sum xi} \text{ x } 100\% \quad (1)$$

Information:

P : Percentage score (rounded)

$\sum x$: Total value of respondents' answers in one item.

$\sum xi$: Sum of ideal scores in one item

The average score results from the validation questionnaire and user responses that have been obtained are then converted into qualitative data to determine the criteria for using multiple representation-based e-modules with augmented reality, which can be seen in Table 2.

Table 2. Questionnaire Criteria Interval

Percentage (%)	Criteria
81-100	Very good/ very feasible/ very valid/ does not need revision.
61-80	Good/ eligible/ valid/ no need for revision
41-60	Good Enough/ Inadequate/ Invalid/ Revision Required
21-40	Not good/insufficient/invalid/requires revision
< 20	Extremely Unfavorable/ Extremely Inappropriate/ Extremely Invalid Needs Revision

(Arikunto, 2010)

The data obtained from the pretest and posttest were first subjected to a normality test using the Kolmogorov-Smirnov method with the assistance of IBM SPSS version 22.0. The normality test aimed to determine whether the data distribution conformed to the standard normal distribution (Rusydi, 2018). Hypothesis testing in this study was conducted using the paired-sample t-test via IBM SPSS version 22 to examine the differences between pretest and posttest scores. The analysis focused on identifying improvements in students' critical thinking skills, as reflected by their ability to analyze and respond to questions related to buffer solution material. Furthermore, the magnitude of the improvement was quantified using the N-Gain formula to evaluate the normalized gain in students' critical thinking performance.

Table 3. N-Gain Interpretation

N-Gain	Upgrade Classification
$g > 0.70$	High
$0.30 < g \leq 0.70$	Medium
$g \leq 0.30$	Low

(Hake, 1998).

RESULT AND DISCUSSION

Analysis

Front-end analysis was conducted through interviews with three chemistry teachers from State Islamic Senior High School 1 Pekanbaru, State Islamic Senior High School 3 Pekanbaru, and State Senior High School 14 Pekanbaru. The interviews revealed that chemistry lessons are generally perceived as difficult and less engaging. This perception can be attributed to the abstract and complex nature of chemistry, which demands higher-order cognitive abilities and considerable effort to comprehend (E. Susilaningsi, 2019). Additionally, teaching chemistry requires linking multiple levels of representation to facilitate student understanding (Sujak & Daniel, 2018).

Based on the interviews, teachers reported that the primary teaching materials for chemistry, particularly on buffer solution topics, consist of printed resources such as textbooks and worksheets. The only electronic-based teaching materials currently used are PowerPoint presentations. While teachers have attempted to integrate technology into chemistry instruction, its utilization has not been maximized due to the limited availability of electronic teaching resources. Consequently, challenges remain in meeting the demands of the 4.0 Industrial Revolution and the 21st-century educational landscape, as outlined in the implementation of the 2013 curriculum. Although various technology-based learning media are increasingly adopted in contemporary academic settings, their full potential has yet to be realized.

Moreover, as the participating institutions are State Islamic Senior High Schools, the integration of Islamic Education principles is emphasized. This integration ensures that learning activities encourage students to appreciate the harmony between scientific knowledge and the understanding of Allah's creation. Embedding these value-based principles aims to foster not only intellectual competence but also spiritual and moral awareness within the chemistry learning process.

Student analysis was conducted to evaluate the conditions of learners' engagement and learning processes prior to the study. The subjects consisted of class XI MAN Science students aged 15–17 years, representing the transitional period from adolescence to adulthood. Student analysis was performed using questionnaires to capture opinions, learning conditions, needs, and difficulties experienced during chemistry lessons. Results from the questionnaire highlighted several key points. Approximately 50% of students rated chemistry lessons as mediocre. Regarding learning preferences, 40.3% favored collaborative group learning. When students encountered difficulties in understanding chemistry content through teacher-provided materials, 61.6% reported seeking assistance from peers with a stronger grasp of the subject. In terms of learning media, 45.2% of students preferred electronic-based resources. From an Islamic Education perspective, the emphasis on collaboration, mutual respect, and the pursuit of knowledge (thalabul 'ilm) aligns with students' preference for interactive and cooperative learning. This reflects a holistic approach to education, addressing both intellectual development and character formation.

Subsequently, a curriculum analysis was conducted to ensure that the preparation and development of the Multiple Representations-based e-module aligned with the school's educational framework. The schools involved in this study implemented the 2017 revised K13 curriculum.

Curriculum analysis is a critical step to guarantee that the e-module's learning objectives, core competencies, and basic competencies correspond to the intended learning outcomes. Furthermore, this process ensures that the developed learning materials not only comply with the national curriculum framework but also support the cultivation of 21st-century skills, including critical thinking, problem-solving, collaboration, and scientific literacy (Kemendikbud, 2017; Nugraha et al., 2020; Rahmawati & Prasetyo, 2021).

In addition, Islamic Education values such as responsibility (amanah), discipline (istiqamah), and reflection on Allah's creation were incorporated into the curriculum alignment process. This integration ensures that the e-module fosters both academic skills and spiritual development, consistent with the objectives of Islamic education. Therefore, curriculum alignment represents a foundational stage in the development process, ensuring the relevance, validity, and pedagogical effectiveness of the e-module.

Design

At the planning stage, the media design aspects to be developed were determined. The Multiple Representation-based e-module was designed using Flip Builder Software as a solution to the problems identified during the preliminary analysis phase.

Instrument for Assessing the Quality of Teaching Materials

The instrument employed to evaluate the quality of the teaching materials consisted of a questionnaire assessing the e-module based on Multiple Representations developed using Flip Builder Software. At this stage, the researchers constructed a product assessment questionnaire grid. The assessment instruments included a checklist for material experts, media experts, and learning practitioners (i.e., chemistry teachers), as well as a questionnaire for students. These instruments were reviewed and validated by chemistry education lecturers at Riau University. Validation results from three material experts and three media experts indicated that the product was deemed "Suitable for Use Without Revision."

Prototype Content Design

The contents of the Multiple Representation-based e-module prototype were prepared with reference to the indicators of competency achievement and learning materials identified during the material analysis stage. The content sources included high school/MA chemistry textbooks, university-level chemistry textbooks, and relevant internet resources, particularly related to molecular shapes and intermolecular interactions. Learning activities within the e-module were structured according to the principles of Multiple Representations, which include: (1) orienting students to problems containing multiple representation aspects, namely macroscopic, submicroscopic, and symbolic; (2) organizing students to engage in structured learning; (3) guiding students both individually and in groups to discover concepts; (4) facilitating the development and presentation of individual or group work; and (5) analyzing and evaluating the problem-solving processes presented through multiple representations (Khoiriyah, 2015)

Product Design (Storyboard)

The e-module was designed through several stages, beginning with the creation of the cover page using Photoshop by applying the polygon tool, clipping mask, blending, and type tools. The cover features essential elements such as the e-module title, subject name, class, and semester, along with the logos of Tut Wuri Handayani, Riau University, and K-13, as well as an image representing the course topic and the author's identity. The content layout was then developed in Canva using various tools such as shape menu, shape fill, text boxes, and background, organizing the material systematically into three main parts: introduction, core, and conclusion. Finally, the closing section

includes a bibliography containing all references used in the development of the e-module materials.

Development

The development phase involves two processes: prototyping and material validation.

The prototyping process

The prototyping process involves transforming the storyboard design into an actual Multiple Representation-based e-module prototype. Flip Builder Software technology was used for this purpose. Following material collection and design, the teaching materials were developed using Canva to present content in an engaging manner. The prototype was enhanced with 3D visualizations, including embedded links and YouTube videos, to enrich the learning experience. Flip Builder offers the advantage of integrating diverse multimedia content such as audio, music, flash animations, videos, and hyperlinks within the teaching materials. The developed teaching materials were initially produced in PDF format and subsequently uploaded to the Flip Builder application. Flip Builder supports multiple publishing options beyond flash-based formats, including HTML and EXE, allowing the e-module to be accessed both offline and online.

Validation

Validation was conducted by expert validators to assess the prototype in terms of material content, learning design, visual presentation (visual communication), and software utilization, using the provided validation sheets and rubrics. Three material experts and three media experts participated in the validation process. The validation outcomes included suggestions, comments, and feedback, which served as the basis for revising the e-module and preparing it for student trials.

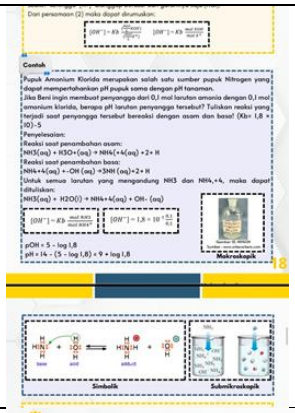
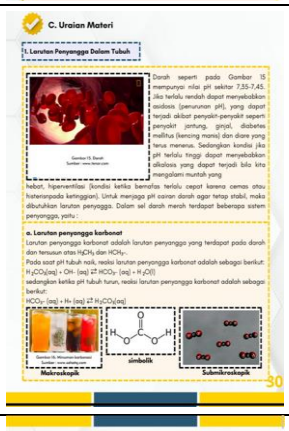
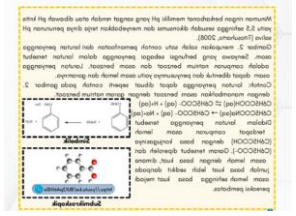
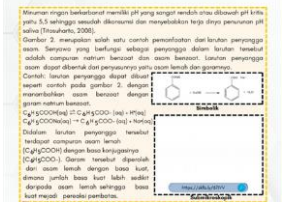
Material Validation, Assessment by three material validators uses a validation sheet in the form of a 1-4 Likert scale. Material expert validation assessment is based on content, pedagogic, language, and graphic aspects. The results of the average percentage of each aspect of the material validation assessment can be seen in Table 4.

Table 4. Percentage of Material Expert Validation Results

No.	Rated aspect	Percentage (%)	
		Validation I	Validation II
1	Content Eligibility	78.8	92.9
2.	Pedagogy	81.8	96.2
3.	Language Assessment	68.7	91.7
4.	Graphics	80.6	93.05
Average		**77.5**	**93.5**

The material validation stage was conducted in two rounds. In the first validation, the average score across the four assessed aspects reached 77.5%, categorizing the e-module as valid. Although the initial results indicated validity, the material validators provided suggestions for improvement. Based on this feedback, the researchers revised the e-module to enhance its quality according to the Multiple Representations approach. Following these revisions, a second validation was conducted, resulting in an increased average score of 93.5%, which falls into the "very valid" category.

Table 5. Results of Material Expert Validation Revision

No	Form	Physical Results		Description
		Initial	Final	
1	Replace inappropriate images so as not to cause errors in meaning			Replacing inappropriate images that can cause errors in meaning.
2	Adjust the material to multiple representative levels.			Adjust the material to multiple representative levels
3	Adjust the writing of the molecular formula			Adjust the writing of the molecular formula

Media Validation, media validation involves one validator, who is an expert lecturer in the media field. Media validation uses a validation sheet in the form of a Likert scale of 1–4. The purpose of this media validation is to assess *e-modul* based on a Multiple Representations approach based on three aspects: *e-modul* cover design, and *e-modul* content. The results of the average percentage of each aspect of the media validation assessment can be seen in Table 6.

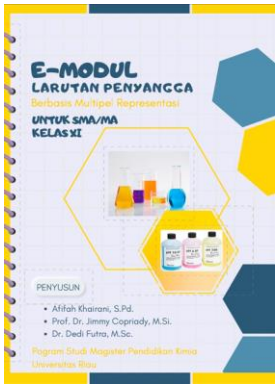
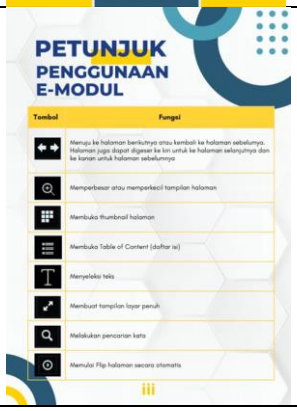
Table 6. Results of Media Expert Validation

No.	Rated aspect	Percentage (%)	
		Validation I	Validation II
1.	*e-modul* cover design	70.8	93.8
2.	*e-modul* content design	80.3	92.4
Average		**75.5**	**93.1**

The media validation stage was conducted in two rounds. In the first validation, the average score across the three assessed aspects was 75.5%, categorizing the e-module as valid. Although the initial results were deemed valid, the media validators provided suggestions for improvement. In response, the researchers revised the e-module to enhance its quality, incorporating Multiple

Representations with the addition of augmented reality content on molecular shapes and intermolecular interactions. Following these revisions, a second validation was carried out, resulting in an increased average score of 93.1%, which is classified as "very valid."

Table 7. Media Expert Validation Revision Results

No	Form	Physical Results		Description
		Initial	Final	
1	On the e-module cover, increase the font size, add a logo, drafting team and change the image.			Increase the size of the letters, add logos, composition teams and change images.
2	Add instructions for using the e-module equipped with buttons and their functions.			Added instructions for using the e-module which is equipped with buttons and their functions.

Implementation

This step is to implement learning media in the learning process at school. By conducting one-on-one trials, small-scale trials, and large-scale trials involving students, we can find out students' responses to e-modul.

Test each one one by one

The one-on-one test of the Multiple Representation-based e-module involved three class XII students from State Islamic Senior High School 1 Pekanbaru, who had previously studied buffer solution material in class XI. The test was conducted sequentially, with each student completing the session individually before the next student began. The participants were selected to represent different academic ability levels: high, medium, and low. During the test, each student received worksheets aligned with the Multiple Representations approach and was guided by the researchers in using the e-module. Students actively participated in the learning activities and completed the exercises contained within the e-module. After the session, interviews were conducted to gather students' feedback, comments, and suggestions for improving the e-module. The collected feedback is summarized in Table 8.

Table 8. Student Comments and Suggestions on the One-on-One Test

Student Code	Comments and Suggestions
ZHI	Comment: 1. The *e-modul* used is very interesting, and the color combination is just right, so it keeps me from getting bored quickly while studying. 2. The writing is easy to read and clear. Suggestion: Picture quality was clarified.
SA	Comment: 1. The provided *e-modul* is interesting and unique, and it can serve as adequate teaching material for online learning. 2. The tasks given are not too many so they are efficient in terms of processing time. Suggestion: There are some typos that need to be fixed.
PR	Comment: The given *e-modul* has a good appearance and is easier to use. Suggestion: There are some typo words that need to be fixed.
Conclusion	Comment: *e-modul* is developed attractively and easy to use. Suggestion: Improve image quality and fix typo words.

Based on Table 8, students provided positive feedback regarding the Multiple Representation-based e-module. They stated that the e-module increased their interest in learning, maintained their engagement, and prevented boredom during study sessions. This was attributed to the e-module's visually appealing design, unique features, and user-friendly interface. These findings align with Adawiyah (2020), who noted that engaging teaching materials can enhance students' interest and motivation to participate in learning. Interviews conducted during the one-on-one test further revealed that the clarity of learning content in the e-module was considered good. However, some vocabulary used was non-standard and required revision. In terms of impact, students perceived the e-module positively, as it facilitated better understanding of the material through diverse multimedia content and was consistent with their cognitive preferences.

Small-Scale Trials

At this stage, the researcher acted as an observer without directly interacting with the participants. Responses during the small-scale trial were collected from three chemistry teachers and 30 students using a structured small-trial response questionnaire. Data collection was conducted at State Islamic Senior High School 1 Pekanbaru, State Islamic Senior High School 3 Pekanbaru, and State Senior High School 14 Pekanbaru. For the teacher response assessment, teachers were first provided with the e-module and given sufficient time to review its content thoroughly before completing the response questionnaire. The results of the teacher response questionnaires are summarized in Table 9, reflecting teachers' evaluations of the e-module's quality, usability, and effectiveness in supporting chemistry learning.

Table 9. Teacher Response Questionnaire Data

Respondent	Percentage (%)	Criteria
Teacher 1	93.75	Very good
Teacher 2	87.5	Very good
Teacher 3	91.25	Very good
Average	**91**	**Very good**

With an achievement rate of 91%, the teacher responses to the e-module were classified as very good. As shown in Table 9, teachers considered the e-module to be highly user-friendly, with information and learning activities presented in an organized manner that aligns with the learning indicators and objectives. Additionally, teachers expressed strong support for the development of this e-module, recognizing it as an effective alternative teaching tool capable of capturing and maintaining students' attention.

Student response questionnaire data, the collection of student responses was conducted using questionnaires administered to 30 class XII Science students from three different schools: State Islamic Senior High School 1 Pekanbaru, State Islamic Senior High School 3 Pekanbaru, and State Senior High School 14 Pekanbaru. Students were provided with the e-module and given sufficient time to review its content before completing the response questionnaire. The results of the student response questionnaires are presented in Table 10, reflecting students' evaluations of the e-module's usability, content clarity, and overall learning experience.

Table 10. Student Response Questionnaire Data

School	Percentage (%)	Criteria
MAN 1 Pekanbaru	92.1	Very good
MAN 3 Pekanbaru	93.9	Very good
SMAN 14 Pekanbaru	95.0	Very good
Average	**93.7**	**Very good**

Based on Table 10, the distribution of student response questionnaires across the three schools yielded an average score of 93.7%. This indicates that the Multiple Representation-based e-module developed in this study received a very positive response from students. These findings are consistent with previous research on worksheet development by Apriani et al. (2021), which reported an average student response score of 87%, also categorized as very good. The high student response reflects that the developed e-module effectively captures students' attention due to its visually appealing design, engaging presentation, and use of multimedia that facilitates understanding. Additionally, the e-module contains learning activities that promote active student participation, thereby enhancing enthusiasm and motivation to learn. Based on the results of the small-scale trials, it can be concluded that the Multiple Representation-based e-module received very positive feedback from both teachers and students as end users. Following the validation and small-scale testing stages, necessary revisions were implemented, resulting in the finalized version of the e-module.

Big-scale trials

As for the large-scale trial stage that is being carried out, it is to test the effectiveness of the product. Field trials were carried out at State Islamic Senior High School 1 Pekanbaru on students in class XI IPA Riset 1, totaling 34 people as the experimental class, and class XI IPA IT 2, totaling 32 people as the control class.

Scientific Literacy, Large-scale trials represent the implementation stage of the developed teaching materials. This stage aimed to evaluate the effectiveness and impact of the Multiple Representation-based e-module on students' scientific literacy. The influence of the e-module on scientific literacy and learning independence was assessed using pretest and posttest data, collected through questionnaires and a set of 20 multiple-choice questions designed based on scientific literacy indicators. Data on students' interest in learning were obtained from questionnaires administered before and after the use of the Multiple Representation-based e-module. These data provide insights into changes in students' scientific literacy and engagement resulting from the implementation of the developed teaching materials, as summarized in Table 11.

Table 11. Descriptive Statistics on the Value of Scientific Literacy Ability

	Experiment Class		Control Class	
	Pretest	**Posttest**	**Pretest**	**Posttest**
Sampel	34	34	32	32
Average	38.53	71.76	38.75	61.09
Score Max	65	90	60	90
Score Min	20	55	20	40

Based on the data presented in Table 11, the experimental class consisted of 34 students, while the control class consisted of 32 students. The average pretest score of the experimental class was 38.53, which increased to 71.76 in the posttest. In the control class, the average pretest score was 38.75, rising to 61.09 after instruction. In the experimental class, the highest pretest score was 65, and the highest posttest score reached 90, while the lowest pretest score was 20 and the lowest posttest score was 55. For the control class, the highest pretest score was 60, increasing to 90 in the posttest, whereas the lowest pretest and posttest scores were 20 and 40, respectively. A normality test was conducted using SPSS version 24 by applying the Kolmogorov-Smirnov test with a significance level of 0.05. The Kolmogorov-Smirnov method is considered an effective and valid approach for testing the normality of large samples. According to Dahlan (2010), for sample sizes greater than 50, the Kolmogorov-Smirnov test is recommended, whereas the Shapiro-Wilk test is used for samples of 50 or fewer. The results of the normality test for the learning interest data are presented in Table 12.

Table 12. Data Normality Test of Scientific Literacy Ability

	Kolmogorov-Smirnov		**Conclusion**
		Sig.	
Pretest	Experiment	0.189	Normal
	Control	0.74	Normal
Posttest	Experimet	0.176	Normal
	Control	0.189	Normal

Based on the significance values presented in Table 12 from the normality test, the pretest and posttest scores for scientific literacy in both the control and experimental classes were found to be normally distributed. This is indicated by significance levels greater than 0.05 ($p > 0.05$). Therefore, it can be concluded that all data meet the assumption of normality. Hypothesis testing for the pretest-posttest data on students' scientific literacy was conducted using the paired sample t-test with SPSS version 23. The criteria for the paired t-test are as follows: if the significance value (sig) is greater than 0.05, the null hypothesis (H_0) is accepted and the alternative hypothesis (H_a) is rejected; conversely, if the significance value is 0.05 or less, H_a is accepted and H_0 is rejected. The results of the hypothesis test on students' learning interest data are presented in Table 13.

Table 13. Results of Hypothesis Testing Data Test of Scientific Literacy Ability

					t-test for equality of means				
Class		**N**	**Mean**	**SD**	**F**	**T**	**Df**	**Sig. (2-tailed)**	**Conclusion**
Pretest	Experiment	34	38.53	12.218	2.552	0.082	64	**0.935**	
	Control	32	38.75	9.246					Ha Accepted (There are differences)
Posttest	Experiment	34	71.76	9.035	3.679	4.062	64	**0.000**	
	Control	32	61.09	12.164					

The results of the Independent Sample T-Test indicated a difference between the pretest and posttest scores. Specifically, the posttest significance value (2-tailed) was 0.000, which is less than 0.05. This demonstrates that there is a statistically significant difference in scientific literacy between students in the experimental group and those in the control group. Since the 2-tailed significance value is <0.05, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_a) is accepted. Therefore, it can be concluded that students' scientific literacy skills in the experimental class significantly differ from those in the control class. The improvement in students' scientific literacy in both the control and experimental classes was further analyzed using the normalized gain (N-Gain) score. The results of this analysis are presented in the following Table 14.

Table 14. Data on The Improvement of Learning Outcomes in The Experimental and Control Classes

Class	Mean N-Gain	Category	Frequency	Percentage (%)
Experiment	53.93 (Medium)	High	4	12
		Medium	29	85
		Low	1	3
	Jumlah		32	100
Control	30.00 (Low)	High	2	6
		Medium	19	59
		Low	11	35
Total			**32**	**100**

From the results of the analysis above, it can be seen that the average gain score for students' scientific literacy abilities in the control class is 30%, which is included in the low category. Meanwhile, the average gain score for scientific literacy abilities in the experimental class is 54% and is included in the medium category, so it can be concluded that there is a difference in scientific literacy ability scores between the control class and the experimental class. In the experimental class there was an increase in learning outcomes with an average N-Gain of 0.54. This value is included in the medium category ($0.30 \leq N - Gain \leq 0.70$).

Learning Independence, The results of measuring Learning Independence can be presented in the form of descriptive statistics in the form of the average value (mean) and its increase for both the control class and the experimental class. These results can be presented in the following table

Table 15. Descriptive Statistics Value Learning Independence

No.	Learning Independence Indicator	Percentage (%)	
		Before Using e-module	After Using e-module
1.	Confident	65	92
2.	Motivation	59	83
3.	Initiative	66	83
4.	Responsible	71	95
Percentage (%)		**66**	**88**

Based on the data in Table 15, shows that students' learning independence achieved a combined average percentage of 66% before using the e-module using flip builder software with buffer solution material and increased to 88% after using the e-module. This data shows that students' learning independence increases after taking part in learning using multiple representative based e-modules using flip builder software with buffer solution material. The results of the normality test for each variable are as follows:

Table 16 Normality Test of Learning Independence

Data Learning Independence	*Kolmogorov-Smirnov*		
	Statistic	***df***	***Sig.***
experiments before	0.106	34	0.200*
experiment after	0.139	34	0.122

Data Learning Independence	*Kolmogorov-Smirnov*		
	Statistic	***df***	***Sig.***
control before	0.131	32	0.179
control after	0.118	32	0.200*

Based on the significance level in Table 16, which has been presented for the normality test, it shows that the pretest and posttest values of Learning Independence for the control and experimental classes are normally distributed; this is indicated by a significance level that is greater than 0.005 or p> 0.005. So it can be concluded that all data is normally distributed.

Table 17. Learning Independence t-test

		F	**Sig.**	**T**	**df**	**Sig. (2-tailed)**
Value	Equal variances assumed	18.539	.000	9.943	64	.000
	Equal variances not assumed			9.715	39.122	.000

Table 17 presents the results of the hypothesis test on learning independence using the paired t-test, which yielded a significance value of 0.000. This indicates that the alternative hypothesis (H_a) is accepted, as the significance value is less than 0.05. Therefore, it can be concluded that there is a significant difference in learning independence resulting from the implementation of the Multiple Representation-based e-module using Flip Builder software among class XI students at MAN 1 Pekanbaru. Based on these findings, it can be stated that the Multiple Representation-based e-module developed using Flip Builder software positively affects students' learning independence in buffer solution material. These results are consistent with the study by Munifatun Muthoharoh et al. (2017), which reported that the use of Multiple Representation-based e-modules enhanced students' learning independence, as evidenced by improvements observed after participants engaged with the e-modules in chemistry learning.

Evaluation

The evaluation stage in this study was conducted at each phase of the ADDIE model. The purpose of the evaluation was to analyze data obtained from various research stages, including (1) analysis, comprising initial analysis, student analysis, curriculum analysis, and material analysis; (2) the design phase, including the development of assessment instruments, storyboard creation, material preparation, and compilation of tools and resources; (3) the development phase, involving validation by material and media experts; and (4) the implementation phase, which included one-on-one testing, limited trials, and field trials. The final evaluation results indicate that the e-module developed is highly valid, receives positive responses from both teachers and students, and effectively enhances scientific literacy.

From the perspective of Islamic education, evaluation encompasses not only cognitive achievement but also the integration of adab (moral conduct) and akhlaq al-karimah throughout the learning process. This aligns with the Islamic principle that knowledge ('ilm) should lead to ethical behavior and awareness of Allah (taqwa). Consequently, each stage of the ADDIE model indirectly contributes to students' intellectual, spiritual, and moral development, supporting the goal of holistic education (tarbiyah kamilah).

However, this research also faced several challenges, particularly in the use of the Multiple Representation-based e-module developed with Flip Builder software. A primary obstacle was students' mobile network connectivity, as the e-module relies on internet access. Additionally, some students experienced difficulty understanding the problems presented, which hindered their ability to proceed with learning tasks. Interviews revealed that while students found the e-module engaging, technical issues—such as broken or slow-loading links—occasionally disrupted the learning process, affecting their motivation. These challenges can be mitigated by providing

alternative visualizations, such as linking submicroscopic representations to videos embedded within the e-module. In Islamic-based learning environments, such as Madrasah Aliyah Negeri, these technical challenges also offer opportunities to instill values of sabr (patience) and istiqamah (perseverance), as emphasized in the Qur'an (Al-Baqarah: 153). Students are encouraged not only to rely on technology but also to maintain discipline, cooperate with peers, and apply problem-solving skills grounded in Islamic work ethics.

The Multiple Representation-based e-module using Flip Builder software provides several advantages for enhancing students' scientific literacy. It promotes higher-order thinking by requiring students to analyze and understand concepts before solving problems. Students engage with content across three levels of chemical representation—macroscopic, submicroscopic, and symbolic—allowing them to contextualize and internalize the material, particularly for complex topics like buffer solutions. The inclusion of 3D visualizations accelerates comprehension of submicroscopic structures, while embedded multimedia encourages independent exploration, research, and group discussions. This approach aligns with the concept of scientific literacy, which emphasizes that science is a process of discovery rather than mere memorization of facts, concepts, or principles (Pratiwi, 2019).

Within the framework of Islamic education, this discovery process encourages students to engage in *tadabbur*—reflective observation of Allah's creation—and to recognize the signs (ayat *kauniyah*) manifest in nature as evidence of divine knowledge. Studying chemistry through multiple representations thus cultivates not only scientific reasoning but also spiritual awareness, helping students appreciate that every chemical process reflects Allah's grand design in maintaining universal balance (*mizan*). Consequently, students' scientific literacy can be enhanced through the use of Multiple Representation-based e-modules developed with Flip Builder software. These e-modules foster high-level cognitive skills, independent information gathering, and comprehensive understanding across the symbolic, macroscopic, and submicroscopic levels of chemical representation. When integrated with Islamic education values, this approach promotes holistic intelligence, combining scientific reasoning with faith-based reflection, and encourages learners to perceive science and religion as complementary avenues toward understanding truth (al-*haqq*), nurturing both intellectual mastery and spiritual growth in pursuit of comprehensive education (*ta'dib*).

CONCLUSION

The Multiple Representation-based e-module on buffer solution material developed using Flip Builder software was found to be highly valid. Material validation confirmed its appropriateness in terms of content, pedagogy, language, and graphics, while media validation demonstrated the quality of module size, cover design, and e-content layout. The e-module also received very positive user responses, being regarded as highly practical by teachers and engaging by students. The implementation of the e-module was effective in enhancing students' scientific literacy, as evidenced by the N-Gain analysis, which indicated a moderate improvement in scientific literacy after using the module. Additionally, the e-module fostered students' learning independence, as shown by increased scores from the learning independence questionnaires and confirmed through paired t-test results. A positive correlation of moderate strength was observed between students' scientific literacy and learning independence. Furthermore, the integration of Islamic educational values within the e-module design encouraged students to perceive scientific learning as a form of tadabbur (reflection) on Allah's creation. This approach simultaneously nurtures intellectual, analytical, and spiritual development. Thus, the developed e-module not only improves students' scientific literacy and learning independence but also aligns with the objectives of Islamic education, supporting the formation of holistic learners who are both critically minded and spiritually grounded.

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