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Transforming Physics Education in Boarding Schools: Development of STEM-Q-Based E-Modules to Improve Science Literacy

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Abstract

Digital transformation in education is a key effort by the Indonesian government to enhance the quality of national education. This study aims to develop and implement a STEM-Q (Science, Technology, Engineering, Mathematics, and Qur'an) e-Module as an innovative solution to improve science literacy in Islamic boarding schools (pesantren). The e-Module integrates scientific concepts with Qur'anic values, providing students with a contextual and relevant learning experience. The research employs a Research and Development (R&D) approach with the 4D model (Define, Design, Develop, Disseminate). Data analysis techniques involve media validity/feasibility tests using quantitative (Likert scale) and qualitative analyses based on expert assessments, calculated by percentage. A practicality test was conducted through student response questionnaires, which were analyzed with quantitative descriptive methods to evaluate material, benefits, and media suitability. An implementation test with a one-group pretest-posttest design was analyzed using descriptive statistics and the N-Gain test. Evaluation procedures include expert validation, practicality testing, and analysis of science literacy outcomes using pretest and posttest data. Expert validation results indicate that the e-module is highly quality regarding content, usefulness, ease of use, and media suitability. Practicality tests show positive reception in the field, varying scores across participating schools. Data analysis showed a significant increase in students' science literacy after applying the electronic module, with an N-Gain value in the medium category. Developing and implementing the STEM-Q e-module effectively enhances science literacy in pesantren-based schools.

Keywords: digital transformation, STEM-Q E-Module, islamic boarding school, science literacy

INTRODUCTION

One of the developments occurring in the globalization era is digital transformation, which impacts various aspects of human life, including education. Digitalization in education brings many advances that make learning more effective, interactive, and flexible (Rahayu, Iskandar, & Abidin, 2022). According to Christensen, Johnson, and Horn (2008), digital transformation in education can improve the quality of learning by incorporating technologies that enable wider access to information and more creative learning approaches.

In Indonesia, digital transformation in education is an integral part of the government's efforts to improve the quality of national education. The Ministry of Education and Culture encourages the application of more flexible learning methods oriented toward students' needs (Sherly, Dharma, & Sihombing, 2021). One important aspect of this is the integration of technology in learning, which has the potential to enhance the effectiveness and relevance of education at various levels and types of schools (MoEC, 2022).

However, the application of this digital transformation has not been fully distributed, especially in educational institutions such as Islamic boarding schools. Islamic boarding schools are Islamic educational institutions that have become an integral part of the character building of the education system in Indonesia (Syafe'i, 2017). Boarding school-based schools have unique characteristics, integrating religious learning with general education (Kusnandi, 2017). However, these schools often face various challenges in science education, especially physics. Limited facilities, lack of resources, and traditional teaching methods can hinder the development of students' science literacy (Gunawan & Bahari, 2024).

As a branch of science, physics has an important role in developing critical thinking and problem-solving skills. However, in Islamic boarding schools, physics learning often receives less attention than religious subjects. This can potentially cause an imbalance in the mastery of science knowledge among pesantren students (Aziz & Zakir, 2022). Therefore, it is important to develop solutions that can help improve physics learning in a boarding school environment.

An approach often used in school learning is the STEM approach, which integrates 21st-century skills into education by adapting them to the latest curriculum components (Shofiyah, Wulandari, Mauliana, & Pambayun, 2022). STEM is an interdisciplinary learning approach that integrates four disciplines: Science, Technology, Engineering, and Mathematics to solve real-world problems (Pimthong & Williams, 2018). STEM-based learning can improve students' attitudes towards STEM and cognitive learning outcomes in science (Pambayun & Shofiyah, 2023). This approach also showed a significant relationship between students' attitudes towards STEM and cognitive learning outcomes in science. STEM learning integrates four fields of science: science, technology, engineering, and math. This integration helps students understand and apply science concepts in everyday life, thus improving science literacy (Purbaningrum, Ganjarjati, & Darmawan, 2024; Pujiati, 2019).

In reality, physics learning in boarding school-based schools still lacks integration between STEM and the Qur'anic approach. Qur'anic values have great potential to improve scientific understanding through good character education (Sugihati, Nurwahidin, & Sudjarwo, 2022), integration between morality and science (Ardimen, 2024), and the relevance of its teachings to the challenges of modern times. Through applying these values, individuals can be equipped with knowledge that is not only academically useful but also supports the development of good character (Nurlita, Ramadhania, Putri & Santoso, 2023).

However, in physics learning in boarding school-based schools, there is still a lack of integration between STEM and the Qur'anic approach. The STEM-Q (Science, Technology, Engineering, Mathematics, and Qur'an) approach was developed to combine scientific concepts with Qur'anic values to overcome this. This approach

aims to create learning that teaches science and integrates religious values relevant to students' daily lives. Integrating STEM-Q in education can increase students' learning motivation (Yusuf & Ma'rufi, 2022) and help them link science knowledge with moral and spiritual values.

Applying the STEM-Q approach in physics learning in Islamic boarding schools aims to bridge the religious and science education gap. By integrating Qur'anic values in physics materials, students are expected to understand scientific concepts in a context that is more relevant to their lives, while increasing engagement in the learning process and reducing the sense of unfamiliarity with science materials (Yulia, Zubainur, & Johar, 2019). To support this approach, technology-based e-modules are one of the learning media that allow students to access materials interactively and flexibly. E-modules equipped with text, images, videos, and quizzes can strengthen student involvement in teaching and learning (Prihatiningtyas & Alimah, 2021). Therefore, the development of STEM-Q-based e-modules is expected to provide practical solutions in overcoming the limitations of physics learning in Islamic boarding schools. The e-module is designed to integrate science materials with the values of the Qur'an. Using e-modules, students can learn physics with an approach that is more contextual and relevant to their religious teachings. In addition, e-modules allow learning to be done independently, providing flexibility for students to learn according to their rhythm (Prihatiningtyas & Sholihah, 2020).

This study aims to develop and implement STEM-Q-based e-modules to improve science literacy in boarding schools. The research includes several stages: e-module development, expert validation, practicality test in schools, and dissemination. This research is expected to find an effective way to improve physics learning in Islamic boarding schools through an approach that integrates Qur'anic values with STEM concepts.

METHOD

The method applied is research and development, an approach that focuses on creating new products and testing the effectiveness of these products (Sugiyono & Alfabeta, 2003). This development study refers to the concept of the 4-D model proposed by Thiagarajan, which consists of four main steps: define, design, develop, and disseminate (Ekantini & Wilujeng, 2018). In this study, the model was modified into a 4-P model, which includes the steps of Defining, Designing, Developing, and Disseminating. The purpose of using this model in the development of a course (Prihatiningtyas, Prastowo, & Jatmiko, 2012) is to (1) in the early stages of learning, students can know and be able to do activities related to the material that will be learned in the end, (2) create connections between each component, especially in terms of learning media, learning models, and desired learning objectives, (3) explain the steps needed in designing learning designs, (4) provide teaching about science literacy.

This research was conducted on Class XI students of Madrasah Asliyah (MA) but in the environment school in Jombang in the academic year 2024/2025, involving as many as 90 students. The research subject is e-module learning media based on the STEMQ approach, which was tested on grade XI students at MA X, MA Y, and MA Z in Jombang to build science literacy. The STEMQ-based e-module was developed through four systematic stages of the 4-D model:

1. Define: Conducting preliminary studies and needs analysis
2. Design: Structuring learning content and multimedia elements
3. Develop: Creating prototypes and conducting validations
4. Disseminate: Implementing and evaluating the final product

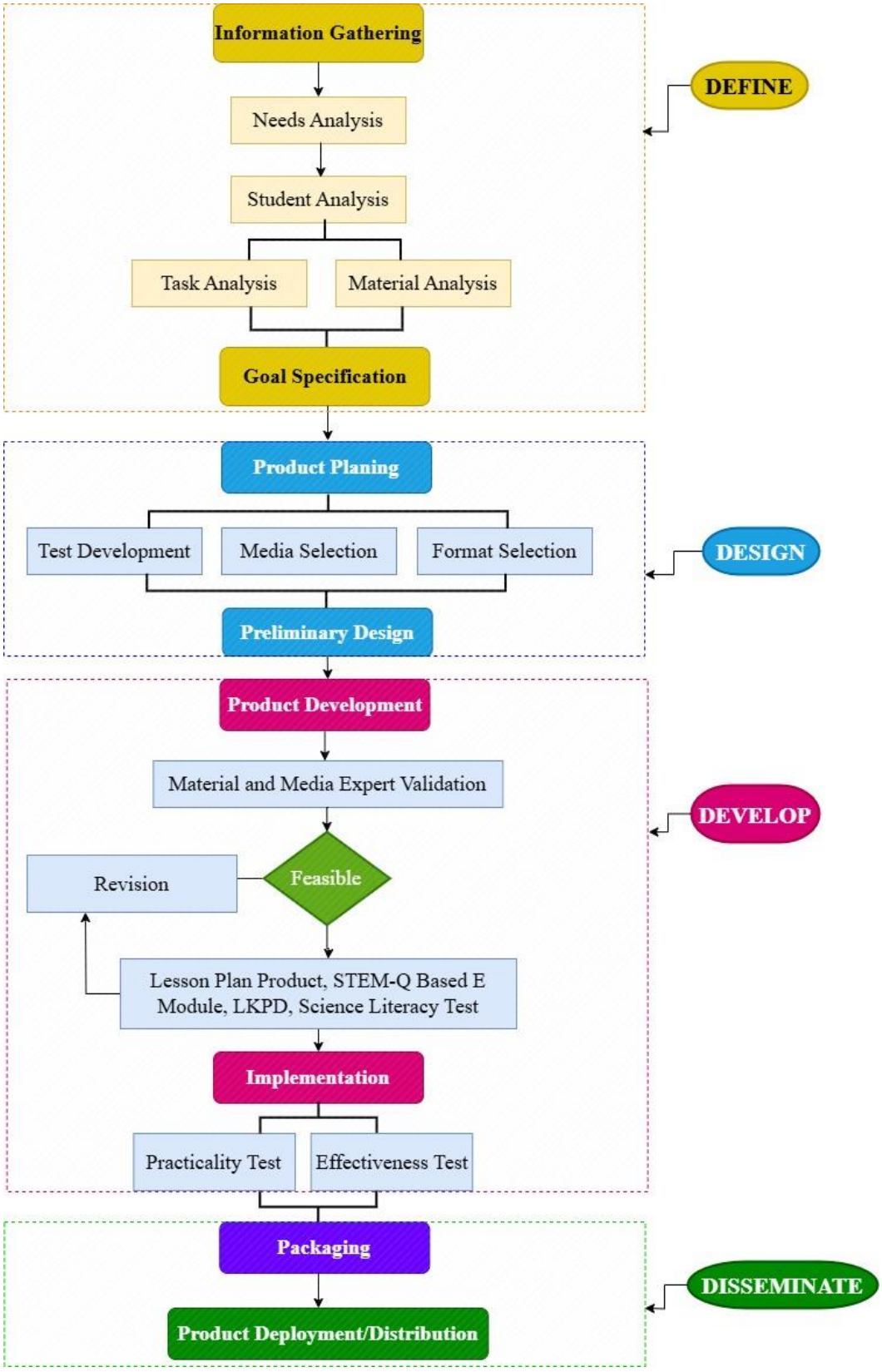


Figure 1. 4D Development Model

Before e-modules can be widely applied, it is important to conduct evaluation and validation to ensure their practicality and effectiveness. This evaluation involves assessment by experts in education and field trials to obtain comprehensive feedback. This validation ensures that the e-modules meet the necessary quality standards and can be used effectively in the intended educational environment (Gunada, Wahyudi, Ayub, Taufik, & Busyairi, 2023). Evaluation of e-modules covers various aspects such as content, benefits, ease of use, media suitability, visuals, and audio. This assessment helps identify the strengths and weaknesses of the e-module and make necessary improvements before wider implementation. This is important to ensure that e-modules can provide an Optimal learning experience for students (Prihatiningtyas, Putra, Wulandari, Pertiwi, & Riduwan, 2023).

Data collection and analysis techniques

The data for this study were collected through observation, interview, and questionnaire techniques (Cln & Iro, 2013). The data analysis techniques used in this study are described as follows:

1. Media Validity/Feasibility Test

E-module Feasibility Test was conducted by utilizing the quantitative and qualitative data analysis results as a guide to assess the suitability of the developed media, which can be referred to in Table 1.

Table 1. The validity assessment grid

Content Components and Feasibility	
A. Material Coverage	a. Breadth of material
	b. Depth of material
B. Material Accuracy	a. Accuracy of facts
	b. Accuracy of concepts
	c. Accuracy of principles/laws
	d. Accuracy of procedures/methods
	e. Accuracy of theories
C. Up-to-Date Content	a. Relevance to scientific and technological developments
	b. Timeliness of features (examples)
	c. Use of the International System of Units (SI)
D. Promoting Productivity Awareness	a. Encouraging entrepreneurial spirit
	b. Promoting work ethics
	c. Stimulating innovation, creativity, science literacy and critical thinking
E. Stimulating Curiosity	a. Encouraging a sense of curiosity
	b. Providing challenges for more active learning
F. STEMQ Integration	a. Relevance to science concepts
	b. Use of relevant technology
	c. Application of engineering principles
	d. Incorporation of mathematics in the content
	e. Integration of Qur'anic values into the content
Language Components	
A. Suitability for Student Development	a. Appropriateness for students' cognitive development level
	b. Appropriateness for students' social-emotional development
B. Communicative	a. Clarity of the message conveyed to students
	b. Relevance of illustrations to the content
C. Conciseness	a. Accuracy of sentence structure
	b. Proper use of terminology
D. Coherence and Logical Flow	a. Connection between chapters, and between sections and subsections within a chapter
	b. Connection between sentences within a paragraph
	c. Consistency of meaning within chapters, sections, and paragraphs
E. Adherence to Correct Language Rules	a. Accuracy of grammar
	b. Correct spelling
F. Use of Terms and Symbols	a. Consistency in the use of terms
	b. Consistency in the use of symbols
Presentation Components	
A. Presentation Techniques	a. Consistency in the structure of presentation within chapters
	b. Logical presentation
	c. Sequencing of concepts
	d. Connections between facts, concepts, principles, and theories

	e. Balance between chapters and between the content of sections within a chapter
	f. Relevance of illustrations to the chapter content
	g. Tables, figures, and appendices should include up-to-date references
	h. Identification of tables, figures, and appendices
B. Supporting Material Presentation	a. Introduction
	b. Appendices: Summary
	c. Appendices: Glossary
	d. Appendices: Index
	e. Appendices: Bibliography
C. Learning Presentation	a. Student-centered approach
	b. Student engagement
	c. Interactive communication
	d. Appropriateness for the characteristics of the subject matter
	e. Ability to stimulate students' higher-order thinking

Quantitative research uses a questionnaire with a Likert scale as the main instrument. Instructions related to scores using the Likert scale can be found in Table 2.

Table 2. Quantitative Analysis Score (Putra, Russitta, & Wulandari, 2023).

No	Quantitative Analysis	Score
1	Strongly agree	4
2	Agree	3
3	Disagree	2
4	Strongly disagree	1

The data collected was analyzed by adding up, comparing against the desired value to produce a percentage, which can be systematically written down:

$$\text{Percentage of eligibility (\%)} = \frac{\text{Observed score}}{\text{Expected score}} \times 100\% \quad (1)$$

The data was assessed using a quantitative descriptive analysis method represented through the distribution of scores and percentages against The predetermined rating scale categories. After being presented in percentage form, the next step is to do further description and make conclusions about each indicator. To determine the validity of learning media development, the qualification criteria can refer to Table 3.

Table 3. Conversion of Achievement Levels (Prihatiningtyas & Sholihah, 2020)

Level of achievement (%)	Qualification	Description
90 - 100	Very feasible	No need for revision
75 - 89	Feasible	Revised
65 - 74	Reasonably feasible	Revised
55 - 64	Less feasible	Revised
0 - 54	Not feasible	Revised

2. Practicality Test

The questionnaire sheet used to collect student responses to the learning media is used to evaluate how practical the learning media is, as shown in Table 4.

Table 4. The practical usability evaluation grid

Aspect	Indicator
Material	a. Clarity of the introductory material
	b. Alignment with Competency Standards (KD), Core Competencies (KI), and learning indicators
	c. Coherence of material presentation
Benefit	a. Easy to understand
	b. Provides new learning experiences
	c. Ease of use
	d. Promotes literacy skills
Usage	a. Can be used anytime
	b. Can be used anywhere
	c. Suitable for independent learning
	d. Suitable for classical (classroom) learning
Media Suitability	a. Compatibility of e-Module content with the material
	b. Adequate duration of videos in the e-Module
	c. Appropriateness of language usage
Visual	a. Typography (font arrangement)

Aspect	Indicator
	b. Image quality
	c. Text readability
	d. Color consistency of the text
	e. Layout
Audio	a. Clarity of the audio in videos
	b. Appropriateness of sound effects

The practicality evaluation sheet is then distributed to students to assess whether the media have met practical criteria or still require further adjustment, then analyzed using the following equation:

$$\text{Percentage of eligibility (\%)} = \frac{\text{Observed score}}{\text{Expected score}} \times 100\% \quad (2)$$

The determination of the level of practicality is then carried out by referring to Table 5:

Table 5. User Response Criteria (Prihatiningtyas & Sholihah, 2020)

Percentage of Weight (%)	Letter	Value	Predicate
86 - 100	A	4	Very good
76 – 85	B	3	Good
60 – 75	C	2	Good enough
55 – 59	D	1	Poor
0 – 54	E	0	Not good

3. Implementation Test

The method used in this research is a quantitative-based pre-experimental design with a one-group pretest-posttest design. Students are tested before and after learning e-modules based on the STEMQ approach. Science literacy indicators are assessed as shown in Table 6.

Table 6. Science literacy indicators assessed.

Science Literacy Indicator	Sub-Indicator
Scientific Inquiry	a. Applying the results of scientific investigation
	b. Designing and conducting investigations
	c. Formulating a hypothesis
	d. Collecting and analyzing data
	e. Interpreting results
Problem Solving	a. Identifying problems
	b. Formulating a hypothesis
	c. Applying scientific concepts
	d. Evaluating solutions
	e. Developing problem-solving strategies
Scientific Reasoning	a. Logical reasoning
	b. Using scientific models
	c. Evaluating evidence
	d. Identifying assumptions
	e. Constructing evidence-based arguments

Data analysis techniques in this study used descriptive statistical analysis techniques. A descriptive statistical analysis technique was used to provide an overview of students' science literacy achievement characteristics. Data on student science literacy results were calculated by comparing the scores obtained by students with the maximum number of scores, then multiplied by 100%. The following is the category of the success rate of students, which can be referred to in Table 7 (Riduwan, 2022).

While the increase in students' concept understanding was analyzed using the pre- and post-test results, using the normality test (N-Gain) with the formula (Meltzer, 2002, in Prihatiningtyas, 2020).

$$\text{N gain} = \frac{\text{(post-test value – pre-test value)}}{\text{(maximum value – pre-test value)}} \quad (3)$$

N-Gain criteria (increasing students' concept understanding) can be seen in Table 8.

Table 7. Learner Success Level Categories

Success Rate (%)	Category
81-100	Very high
66-80	Good
56-65	Fair
0-55	Less

Table 8. N-gain categorization

Normalized Gain	Category
N-Gain ≥ 0,7	High
0,3 ≤ N-Gain < 0,7	Medium
N-Gain < 0,3	Low

RESULT AND DISCUSSION

This research uses the research and development (R&D) method. The development model used is 4D: define, design, develop, and disseminate. The more complete explanation is as follows:

a. Define

1) Task Analysis

Task analysis aims to identify tasks and competencies that students must master in learning material about light and optical devices. Based on this analysis, it is known that learning about light and optical devices requires an understanding of physics concepts, analytical skills, and application of concepts in the context of everyday life. Integrating STEM aspects and Qur'anic values in the e-module will help students understand concepts holistically and applicably.

2) Material Analysis

The materials analyzed in this study include basic concepts about light, the properties of light, refraction, shadow formation, and the use of optical devices such as lenses, magnifying glasses, and microscopes. This material was chosen because of its relevance and application in everyday life and the basic competencies that students in Islamic boarding schools must achieve.

The specifications for developing this e-module aim to create a STEM-Q-based learning media that integrates science, technology, engineering, and mathematics with Qur'anic values. The primary goal is to provide students with a comprehensive understanding of the concepts of light and optics and their relevance to daily life. This e-module aims to facilitate more interactive, engaging, and easy-to-understand learning by incorporating content that links scientific concepts with religious teachings. In this context, several relevant Qur'anic verses can support the education of light and optics, such as Surah An-Nur (24:35), which portrays light as a symbol of Allah's guidance that illuminates the hearts of the believers. This verse provides a metaphorical depiction of light, relating it to scientific knowledge and its enlightening effect on spiritual understanding. Additionally, Surah Al-Mulk (67:3) mentions the creation of the heavens with orderly light, which can be connected to the principles of light physics and optical phenomena such as reflection and refraction. These verses support science learning, especially in light and optics, by linking the scientific concepts being studied with the spiritual values found in the Qur'an.

Based on the analysis of students' needs and characteristics, it was found that students in boarding schools have unique learning needs. In addition to understanding science concepts, they also need learning that not only hones academic skills, but also integrates religious values. Therefore, the development of STEM-Q-based e-modules is relevant and important to provide complete learning, both

from the cognitive (Walidain & Ardianti, 2024), affective (Santosa et al, 2021), and spiritual aspects (Raharjo & Puspita, 2023).

Integrating the Qur'an in science learning, especially in light and optical devices, can give students a deeper and more contextual understanding. With this approach, students are expected to understand science concepts logically and analytically and see the connection between science and the religious values they believe in. Overall, the analysis results show that the development of STEM-Q-based e-modules has great potential in improving the quality of learning, especially in boarding schools. The developed media can answer learning needs in an innovative, holistic way, and in the context of education in pesantren.

b. Design

In the development stage of the STEMQ-based e-module with Flipbook assistance on light and optics, the researcher designed and created an initial product through several stages. The first stage involved drafting the e-module, which included components such as the cover, introduction, intended learning outcomes, indicators, and content related to light and optics, like the principles of the eye, camera, microscope, magnifying glass, periscope, projector, and telescope. Additionally, the e-module was equipped with example problems and solutions, practice questions for each subtopic, student worksheets, summaries, and competency tests to assess students' understanding.

After drafting the content, the next step was editing and formatting the e-module file, which was saved in .pdf format. The file was then integrated into the Flipbook PDF Professional application to enhance interactivity, providing users a more engaging and dynamic learning experience.

The design of the e-module is divided into three main sections:

a. Front Section: This includes the cover page, introduction, core competencies, basic competencies, competency achievement indicators, learning objectives, and a concept map of the light and optics topic. The initial presentation aims to provide an overview of the e-module's content and the learning goals to be achieved.

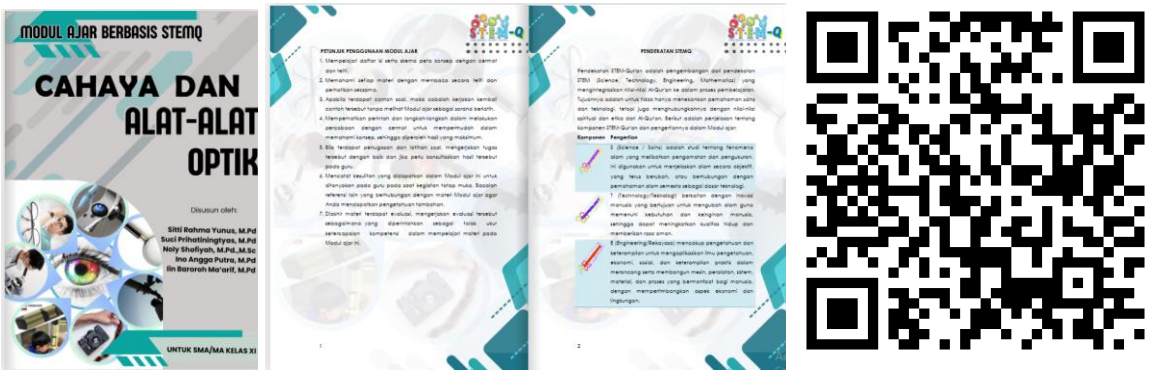


Figure 2. Example of the front section (Scan the QR code below to access more information)

b. Content Section: This section contains the primary material of the e-module, structured based on the STEMQ approach, with information about light and optics and relevant scientific processes. The material is presented in text, images, and videos supporting concept comprehension and complemented by a "Quick Info" feature to enrich students' insights. A gallery of works is also included to showcase students' experiments or projects related to the topic.

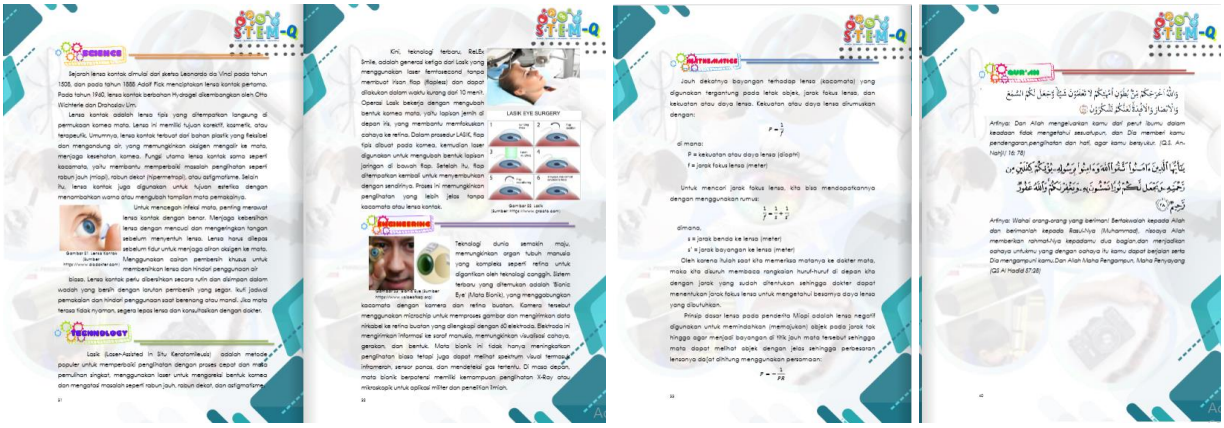


Figure 3. Example of the Content Section

c. Closing Section: It features a summary of all the material covered, a competency test to measure students' mastery, and a bibliography for references. This section reinforces students' understanding of the material and facilitates review.

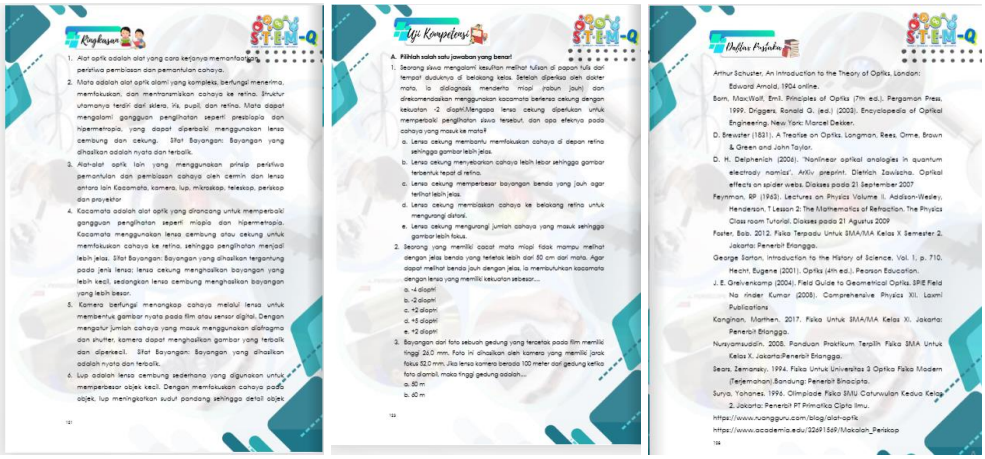
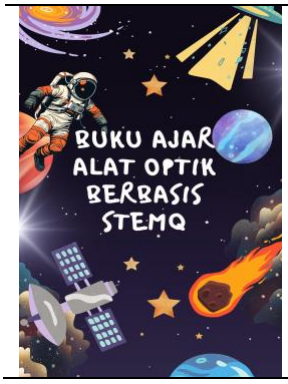


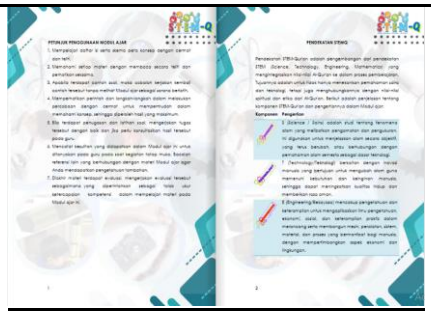
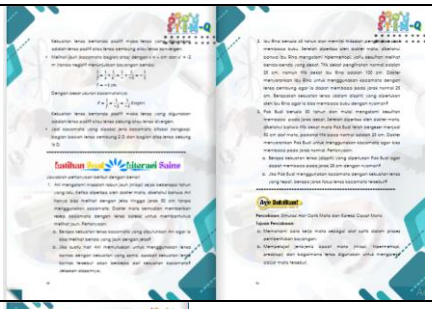
Figure 4. Example of the Closing Section

The complete design of the STEMQ-based e-module on light and optics can be viewed interactively through the Flipbook application, allowing for easier and more flexible access via the link https://heyzine.com/flip-book/cf10ab6ebc.html#page/1.

A comparison of the module before and after validation can be seen in Table 9, which highlights the improvements made in the developed module.

Table 9. A comparison of the module before and after validation

Parts that need to be revised	Parts that have been revised	Description
		**Cover Design** **Before:** The cover did not align with the optical instruments theme, and the creator's name was missing. **After:** The revised cover now depicts an optical instrument application with improved visual appeal.

Parts that need to be revised	Parts that have been revised	Description
		**User Guide** **Before:** The module lacked usage instructions. **After:** A user guide and STEMQ instructions were added.
No practical tasks		**Practical Activities & Exercises** **Before:** No practical tasks or scientific literacy questions were included. **After:** Each subsection now features hands-on activities and science literacy exercises.
		**References & Supplementary Materials** **Before:** Minimal references; no index or glossary. **After:** Expanded bibliography, with the addition of an index and glossary

c. Develop

1) Validation of Learning Tools

The development phase includes evaluations by experts and practitioners and testing of the developed product. The average validation results from media experts and subject matter experts are shown in Table 10.

Table 10. Evaluation Results of Learning Tools

Assessment Aspect	Average Score	Category	Reliability (%)
Content Components and Feasibility	3.30	Good	92
Language Components	3.00	Good	100
Presentation Components	3.10	Good	99

Based on the validation results of STEM-Q-based e-modules, the following is an analysis and discussion of these results: The STEM-Q-based e-module received an average score categorized as "Good" across all aspects, with content feasibility at 3.30 (92% reliability), linguistic components at 3.00 (100% reliability), and presentation components at 3.10 (99% reliability). These results

indicate that the e-module is generally feasible and effective in supporting STEM-Q-based learning. However, the linguistic component, which received the lowest score (3.00), suggests the need for further review, particularly in using appropriate and contextual language in the pesantren environment. The presentation component can also be improved by enhancing the structure and creating a more engaging and interactive interface.

Overall, the validation results indicate that the developed teaching materials meet the eligibility criteria for implementation in STEM-Q-based learning in the pesantren environment. The average scores, categorized as "Good" to "Very Good," show that these tools are practical, although some aspects still need improvement, particularly in language use and content presentation. With improvements in these components, these learning tools are hoped to provide more optimal results and support holistic and contextual learning in line with Islamic values. The integration of STEM into these learning tools makes them more meaningful (Lutfi, Ismail, & Azis, 2018; Afriana, Permanasari, & Fitriani,.2016), highlighting the importance of implementing learning with teaching materials that effectively achieve learning objectives. Therefore, selecting the STEM approach in this research is highly appropriate.

2) Implementation in Learning

After implementing the STEM-Q-based flipbook e-module, the next step was to measure students' scientific literacy through a posttest. The questions were grouped according to three scientific literacy indicators: scientific inquiry, problem-solving, and scientific reasoning. The percentage of correct answers was calculated for each indicator, then averaged and categorized into five achievement levels: excellent, good, fair, poor, and very poor (see Table 5). The results are presented in Figure 4, which shows the differences in scientific literacy achievement among MA_A, MA_B, and MA_C.

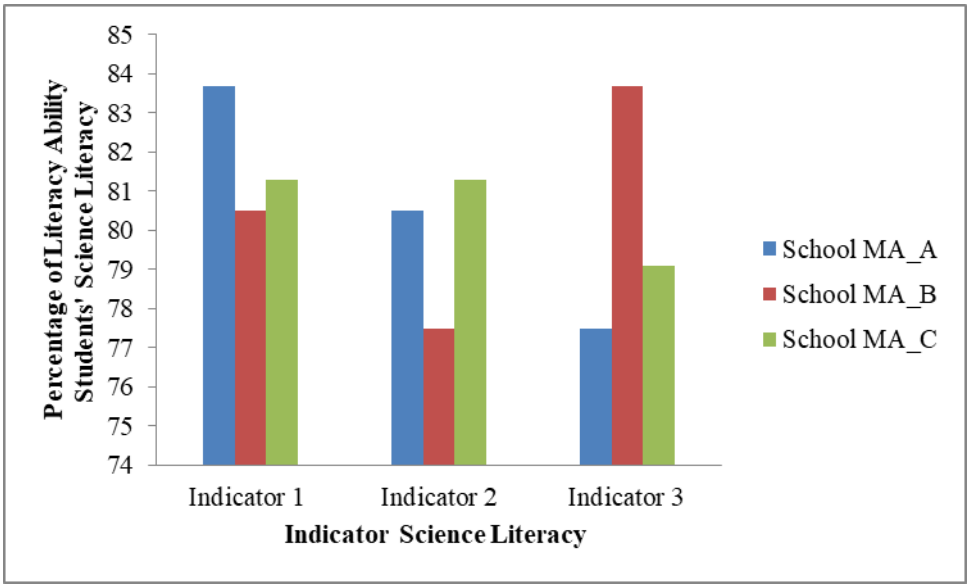


Figure 5. Percentage of Literacy Ability: Students' Science Literacy

Based on Figure 5, MA_A scored the highest (83.7) in Indicator 1 (Scientific Inquiry), while MA_B and MA_C scored 80.5 and 81.3, respectively. MA_A's strong performance may be attributed to students' high motivation, solid foundational knowledge, and interactive teaching methods, such as lab experiments and science projects. Meanwhile, MA_C excelled in Indicator 2 (Problem-Solving) with a score of 81.3, whereas MA_B had the lowest score (77.5). This suggests that MA_C students are more skilled in analyzing problems and developing solutions, possibly due to problem-based learning (PBL) or structured group discussions.

For Indicator 3 (Scientific Reasoning), MA_B outperformed the others with a score of 83.7, surpassing MA_A (77.5) and MA_C (79.1). This success may stem from students' critical thinking skills and a teaching approach integrating religious values with science, as seen in the STEM-Q curriculum.

These variations demonstrate that scientific literacy is not solely determined by students' abilities but also by external factors such as teaching methods, school facilities, and educational policies. Schools with better learning resources and innovative strategies tend to perform better, while limited infrastructure or insufficient teacher training can hinder progress.

The results of the STEM-Q-based e-module implementation, after being tested using the science literacy test, showed an increase, as shown in Figure 6.

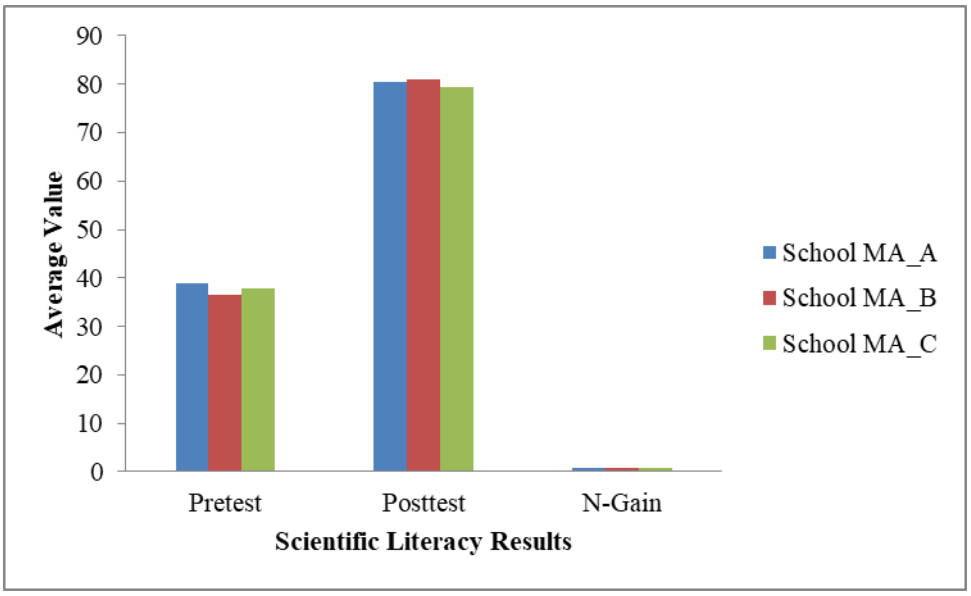


Figure 6. Improvement in Scientific Literacy Results for Three Schools

Implementing the STEM-Q-based e-module in three Madrasah Aliyah (MA) in Jombang significantly improved students' scientific literacy scores. This improvement was measured by comparing pretest and posttest scores and calculating the n-gain value. The average pretest score at MA X was 38.89, indicating a relatively low initial understanding of scientific literacy. After learning with the STEM-Q-based e-module, the posttest score significantly increased to 80.58. The N-Gain score of 0.64 indicates that the improvement in students' understanding is in the moderate category. This suggests that the STEM-Q-based learning method positively and effectively enhanced students' scientific literacy. Students at MA Y also experienced significant improvement. The average pretest score of 36.58 increased to 80.93 in the posttest. The N-Gain score of 0.67 indicates that the increase in scientific literacy is in the moderate category and is slightly higher than at MA X. This demonstrates that the e-module used was able to bridge the initial gap in students' understanding of science and effectively improve their competence. At MA Z, the average pretest score was 37.73 and increased to 79.51 in the posttest. The N-Gain score obtained was 0.64, also in the moderate category. Although the results are not significantly different from the other two schools, this improvement shows that using the STEM-Q-based e-module consistently enhanced students' scientific literacy.

Overall, the results from the three schools indicate that the STEM-Q-based e-module effectively improves students' scientific literacy in pesantren environments. With N-Gain scores ranging from 0.64 to 0.67, the improvement achieved falls within the moderate category. This suggests that the e-module helps students better

understand scientific concepts (Arnila, 2021), integrating Quranic values with the STEM approach, which is relevant to the learning needs of pesantren-based madrasahs.

This success may indicate that the learning method integrating science, technology, engineering, and mathematics with the Quran can enhance students' understanding and interest in scientific literacy (Kiswanda, Aswirna, & Nurhasnah, 2022).

3) Practicality Test

After the implementation, activities were carried out, and the practicality of the STEM-Q-based e-module was tested by having students fill out a practicality questionnaire to assess how practical the developed media is. Figure 7 shows the results of the practicality test from the three schools.

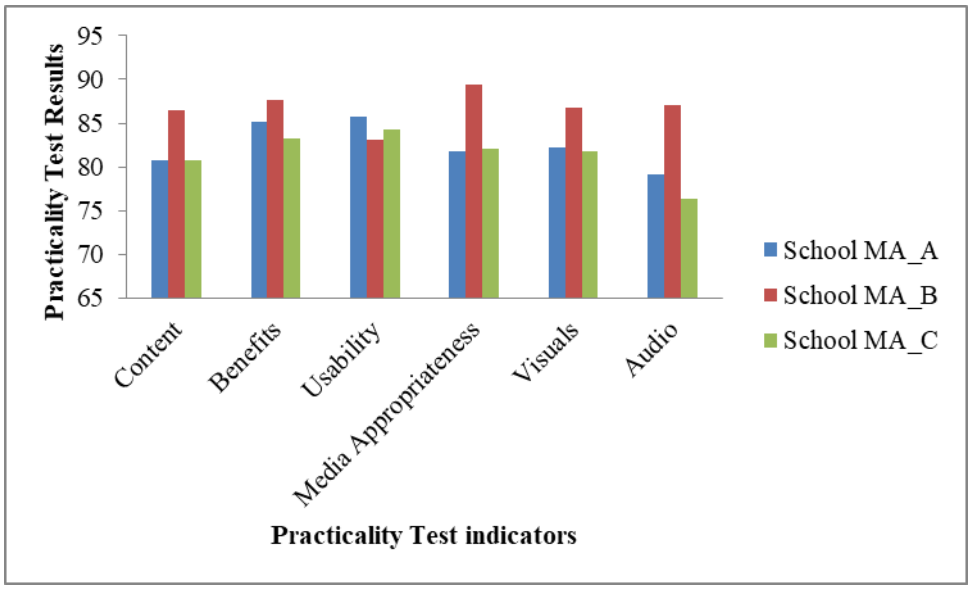


Figure 7. Practicality Test Results of STEM-Q Based E-Module Learning Media

The results of the practicality test for the STEM-Q-based e-module from three Madrasah Aliyah (MA) in Jombang indicate that this learning media is generally considered practical by users across various aspects, such as content, benefits, ease of use, media relevance, visuals, and audio. The following is a more detailed discussion of the results:

The average content aspect rating shows that the material in the e-module was rated quite well by all three schools. MA Y gave the highest score (86.5), indicating that students and teachers at this school felt the material presented was highly relevant to their learning needs. Although MA X and MA Z had lower scores (80.8), this aspect is still considered reasonable and appropriate, with room for improvement in content delivery. The benefit aspect received high ratings from all three schools, with the highest score at MA Y (87.7). This indicates that the e-module significantly supported students' learning, especially in the pesantren context. The slight differences in scores between MA X and MA Z show that the benefits of this e-module are felt almost evenly across different school environments. The ease of use aspect was rated quite well in all schools, with the highest score at MA X (85.7). This suggests that the interface and structure of the e-module are easy for users to understand and operate. The differences in scores between schools are insignificant, indicating that this e-module is user-friendly across various contexts. The relevance of the media to learning needs was rated highest at MA Y (89.4). This shows that the e-module is highly relevant to that school's curriculum and learning situation. The slightly lower scores at MA X and MA Z (81.7 and 82.1) still indicate good relevance, though some adjustments may be

needed to optimize it further. All schools rated the visual aspect well, with the highest score at MA Y (86.8). This shows that the graphical design and layout of the e-module are attractive and support the learning process. The other schools also gave favorable ratings, although there is room for improvement in visual elements to make them more engaging and interactive. The audio aspect received more varied ratings, with MA Y giving the highest score (87.1), while MA Z had the lowest score (76.3). This indicates that audio quality and clarity could be improved, especially at MA Z. It is important to ensure that the audio in the e-module is clear and easy for all students to understand.

The practicality test results show that the STEM-Q-based e-module is generally practical for use in pesantren-based madrasahs. Overall, the feedback from teachers and students regarding the STEM-Q-based e-module is very positive. This is due to the ease of access (Herlina, Ramlawati, & Hasri, 2022), which can be used via smartphone or personal computer as a link, PDF, or image (JPG/PNG). The e-module is designed with appealing colors and designs, so students do not get bored while studying physics. Additionally, the learning videos included in the module help students improve their understanding through audio-visual media.

d. Dissemination

At the dissemination stage, the primary focus is to introduce and apply the STEM-Q-based e-module more widely after it has undergone validation and limited implementation in three Madrasah Aliyah (MA). The dissemination is carried out to ensure that more students can feel the benefits of this e-module, especially in pesantren-based schools.

CONCLUSION

The research on developing and implementing a STEM-Q-based e-module for madrasahs in Jombang's pesantren environment has shown positive and significant results in improving students' science literacy. The e-module successfully integrates the STEM approach with Qur'anic values, creating a learning medium that is academically relevant and contextualized to the pesantren setting. Validation results indicate that the e-module exhibits good practicality, receiving positive evaluations regarding content quality, benefits, ease of use, media compatibility, visual elements, and audio clarity. Implementation in three schools significantly improved students' science literacy scores, with an N-Gain value categorized as moderate, demonstrating the effectiveness of the e-module in the learning process. Dissemination to other schools also showed good reception, with positive feedback from new users, including teachers and students. This suggests that the STEM-Q-based e-module has the potential for broader application in pesantren-based educational settings.

Recommendations. Given the positive outcomes, it is recommended that the STEM-Q-based e-module be distributed to more madrasahs, both within pesantren environments and general schools. Support from relevant authorities, such as the Ministry of Religious Affairs and other educational institutions, is essential to expand access to and application of this module. To optimize the distribution and utilization of the module, a digital platform that facilitates easy access to the e-module is needed. With wider online access, students and teachers from various regions can utilize this module without geographical barriers.

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