

DEVELOPMENT OF A PROBLEM-BASED LEARNING SCIENCE E-MODULE INTEGRATED WITH QUR'ANIC KAUNIYAH VERSES

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ABSTRACT

Scientific literacy and critical thinking are essential competencies for Madrasah Tsanawiyah students, particularly when science learning addresses environmental problems and responsible decision-making. This study aimed to develop and preliminarily evaluate a Problem-Based Learning science e-module integrated with Qur'anic kauniyah verses on ecosystem content. The study used a Research and Development design with the ADDIE model. Expert validators, teachers, and seven students at MTs Ma'arif Ambulu Jember participated in product review and a limited trial. Data were collected using product-validation sheets, teacher and student practicality questionnaires, a Problem-Based Learning observation sheet, and essay tests of scientific literacy and critical thinking. The test blueprints and scoring rubrics underwent expert content review; separate psychometric reliability estimates were not calculated because the trial sample was very small. The e-module obtained an average validity score of 92.50% and an average practicality score of 95.24%. In the uncontrolled pretest-posttest trial, scientific literacy increased from 45.00 to 85.00 (normalized gain = 0.73; Cohen's d_z = 5.81), while critical thinking increased from 59.57 to 88.71 (normalized gain = 0.72; Cohen's d_z = 6.78). These statistics indicate preliminary within-group improvement patterns, not causal effectiveness, because the trial involved only seven students and no comparison group. The study contributes an alignment framework that sequences contextual problems, scientific inquiry, evidence-based reasoning, and Qur'anic ethical reflection in one e-module.

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1. INTRODUCTION

Science education in the twenty-first century is expected to help students understand scientific concepts, use evidence, solve contextual problems, and participate responsibly in social and environmental issues. Contemporary scientific literacy frameworks emphasize the ability to explain phenomena, evaluate and design scientific inquiry, and interpret data and evidence for decision-making, while the most recent PISA direction also highlights agency in environmental and sustainability contexts (OECD, 2019, 2023, 2025; White et al., 2023). Therefore, science learning is no longer sufficient when it only requires students to memorize definitions or reproduce textbook information. Students need learning experiences that encourage them to observe phenomena, analyze data, formulate explanations, evaluate arguments, and connect science with

real-life decisions (Guerrero & Sjöström, 2025; Osborne & Allchin, 2025; Osborne & Pimentel, 2023).

Scientific literacy refers to students' capacity to use scientific knowledge, evaluate evidence, and make informed decisions in everyday contexts. Critical thinking complements scientific literacy because students must identify problems, distinguish relevant and irrelevant information, develop logical arguments, and evaluate claims based on evidence (Ennis, 2018; García-Carmona, 2025; Kuhn & Lerman, 2021). In ecosystem learning, these competencies are especially important because students encounter daily issues such as waste accumulation, water pollution, habitat disturbance, population imbalance, and human responsibility for environmental sustainability (Kubisch et al., 2022; Kumar et al., 2024; Tasquier et al., 2022).

In Madrasah Tsanawiyah, science learning also has a distinctive opportunity to integrate scientific concepts with Islamic values. Qur'anic kauniyah verses invite learners to observe natural signs, reflect on the order of creation, and develop responsible attitudes toward the environment. Recent studies on science e-modules integrated with Qur'anic verses indicate that Islamic value integration can support students' engagement and scientific literacy when the verses are connected meaningfully with scientific concepts and learning activities rather than used only as decorative quotations (Permana et al., 2023; Prihatiningtyas et al., 2025; Wulandari et al., 2022).

Problem-Based Learning can support this need because it begins with contextual problems and guides students to investigate, discuss, develop solutions, and evaluate their reasoning. Recent systematic and empirical studies show that PBL is relevant for fostering critical thinking, scientific literacy, argumentation, collaboration, and problem solving when students receive clear scaffolding and opportunities to use evidence (Anggraeni et al., 2023; Dwiningsih et al., 2024; Hestari et al., 2023; Kuswandi et al., 2025). A digital e-module can make this model more accessible because it can present problems, images, learning objectives, investigation prompts, links, reflection spaces, and formative assessment in a structured sequence (Adhelacahya et al., 2023; Hamidi et al., 2024; Mayer, 2021).

Prior development studies establish the value of the individual components but leave a specific design gap. Qur'an-integrated science e-modules have combined digital content with verses and virtual simulation (Permana et al., 2023; Wulandari et al., 2022), and a STEM-Qur'an flipbook has targeted scientific literacy in an Islamic boarding-school context (Prihatiningtyas et al., 2025). By contrast, SSI- and STEM-PBL e-modules have targeted scientific literacy and critical thinking through contextual problems (Kusumaningsih et al., 2025; Kuswandi et al., 2025; Liunima et al., 2025), while socio-cultural and local-wisdom e-modules have emphasized contextual relevance (Utari et al., 2024; Zainuri et al., 2024). These strands demonstrate feasibility, but they do not show how PBL stages, scientific-literacy tasks, critical-thinking prompts, and Qur'anic ethical reflection can be aligned within the same learning sequence for ecosystem education in Madrasah Tsanawiyah.

Accordingly, the research gap is not the absence of digital modules or religious content as separate features. The unresolved problem is the absence of a coherent alignment architecture that assigns PBL, scientific-literacy tasks, critical-thinking prompts, and Qur'anic reflection distinct functions within one learning sequence. In earlier Qur'an-integrated modules, verses commonly contextualize science content or accompany digital presentation (Permana et al., 2023; Prihatiningtyas et al., 2025; Wulandari et al., 2022), whereas PBL-oriented modules foreground investigation and problem solving without an explicit ethical-reflective layer (Kusumaningsih et

al., 2025; Kuswandi et al., 2025; Liunima et al., 2025) . The theoretical and design question that remains is how these functions can interact without allowing religious text to replace empirical evidence.

The present framework addresses that gap through a functional and temporal distinction. The kauniah component has two bounded functions: an initial orientation poses an ethical question about human responsibility without supplying a scientific answer, and a final reflection appraises the responsibility, stewardship, and consequences associated with the evidence-based solution. Between those points, scientific investigation forms the epistemic core and claim-evidence-reasoning tasks make students' cognitive justification visible. Thus, a verse neither validates a scientific claim nor substitutes for empirical inquiry. Scientific adequacy remains warranted by observation, data, and concepts, while the concluding reflection helps students evaluate what responsible action should follow from a defensible conclusion. This two-stage, non-substitutive sequence differentiates the framework from simply placing religious quotations beside science content and links evidence-based reasoning with ethically informed agency (Sjöström, 2025; Yacoubian & Khishfe, 2018).

The study therefore contributes (1) a design framework that assigns PBL syntax, scientific-literacy indicators, critical-thinking indicators, and Qur'anic kauniah reflection complementary rather than interchangeable roles; (2) a product blueprint that makes the function, order, and boundary of each component explicit; and (3) preliminary evidence concerning product validity, practicality, and within-group learning-change patterns in a limited MTs pilot. Specifically, the study aimed to develop the e-module, examine its validity through material, media, and Qur'anic-integration review, determine its practicality through teacher and student responses, and describe preliminary pretest-posttest patterns in scientific literacy and critical thinking. It did not aim to establish comparative or population-level effectiveness.

2. METHOD

2.1. Research Design and Setting

This study used a Research and Development approach to produce and formatively evaluate an instructional product. The development procedure followed the ADDIE model: analysis, design, development, implementation, and evaluation. The model was selected because it supports iterative needs analysis, prototype design, expert review, limited implementation, and revision (Dwiningsih et al., 2024; Hamidi et al., 2024; Jasmi & Yulkifli, 2024; Utari et al., 2024). The research was conducted at MTs Ma'arif Ambulu Jember from January 5 to March 10, 2026. The product was a Problem-Based Learning science e-module integrated with Qur'anic kauniah verses for ecosystem learning.

2.2. Development Procedure and Limited Trial

At the analysis stage, the researcher identified the learning needs through preliminary observation, teacher interviews, curriculum analysis, student characteristics, and learning resource analysis. The observation focused on the use of digital learning media, student participation, scientific explanation, problem analysis, daily-life contextualization, Problem-Based Learning

implementation, and Qur'anic integration. The interview explored the condition of science learning, students' difficulties, existing learning media, students' scientific literacy and critical thinking, previous integration of Qur'anic verses, and the need for a Problem-Based Learning e-module.

At the design stage, the researcher prepared the e-module structure, learning objectives, ecosystem concept map, learning activities, Problem-Based Learning syntax, Qur'anic verse integration, scientific literacy tasks, critical thinking tasks, and assessment instruments. The e-module structure included cover, instructions for use, learning objectives, concept map, problem orientation, Qur'anic kauniyah verse reflection, science content, investigation activity, group discussion, presentation task, formative test, reflection, glossary, and references. The selected verses included Q.S. Ar-Rum [30]: 41, Q.S. Al-A'raf [7]: 56, Q.S. An-Nahl [16]: 10-11, Q.S. Al-Baqarah [2]: 164, Q.S. Yasin [36]: 33-35, and Q.S. Al-Mulk [67]: 3-4.

At the development stage, the researcher produced the e-module prototype and submitted it to expert validation. The material validation assessed content suitability, concept accuracy, depth, Problem-Based Learning alignment, scientific literacy, critical thinking, and evaluation. The media validation assessed appearance, navigation, readability, interactivity, attractiveness, and usability. The Qur'anic integration validation assessed verse relevance, translation accuracy, contextual suitability, religious values, and language clarity. Each validation sheet used a four-point scale, where 4 = very good, 3 = good, 2 = poor, and 1 = very poor.

At the implementation stage, the e-module was used in a limited formative trial with seven students from the intended MTs user group at MTs Ma'arif Ambulu Jember. The group size was deliberately restricted for the first implementation so that each student's navigation, task completion, misunderstandings, and response pattern could be observed closely and any product defect could be traced before wider testing. Students were coded S-01 to S-07 to protect their identities, while teachers involved in the practicality review were coded G-01 to G-03. Participation required availability for the complete pretest-module-posttest sequence. This stage was therefore a pilot usability and feasibility trial; it did not use probability sampling and was not designed to represent the wider student population or establish causal effectiveness.

2.3. Pilot Participants and Validator Profiles

The pilot participants were the seven coded students and three coded teacher respondents described above. Their role was to provide formative evidence on readability, navigation, task feasibility, and user response. The small group supported intensive observation and individual-level issue tracing; consequently, the scores were analyzed descriptively and were not used for population inference. The expert panel comprised three validators, with one validator assigned to each domain. The purposive selection and assignment criteria were: V-MAT, an academic profile in science or science education with relevant experience in ecosystem-content review and PBL-aligned assessment; V-MED, a profile in educational technology or instructional media with relevant experience in e-module design, navigation, readability, and usability review; and V-QUR, a profile in Islamic education or Qur'anic studies with relevant experience in the contextual interpretation and educational integration of kauniyah verses. Each validator evaluated only the domain corresponding to that profile, so the three scores represent complementary domain judgments rather than inter-rater estimates of the same construct. Personal curricula vitae, highest

degrees, and years of experience were not included in the available study records and are therefore not reported as if verified.

2.4. Instruments and Quality Evidence

Data were collected using material, media, and Qur'anic-integration validation sheets; teacher and student practicality questionnaires; a Problem-Based Learning observation sheet; scientific-literacy and critical-thinking tests; teacher-interview guidelines; and preliminary-observation guidelines. The scientific-literacy test used essay items on explaining ecosystem phenomena, interpreting data and evidence, evaluating environmental problems, applying scientific concepts, and drawing evidence-based conclusions. The critical-thinking test used essay items on problem identification, causal analysis, argument construction, information evaluation, and feasible solution development. Both tests used analytic scoring rubrics ranging from 0 to 4.

Before the pilot, the test blueprints, item wording, cognitive demand, targeted indicators, analytic scoring rubrics, and their alignment with the learning objectives were reviewed for content relevance and clarity. The available dataset contains the final aggregate product-validation scores, but it does not contain item-level expert ratings, repeated administrations, or independent double scoring. Consequently, numerical item-validity coefficients, a content-validity index, internal-consistency coefficients (such as Cronbach's alpha or omega), test-retest reliability, and inter-rater reliability were not calculated and cannot be stated retrospectively. Estimating these coefficients from only seven pilot participants would be unstable and methodologically misleading. The present instrument-quality evidence is therefore limited to expert content review and explicit analytic rubrics, and the outcome scores are interpreted as descriptive preliminary indicators rather than standardized measures. Larger-scale evaluation must calculate item validity, internal consistency, and inter-rater agreement before effectiveness claims are considered.

2.5. Data Analysis

Validation and practicality data were summarized as percentages by dividing the obtained score by the maximum score and multiplying by 100%. The categories were very valid or very practical (81%-100%), valid or practical (61%-80%), fairly valid or fairly practical (41%-60%), less valid or less practical (21%-40%), and invalid or impractical (0%-20%). Within-group pretest-posttest change was summarized using normalized gain, calculated as $(\text{posttest} - \text{pretest}) / (\text{maximum score} - \text{pretest})$, and paired-sample Cohen's d_z , calculated as the mean difference divided by the standard deviation of the paired differences. Normalized-gain categories were reported for descriptive comparison with prior e-module studies (Kusumaningsih et al., 2025; Prihatiningtyas et al., 2025). Because the trial had seven students and no comparison group, neither normalized gain nor Cohen's d_z was interpreted as evidence of causal effectiveness, and no population-level inference was made.

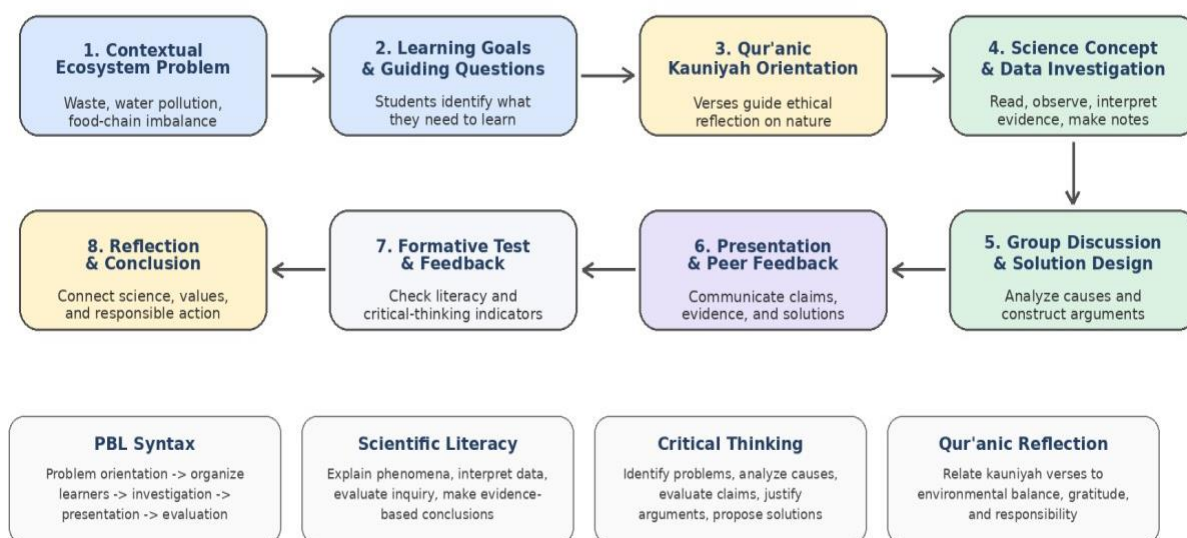
3. RESULTS AND DISCUSSION

3.1. Product Design and Development Result

The product developed in this study is a Problem-Based Learning science e-module for ecosystem learning in Madrasah Tsanawiyah. The product was not designed merely as a digital version of printed material, but as a guided learning environment that organizes students' activities from problem recognition to evidence-based explanation, solution development, and reflective conclusion. Therefore, the design of the e-module combines four main components: Problem-Based Learning syntax, scientific literacy indicators, critical thinking indicators, and Qur'anic kauniyah reflection.

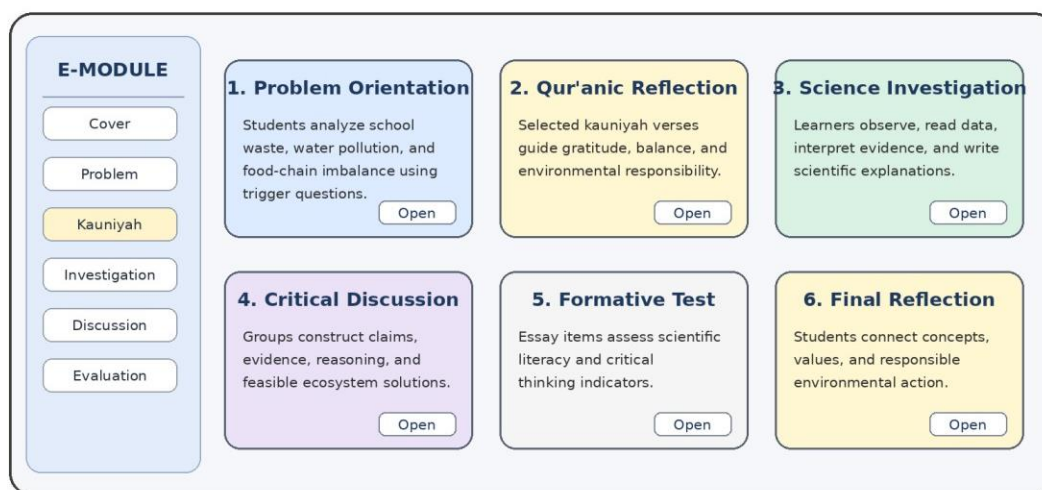
The design begins with contextual ecosystem cases that are close to students' daily experiences, such as waste accumulation in the school environment, water pollution, pesticide use, decreasing fish populations in ponds, and imbalance in a food chain. These cases function as problem orientation and are followed by guiding questions that require students to determine what information is needed, what evidence should be collected, and what possible solutions can be proposed. In this way, the module structure encourages students to move beyond memorizing ecosystem terms and toward explaining phenomena using scientific evidence.

The visual flow of the developed e-module is presented in Figure 1, while the display of the developed media components is shown in Figure 2. Figure 1 explains the learning sequence from contextual problem orientation to reflection, and Figure 2 visualizes how the product presents the cover/navigation menu, problem cases, Qur'anic reflection, investigation worksheet, group discussion, formative test, and final reflection. These visual displays are important because an e-module should not only contain digital text but should organize multimedia, guidance, and assessment in a readable and navigable format (Mayer, 2021; Permana et al., 2023; Wulandari et al., 2022).



Expected outcomes: stronger scientific literacy, critical thinking, and responsible environmental action

Figure 1. Design Flow of the Problem-Based Learning Science E-Module Integrated with Qur'anic Kauniyah Verses



Main product features: navigation menu, contextual cases, verse reflection, worksheets, discussion prompts, and formative assessment
The image illustrates the developed media components inserted into the e-module prototype.

Figure 2. Display of the Developed Problem-Based Learning Science E-Module Media Integrated with Qur'anic Kauniyah Verses

Based on Figure 2, the visible components of the developed e-module media. The product display illustrates how the digital learning media organizes navigation, contextual ecosystem problems, Qur'anic kauniyah reflection, investigation worksheets, discussion prompts, formative tests, and final reflection in one learning sequence.

Table 1. Design Blueprint of the PBL Science E-Module Integrated with Qur'anic Kauniyah Verses

E-Module Component	Design Feature Displayed in the Product	Learning Function
Cover, identity, and instructions	Module title, ecosystem theme, user guide, navigation direction, and learning contract.	Helps students understand how to access, read, complete, and submit activities independently.
Learning objectives and concept map	Objectives are aligned with ecosystem content, scientific literacy, and critical thinking indicators; the concept map links components, interactions, energy flow, and environmental change.	Provides learning direction and helps students see relationships among ecosystem concepts before investigation.
Problem orientation	Contextual cases from the school/community environment are presented with pictures, short narratives, and trigger questions.	Activates prior knowledge and requires students to identify real ecosystem problems.
Qur'anic kauniyah reflection	Selected verses, translations, brief explanations, and reflective questions are connected to environmental balance, human responsibility, and gratitude.	Builds meaningful science-value integration without replacing scientific investigation.

Science content and evidence sources	Concise ecosystem explanations, diagrams, simple data, and observation prompts are provided after the problem is introduced.	Supports students in explaining phenomena and interpreting evidence.
Investigation worksheet	Students collect information, analyze causes, compare evidence, and write provisional answers.	Trains scientific inquiry, evidence interpretation, and analytical reasoning.
Discussion and solution design	Group tasks guide students to develop claims, evidence, reasoning, and proposed environmental solutions.	Strengthens collaboration, argumentation, and critical thinking.
Presentation, formative test, and reflection	Students present findings, answer essay-based questions, receive feedback, and write reflective conclusions.	Measures learning achievement and connects scientific understanding with responsible action.

Based on Table 1, the blueprint clarifies how each component of the product serves a specific pedagogical function. The problem orientation and investigation worksheet are the core of the Problem-Based Learning design; the data interpretation tasks are aligned with scientific literacy; the argumentation and solution prompts are aligned with critical thinking; and the Qur'anic reflection section connects students' scientific conclusions with ethical responsibility toward the environment. Thus, the module design is coherent because each activity has a visible function in achieving the research objectives and aligns with recent findings that digital PBL modules are more effective when they combine contextual problems, structured inquiry, collaborative discussion, and reflective assessment (Adhelacahya et al., 2023; Hamidi et al., 2024; Kuswandi et al., 2025; Liunima et al., 2025).

3.2. Expert Validation Result

The e-module was evaluated by the three domain-matched validators described in Section 2.3: V-MAT reviewed the suitability and accuracy of ecosystem content, depth, PBL alignment, scientific literacy, critical thinking, and assessment; V-MED reviewed appearance, readability, navigation, interactivity, and usability; and V-QUR reviewed verse relevance, translation accuracy, contextual explanation, and appropriateness for Madrasah Tsanawiyah students. This division of responsibility allowed the scientific, media, and religious-integration dimensions to be examined by relevant expertise while preserving the distinct function of each domain.

The validation data showed that the developed e-module met the feasibility requirements for limited implementation. The material expert obtained 56 out of 60, with a percentage of 93.33% and a category of very valid. The media expert obtained 55 out of 60, with a percentage of 91.67% and a category of very valid. The Qur'anic integration expert obtained 37 out of 40, with a percentage of 92.50% and a category of very valid. The average validity was 92.50%, categorized as very valid.

3.3. Practicality Result

Practicality data were collected using teacher and student response questionnaires. The teacher questionnaire assessed ease of use, clarity of instructions, suitability of material, applicability of Problem-Based Learning activities, student engagement, Qur'anic integration, and the feasibility of the e-module as independent learning material. The student questionnaire assessed ease of use, appearance, readability, picture support, clarity of material, contextual problems, activeness, Qur'anic-science connection, scientific literacy support, critical thinking support, and learning interest.

The practicality data showed that the developed e-module was feasible and easy to use in the limited trial. The teacher response obtained 138 out of 144, with a percentage of 95.83% and a category of very practical. The student response obtained 265 out of 280, with a percentage of 94.64% and a category of very practical. The average practicality was 95.24%, categorized as very practical.

3.4. Preliminary Scientific Literacy and Critical Thinking Results

Preliminary learning-change patterns were examined using pretest and posttest scores for scientific literacy and critical thinking. The scientific-literacy test addressed students' ability to explain ecosystem phenomena, interpret simple data, evaluate environmental problems, apply scientific concepts, and draw evidence-based conclusions. The critical-thinking test addressed students' ability to identify environmental problems, analyze causes, evaluate claims, construct arguments, and propose feasible solutions.

Among the seven students, the mean scientific-literacy score changed from 45.00 at pretest to 85.00 at posttest, with a normalized gain of 0.73 and Cohen's *dz* of 5.81. The mean critical-thinking score changed from 59.57 to 88.71, with a normalized gain of 0.72 and Cohen's *dz* of 6.78. Both normalized gains fall in the high descriptive category. Six students had high scientific-literacy gains and one had a medium gain; five students had high critical-thinking gains and two had medium gains. These values describe substantial within-group change in this limited trial, but they do not demonstrate that the e-module caused the change.

Table 2. Preliminary Pretest-Posttest Learning-Change Matrix

Aspect	Mean Pretest Score	Mean Posttest Score	Normalized Gain	Category	Cohen's <i>dz</i>
Scientific literacy	45.00	85.00	0.73	High	5.81
Critical thinking	59.57	88.71	0.72	High	6.78

Table 3. Individual Scientific Literacy Pretest-Posttest Result

Student Code	Pretest	Posttest	Maximum Score	Normalized Gain	Category
S-01	40	80	100	0.67	Medium
S-02	50	85	100	0.70	High
S-03	50	87	100	0.74	High
S-04	30	81	100	0.73	High

S-05	60	90	100	0.75	High
S-06	40	85	100	0.75	High
S-07	45	87	100	0.76	High
Mean	45.00	85.00	100	0.73	High

Table 4. Individual Critical Thinking Pretest-Posttest Result

Student Code	Pretest	Posttest	Maximum Score	Normalized Gain	Category
S-01	50	85	100	0.70	High
S-02	65	88	100	0.66	Medium
S-03	55	86	100	0.69	Medium
S-04	60	90	100	0.75	High
S-05	66	92	100	0.76	High
S-06	56	89	100	0.75	High
S-07	65	91	100	0.74	High
Mean	59.57	88.71	100	0.72	High

3.5. Product Feasibility and Practicality

The average expert-validation score of 92.50% indicates that the e-module met the study's predefined content, media, and Qur'anic-integration criteria for limited implementation. The average practicality score of 95.24% likewise indicates that teachers and students judged the instructions, navigation, contextual cases, and learning activities usable during the formative trial. This direction is consistent with development studies that use expert review and user responses to refine e-modules before wider implementation (Azriyanti & Syafriani, 2023; Jasmi & Yulkifli, 2024; Utari et al., 2024). However, these percentages are evidence of product readiness and acceptability, not evidence that the e-module improves learning outcomes.

The three expert perspectives serve complementary functions. Material review addresses scientific accuracy and alignment with literacy and critical-thinking tasks; media review addresses readability, navigation, and usability; and Qur'anic-integration review addresses verse relevance, translation, and contextual interpretation. Considering these dimensions together is important because a visually practical resource cannot compensate for inaccurate science, while religious appropriateness cannot substitute for inquiry and evidence (Permana et al., 2023; Prihatiningtyas et al., 2025; Wulandari et al., 2022). The teacher score (95.83%) and student score (94.64%) point in the same direction, but their 1.19-point difference and the aggregated nature of the data do not demonstrate that every feature was equally easy to use. Moreover, one validator per domain prevents estimation of inter-rater agreement, and respondent ratings may be inflated by novelty, courtesy, or social desirability. The percentages should therefore be read as convergent formative evidence of readiness for wider testing, not definitive proof of quality or learning impact.

3.6. Preliminary Learning-Change Patterns and Prior Findings

The pretest-posttest pattern was positive for both outcomes: normalized gains were 0.73 for scientific literacy and 0.72 for critical thinking, while paired-sample Cohen's d_z values were 5.81 and 6.78, respectively. These very large standardized values reflect a large mean difference relative to the small dispersion of paired differences in this particular group. With only seven cases, however, effect-size estimates are highly unstable and should not be generalized. They are reported to quantify the observed within-group change, not to establish intervention effectiveness.

The direction of change is consistent with studies reporting that contextual PBL e-modules, SSI-PBL materials, and STEM-PBL modules can support scientific literacy, critical thinking, science-process skills, and engagement (Adhelacahya et al., 2023; Dwiningsih et al., 2024; Hamidi et al., 2024; Kusumaningsih et al., 2025; Kuswandi et al., 2025; Liunima et al., 2025). The current findings cannot be compared directly with their effect magnitudes because the studies differ in topic, sample, assessment instrument, duration, and design. The present evidence therefore adds a context-specific preliminary pattern for ecosystem learning in one Madrasah Tsanawiyah rather than a replication of broad effectiveness.

A plausible pedagogical explanation is that the module repeatedly required students to identify ecosystem problems, interpret information, construct claims, connect evidence with reasoning, and propose solutions. These activities correspond to contemporary views of scientific literacy as evidence-based explanation and data interpretation (OECD, 2019; Pols et al., 2021) and to critical thinking as reflective evaluation of claims and alternatives (Ennis, 2018; García-Carmona, 2025; Kuhn & Lerman, 2021). The individual results also show variation: one student had a medium scientific-literacy gain and two had medium critical-thinking gains. This variation suggests a need for more explicit examples of data interpretation, claim-evidence-reasoning prompts, and teacher scaffolding for students who require additional support.

3.7. Theoretical and Pedagogical Contribution

The contribution of the product is not simply the coexistence of PBL, digital media, literacy tasks, critical-thinking prompts, and Qur'anic verses. Prior studies have already demonstrated several of these components separately: Qur'an-integrated modules emphasize religious contextualization and digital presentation (Permana et al., 2023; Prihatiningtyas et al., 2025; Wulandari et al., 2022), whereas PBL, SSI, STEM, socio-cultural, and local-wisdom modules emphasize problem solving, literacy, or critical thinking (Kusumaningsih et al., 2025; Liunima et al., 2025; Utari et al., 2024; Zainuri et al., 2024). The present framework differs by specifying when each component operates, what kind of judgment it supports, and what it is not permitted to replace.

The proposed mechanism comprises five linked moves. First, a contextual ecosystem problem creates an epistemic need to investigate. Second, an initial *kauniah* orientation raises a question about care, balance, or human responsibility but deliberately leaves the scientific explanation open. Third, students gather and interpret information using scientific concepts. Fourth, claim-evidence-reasoning prompts require them to make the warrant for a solution explicit and open to critique. Fifth, final Qur'anic reflection asks what responsibility, restraint, stewardship, or environmental consequence follows from the scientifically warranted conclusion. Scientific

reasoning therefore answers what the evidence supports, whereas ethical reflection evaluates how that conclusion should guide responsible action. The two processes interact, but they are not interchangeable: a verse does not supply empirical proof, and evidence alone does not determine the ethical priority among otherwise feasible actions.

This ordering also creates a bounded feedback loop. The initial orientation sensitizes students to an ethical problem without predetermining the scientific conclusion; the final appraisal may then prompt them to revisit whether their evidence-based solution overlooks ecological harm, fairness, or long-term consequences. Students must revise any claim or solution through further scientific justification. In this sense, Qur'anic reflection contributes pedagogically by extending reasoning from factual adequacy to responsible agency, while the requirement for renewed evidence protects the activity from becoming a devotional add-on or confirmation of a predetermined answer. The mechanism is consistent with critical scientific literacy that connects evidence, judgment, and socio-ethical action (Sjöström, 2025; Yacoubian & Khishfe, 2018), but it remains a proposition to be tested rather than an established causal pathway.

Three observable propositions follow for future testing: students should produce more explicit evidence warrants after claim-evidence-reasoning scaffolding; they should consider a broader range of environmental consequences after ethical reflection; and revisions made after reflection should remain scientifically justified. The present study did not directly measure these intermediate processes, religious reflection, environmental responsibility, or the contribution of each module component. Consequently, it can claim a theoretically specified and expert-reviewed integration design, but not that the Qur'anic component independently caused cognitive, affective, or behavioral change

3.8. Alternative Explanations and Study Limitations

Several alternative explanations may account for part of the pretest-posttest change. Students encountered similar outcome domains twice and may have benefited from test familiarity or repeated practice. Teacher facilitation, peer discussion, novelty of the digital format, ordinary maturation during the study period, and regression toward the mean may also have influenced scores. Because there was no comparison group, random assignment, or counterfactual condition, these influences cannot be separated from the contribution of the e-module.

The sample comprised only seven students from one madrasah, which limits statistical stability, transferability, and population inference. The high posttest scores also leave limited room to distinguish performance at the upper end. In addition, the study did not report item-level validity coefficients, internal consistency, or inter-rater reliability for the essay tests. This measurement limitation weakens confidence in score precision. Teacher and student practicality responses may also be affected by social desirability, and the study did not include a delayed posttest to examine retention. These constraints require the results to be described as preliminary learning-improvement indications rather than proof of effectiveness.

3.9. Implications and Future Research

The next evaluation should use a larger, more diverse sample and a quasi-experimental design comparing the e-module with conventional learning materials or another active digital

resource. Outcome instruments should undergo item-level validation and report internal consistency and inter-rater agreement; implementation fidelity should also be documented. A delayed posttest would clarify retention, while interviews, observation, or student work analysis could test whether evidence use, argument quality, and ethical reflection develop as proposed. These steps would allow future research to estimate comparative effectiveness and identify which components of the alignment architecture contribute most strongly to learning.

4. CONCLUSION

This study produced a Problem-Based Learning science e-module integrated with Qur'anic kauniah verses for ecosystem learning at MTs Ma'arif Ambulu Jember. Its main contribution is an explicit alignment architecture that bounds an initial kauniah orientation and a post-analysis ethical reflection around scientific inquiry, evidence-based reasoning, and solution construction. Expert review rated the product very valid (92.50%), and teacher-student responses rated it very practical (95.24%) for the limited trial. Among seven students, the descriptive pretest-posttest results showed high normalized-gain categories for scientific literacy (0.73) and critical thinking (0.72), with large within-sample Cohen's d_z values. These results indicate preliminary improvement patterns only. The uncontrolled single-group design, very small sample, and absence of item-level validity and reliability estimates prevent causal attribution and wider generalization. Future studies should compare the e-module with conventional or active digital materials, use larger multisite samples and psychometrically evaluated instruments, document implementation fidelity, and examine retention as well as scientific, critical, and ethical-reflective outcomes.

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