

Development of an Evolution Teaching Module to Remediate Misconceptions on Evolution Theory Among 12th Grade Senior High School Students

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Abstract

Evolution has long been one of the most debated concepts in biology due to its abstract nature and philosophical implications. Despite its central role in understanding biodiversity and life processes, students often struggle with misconceptions about evolutionary theory. This study aims to develop an instructional module on evolution to remediate misconceptions on evolutionary theory among 12th-grade students at an Islamic senior high school. The research employed a Research and Development (R&D) approach using the 3D model (Define, Design, and Develop). Instruments included a three-tier diagnostic test to identify misconceptions and validation sheets from content and design experts as well as biology teachers. The validation results categorized the module as highly feasible, with average expert scores above 90%. The module was then implemented in the classroom, showing an increase in students' conceptual understanding from 35.99% to 93.2% and a decrease in misconceptions from 25.64% to 0.9%. Features such as contextual visuals, integration of reflective inquiry, and clear conceptual progression contributed to the module's effectiveness. This instructional module may serve as an alternative learning resource in biology education, especially for contexts where conceptual challenges around evolution persist.

Keywords: *evolution; instructional module; misconceptions; three-tier test*

INTRODUCTION

The theory of evolution remains one of the most debated and misunderstood concepts in biology education, especially in religious-based schools. Despite its central role in explaining biological diversity and life processes, evolution is frequently misinterpreted due to its abstract nature and perceived contradiction with religious teachings (Kose, 2010). In Indonesia, the delivery of evolution content in classrooms is often minimal or even omitted, partly due to sociocultural tensions and ideological resistance (Handoko & Sipahutar, 2016). Numerous studies have confirmed that high school students commonly hold misconceptions about evolution. These include misinterpretations of scientific terminology, confusion between individual and population-level change, and outright rejection of evolutionary principles. For instance, Adrianto et al. (2017) reported that 33,5% of students in their study misunderstood core

evolutionary concepts. However, such research typically ends with quantifying misconceptions, without offering pedagogical interventions. Similar trends are seen in studies by Jannah & Setiadi (2018) and Asbar (2017), which successfully identify misconceptions using three-tier tests but fall short of developing instructional responses. This trend exposes a significant research gap in evolution education. While the diagnosis of misconceptions has been well explored, there is a lack of follow up action in designing tools to remediate them. Moreover, the unique challenges faced by students in Islamic educational settings where religious perspectives may influence concept acceptance remain insufficiently addressed. Most available learning resources are generic and do not accommodate the cultural-religious context of the learners (Fadilah et al., 2021).

To address this gap, this study developed an evolution teaching module specifically designed to reduce student misconceptions in an Islamic senior high school context. The module integrates conceptual change theory and a guided inquiry approach to support students' epistemological restructuring. This research contributes to the field of biology education in three ways. First, it responds directly to the lack of instructional solutions in evolution misconception studies, which tend to stop at diagnosis. Second, it designs and validates a complete, contextualized teaching module for religious-based schools which represent a population that is often underrepresented in science education research. Third, the module's effectiveness is empirically tested using a three-tier diagnostic instrument, providing strong evidence of its pedagogical impact. In this way, the study not only advances theoretical discourse in conceptual change but also offers a practical tool that bridges science and faith-based educational settings. Specifically, this study seeks to answer the following research questions 1) How feasible is the developed evolution teaching module for classroom use?; 2) How effective is the module in remediating students' misconceptions on evolutionary theory?

METHODS

This study adopted the 4D development model introduced by Thiagarajan et al. (1974), which includes four stages including Define, Design, Develop, and Disseminate. However, considering the limited scope and available resources, this research was limited to the first three stages (Define, Design, and Develop). The objective was to produce a viable and effective teaching module that could address students' misconceptions in the topic of evolution. The define stage focused on identifying key learning problems and the contextual needs of students. A series of classroom observations, teacher interviews, and curriculum analysis were conducted at an Islamic senior high school in Magelang Regency, Central Java, Indonesia. The findings indicated a predominantly passive learning environment, limited student participation, and the absence of teaching materials that aligned with the students' religious and conceptual context. Notably, the biology teacher admitted to skipping several sessions on evolution, citing concerns about its compatibility with students' beliefs.

Based on these findings, the Design stage involved the development of a prototype teaching module based on the principles of conceptual change and guided inquiry. The module was structured to meet the learning outcomes of the Kurikulum Merdeka and was

enriched with visual media, contextual explanations, student worksheets, and reflective questions. In addition to the module content, the researchers also designed evaluation tools, including a three-tier diagnostic test to identify misconceptions and expert validation sheets to assess the quality of the module. The development stage consisted of module development and validation based on expert judgment. Two experts were involved a subject matter expert (biology content specialist) and an instructional design expert. They assessed various aspects of the module, including its scientific accuracy, relevance, clarity of language, layout, and visual appeal. Feedback was also gathered from biology teachers at Islamic senior high school to evaluate the usability and contextual appropriateness of the module in an Islamic school setting. Revisions were made based on the suggestions provided, resulting in a finalized version for classroom implementation.

The participants in this study consisted of 36 students from class XII at a private senior high school in Magelang Regency, Central Java. The participants selected via purposive sampling based on their attendance (above 75%) and relevance to the research objectives. The teaching module was validated by two experts: a biology content expert and an instructional design expert. The purpose of the validation was to assess the scientific accuracy, instructional quality, and suitability of the module for use in an Islamic senior high school context. Each expert completed a validation sheet adapted from [Widiyanti et al. \(2023\)](#), which used a 4-point Likert scale (1 = Very Poor to 4 = Very Good). The assessment covered the following aspects Scientific Accuracy, Clarity of Language and Instruction, Visual Design and Layout, Contextual and Pedagogical Relevance. Each criterion was scored, and the total score was converted into a percentage using the formula: $\text{Score (\%)} = (\text{Total Obtained Score} / \text{Maximum Possible Score}) \times 100$. The percentage scores were then interpreted using the following table 1.

Table 1. Interpretation Of Feasibility Test Data

Score Range (%)	Interpretation
$80 < x \leq 100$	Very Feasible
$60 < x \leq 80$	Feasible
$40 < x \leq 60$	Feasible Enough
$20 < x \leq 40$	Less Feasible
$0 < x \leq 20$	Not Feasible

To assess the module's effectiveness, a three-tier diagnostic test was administered before and after the intervention. This test consisted of three layers: a multiple-choice question (Tier 1), a reasoning justification (Tier 2), and a confidence rating (Tier 3), enabling the researcher to distinguish between students' lack of knowledge and actual misconceptions. To analyze the students' answers, the test results are categorized using the following classification guide table 2.

Table 2. Three-Tier Test Answer Data Recapitulation Guide

Tier Level	Reponses Category	Response Type
<i>Three-tier</i>	Understand the concept	Correct answer + correct reason + confident
	Lack of knowledge	Correct answer + correct reason + not confident
		Correct answer + wrong reason + not confident
		Wrong answer + wrong reason + not confident
		Wrong answer + correct reason + not confident
	Error	Wrong answer + correct reason + confident
	Misconseption	Correct answer + wrong reason + confident
		Wrong answer + wrong reason + confident

RESULTS & DISCUSSION

The development of the evolution teaching module began with the Define stage, which identified key learning problems through curriculum analysis, classroom observation, and teacher interviews at an Islamic senior high school. The findings revealed that students exhibited low engagement and conceptual confusion regarding evolution, while teachers often avoided the topic due to its perceived conflict with students' beliefs. Additionally, existing instructional resources lacked contextual alignment with students' backgrounds and learning needs. Based on these findings, the Design stage focused on constructing a prototype module that integrates conceptual change theory with guided inquiry learning. The module was structured into several learning units corresponding to subtopics in the national biology curriculum. It included contextual visual materials, reflection questions, student worksheets, and embedded assessment activities. Evaluation tools, such as a three-tier diagnostic test and expert validation instruments, were also designed to accompany the module. As a result of the design phase, a prototype of the evolution teaching module was developed. It includes structured learning activities, visual supports, and formative assessments that align with the curriculum. The prototype format and design is illustrated in table 3 and figure 1.

Table 3. Module Content Design

Section	Content Description
Cover	Includes education logo, institution logo, title, topic, author, grade level, and an illustration related to the learning material.
Table of Contents	Lists chapters, subchapters, and corresponding page numbers in a structured format.
General Information	Contains module identity, introductory components, Pancasila Student Profile, facilities and infrastructure, target learners, implementation method, and class management.



Figure 2. Teaching module content:
 (a) Students worksheet,
 (b) student activity content in the worksheet,
 (c) reading material, and
 (d) contextual content featured in the reading section.

In the development stage, the draft module underwent expert validation to evaluate its feasibility in terms of content accuracy, instructional design, and practical usability. The validation process involved two experts and one biology teacher. The results of the validation are presented in Table 4.

Table 4. Results of the Feasibility Test of the Teaching Module

Evaluator	Aspects Evaluated	Average Score (%)	Category
Content Expert	Content suitability, scientific accuracy, integration, language	92,9	Very Feasible
Instructional Design Expert	Format, organization, attractiveness, typography, spacing, consistency	94,2	Very Feasible
Biology Teacher	Presentation, media, language, usefulness, assessment alignment	93,4	Very Feasible

Based on Table 4, the teaching module on evolutionary theory underwent a rigorous validation process involving three evaluators a content expert, an instructional design expert, and a high school biology teacher. Each evaluator provided assessments across several aspects to ensure both pedagogical integrity and practical usability. For instance, the content expert evaluated the module based on the alignment of content with learning objectives, scientific accuracy, integration of concepts, and clarity of language. The average score obtained was 92,9%, which falls into the very feasible category. However, the expert recommended improving the clarity of teacher instructions in the lesson steps. In addition, the instructional design expert focused on layout aspects, including format structure, visual organization, attractiveness, typography, use of space, and design consistency. This evaluation resulted in an average score of 94,2%, also categorized as *very feasible*. Suggestions included revising the module cover to better reflect the topic of evolution. Feedback from the biology teacher emphasized the module's usability in the classroom. Evaluations covered aspects such as material presentation, language clarity, time allocation, and alignment of assessments. The module obtained an average score of 93.4%, again categorized as very feasible. The teacher highlighted the module's ease of use, clarity, and relevance to student needs in an Islamic school setting. Therefore, it was confirmed that the module was ready for classroom use without requiring major revisions.

Following the validation phase, the module was implemented in a 12th grade biology class at privat senior high school in Magelang Regency, Central Java. Its effectiveness was assessed using a pre-test and post-test based on the three-tier diagnostic model. The results revealed a clear improvement in students' conceptual understanding and a reduction in misconceptions related to the topic of evolution. The topics measured included the definition and position of the theory of evolution in science, Darwin's theory of evolution, the mechanism of natural selection, and the limitations of the theory of evolution. The results of the initial assessment of students' conceptual understanding at the beginning of the learning process are presented in Table 5.

Table 5. Average Percentage of Students' Concept Understanding Conditions on Pre-Test

Sub Topic	Average Percentage of Students' Concept Understanding Conditions (%)			
	P	LK	E	M
Darwin's Theory of Evolution	54,1	27,75	1,35	16,6
Definition and Scientific Status of Evolution Theory	22,2	33,3	2,7	41,6
Mechanism of Natural Selection	53,82	28,28	1,1	16,62
Limitations of Evolution Theory	13,85	58,3	0	25,64
Average	35,99	36,91	1,29	25,64

Based on Table 5, the results showed the average level of students' conceptual understanding across each subtopic of the evolution material. The highest percentage in

the Conceptual Understanding category was found in the subtopic “Definition and Scientific Status of Evolution Theory”, with an average score of 54,1%. The highest percentage for the Lack of Knowledge category appeared in the subtopic “Limitations of Evolution Theory”, with an average of 28,28%. For the Error category, the highest percentage was also recorded in the subtopic “Definition and Scientific Status of Evolution Theory”, at 1,35%. Meanwhile, the highest rate of Misconception occurred in the subtopic “Darwin’s Theory of Evolution”, with an average percentage of 41,6%. After the implementation of the teaching module, students’ conceptual understanding was reassessed to measure the effectiveness of the intervention. The post-test results are presented in Table 6.

Table 6. Average Percentage of Students' Concept Understanding Conditions on Post-Test

Subtopic	Average Percentage of Students' Concept Understanding Conditions (%)			
	P	LK	E	M
Darwin’s Theory of Evolution	90,85	9,06	0	0
Definition and Scientific Status of Evolution Theory	96,6	0	3,03	0
Mechanism of Natural Selection	98,76	0,6	0	0,6
Limitations of Evolution Theory	86,3	10,56	0	3,03
Average	93,2	5,06	0,75	0,9

Based on the data presented in Table 6, the highest percentage of Conceptual Understanding was found in the subtopic “Mechanism of Natural Selection”, reaching 100%. Meanwhile, the Lack of Knowledge category was most dominant in the subtopic “Limitations of Evolution Theory”, with a percentage of 15,1%. The highest percentage in the Error category appeared in the subtopic “Darwin’s Theory of Evolution”, at 3,03%. Additionally, the highest Misconception rate was also recorded in the “Limitations of Evolution Theory” subtopic, at 6.06%.

Table 7. Recapitulation of Student Response Categories Before and After Module Implementation

Response Category	Pre-Test (%)	Post-Test (%)	Change (%)
Conceptual Understanding (CU)	35,99	93,2	▲ +57,21
Misconception (M)	25,64	0,9	▼ -24,74
Lack of Knowledge (LK)	21,21	4,7	▼ -16,51
Error (E)	17,16	1,2	▼ -15,96

The data on Table 7 indicate a substantial improvement in students’ conceptual understanding following the implementation of the teaching module. Prior to the intervention, only 35.99% of students demonstrated correct conceptual understanding, while this figure increased dramatically to 93.20% after the module was applied, reflecting a conceptual gain of 57.21%. In contrast, the proportion of students exhibiting

misconceptions decreased significantly, from 25.64% in the pre-test to just 0.90% in the post-test a reduction of 24.74 percentage points. Similarly, responses categorized as lack of knowledge dropped from 21.21% to 4.70%, and errors were reduced from 17.16% to 1.20%. These results highlight the effectiveness of the module in not only increasing students' understanding of evolutionary concepts but also in remediating deeply held misconceptions. The significant drop in misconception rates suggests that the instructional strategies employed such as conceptual change theory, contextual examples, and guided inquiry successfully facilitated cognitive restructuring among students.

The evolution teaching module developed in this study was validated by two expert validators a subject matter expert and an instructional media expert. Both evaluations placed the module in the "very feasible" category for classroom use. This indicates that the module meets both pedagogical and technical standards required for high school biology instruction. In terms of content accuracy and scientific rigor, the module was constructed based on credible primary and secondary sources, such as Campbell Biology (Reece et al., 2010) and Evolutionary Analysis (Herron & Freeman, 2014). The key topics Darwin's theory of evolution, the mechanism of natural selection, the scientific position of evolutionary theory, and its limitations were presented in a clear and systematic manner. The terminology used adhered to standardized scientific language, avoiding ambiguous or non-scientific expressions that could reinforce misconceptions. This aligns with the findings of Trianto (2015), who emphasized that inaccuracies in instructional materials can exacerbate existing misconceptions or even generate new ones, particularly in abstract topics like evolution.

A notable strength of the module is its contextual relevance, particularly for use in Islamic school settings. The content was designed to focus on scientific mechanisms without delving into metaphysical or theological domains, thus respecting students' religious perspectives. This approach is consistent with the findings of Fadilah et al. (2021), who found that learning materials designed for students' real and contextual needs are more effective in achieving instructional goals. It also supports the recommendations of Putra et al. (2023), who stressed that curriculum-aligned, student-centered content enhances the meaningfulness and relevance of learning.

From a design and presentation perspective, the module exhibits structural coherence and navigational clarity. It follows a guided inquiry and conceptual change model, leading students from observation to reflection through a sequence of scaffolded learning activities. Visual components including icons, diagrams, and consistent formatting improve user engagement and facilitate comprehension of complex concepts. The use of Canva to design visual elements enhanced both the aesthetic and functional aspects of the module. Vedyanty and Arif (2023) assert that structured formatting and effective visual presentation directly impact students' understanding and learning outcomes, especially for conceptually demanding topics.

The module also includes supporting components such as student worksheets, supplementary reading materials, and a three-tier diagnostic test. These tools not only assess conceptual understanding but also identify specific misconceptions in depth. This

reflects the principles of the conceptual change model described by Posner et al. (1982), which underscores the need to confront students' prior misconceptions to construct scientifically accurate understanding. Technically, the module demonstrated high levels of consistency and readability. The validators confirmed that the fonts, spacing, and graphical layout were used consistently and appropriately. White space was employed effectively to enhance legibility and navigation, supporting users in understanding the instructional flow. These design choices align with the findings of Nesri and Kristanto (2020), who emphasized that clean visual presentation facilitates ease of use and improves instructional effectiveness.

In conclusion, the expert validation confirmed that the evolution teaching module is highly feasible for classroom implementation. The combination of scientifically sound content, context-sensitive presentation, and user-friendly design ensures that the module meets the pedagogical demands of Kurikulum Merdeka and the specific learning needs of students. This finding is consistent with the perspective of Sanjaya (2012), who stated that instructional materials developed with students' characteristics and learning goals in mind are more likely to produce conceptual change. Similarly, Fitri et al. (2023) highlighted that systematic, accurate, and visually engaging modules can significantly enhance students' understanding of complex scientific concepts like evolution. Therefore, the feasibility of this module is strongly supported by both empirical validation and theoretical justification.

The results of this study demonstrate that the developed evolution teaching module is effective in reducing student misconceptions and increasing conceptual understanding. This conclusion is supported by the comparison between pre-test and post-test results using a three-tier diagnostic test. Prior to the intervention, 25,64% of student responses indicated the presence of misconceptions related to core evolution concepts. The highest rate of misconceptions occurred in the topic of Darwin's Theory of Evolution (41,6%), followed by the limitations of evolutionary theory (27,75%), the mechanism of natural selection (16,62%), and the definition and scientific status of the theory in science (16,6%).

These findings indicate that a substantial proportion of students not only lacked accurate understanding but also held firmly to scientifically incorrect ideas highlighting the persistent and resistant nature of misconceptions, which often require structured and targeted interventions to overcome. After the implementation of the teaching module, the rate of misconceptions decreased dramatically to 0,9%, while the rate of conceptual understanding increased to 93,2%. This represents a conceptual gain of 57,21% and provides strong empirical evidence of the module's instructional effectiveness.

The success of the module can be attributed to its integration of guided inquiry and the conceptual change model (Posner et al., 1982). For instance, in addressing misconceptions surrounding Darwin's theory, the module explicitly clarified the difference between classification and evolutionary lineage. It provided scientific explanations supported by visual aids, such as morphological comparisons of Galápagos finches, and guided reflection through open-ended questions in the student worksheets.

This is consistent with [Fuentes \(2018\)](#), who emphasized that evolutionary understanding must be grounded in empirical biological data rather than taxonomic assumptions.

Regarding the mechanism of natural selection, the module included a case study of *Biston betularia* (peppered moths), contextualized through historical environmental changes during the Industrial Revolution. Visual comparisons of environmental conditions before and after pollution were paired with analytical activities to explain changes in allele frequency not individual transformations. This approach addressed the common misconception that evolution acts on individual traits in real time. [Berry \(1990\)](#) highlighted that effective instruction on natural selection requires historical and ecological context to clarify its population-level nature.

For the subtopic definition and scientific status of theory, the module addressed a key misconception, namely that scientific theories are mere guesses or unproven ideas. Instead, it emphasized the hierarchical structure of scientific knowledge from facts to hypotheses, to theories, and ultimately to laws. This structured approach helped students recognize that evolutionary theory is a comprehensive, evidence-based explanation. This aligns with [Ayala \(2020\)](#), who argued that misconceptions about the term “theory” can be corrected through explicit terminological instruction and visual representation of scientific hierarchies.

In the subtopic limitations of evolutionary theory, the module addressed the frequent misunderstanding that evolution explains the origin of life. The module distinguished clearly between evolution and abiogenesis through comparative tables and diagnostic questions. Students were guided to understand that evolutionary theory explains changes in existing populations over time, while abiogenesis concerns the emergence of the first life forms an entirely different scientific domain. [Syulasmi \(2021\)](#) underlined that this misconception is widespread and must be addressed directly during instruction to avoid conceptual conflation.

The improvements in conceptual understanding across all subtopics reflect not only the module’s scientific accuracy but also its pedagogical alignment with students’ cognitive and contextual needs. The content was adapted to the Islamic school setting by avoiding theological conflicts and focusing on empirical, observable phenomena. According to [Sanjaya \(2012\)](#), instructional materials that match the learning needs and classroom realities of both teachers and students are more likely to produce conceptual transformation. This view is further supported by [Maarif and Wahyudi \(2022\)](#), who affirmed that data-based, diagnostic oriented, and contextually tailored learning materials facilitate deeper understanding and conceptual clarity. In conclusion, the instructional effectiveness of the developed evolution module is evidenced by a substantial reduction in misconceptions and a marked increase in conceptual understanding. This outcome supports the value of modules grounded in conceptual change theory and inquiry-based learning, particularly when adapted to the learners’ sociocultural context.

CONCLUSION

The developed evolution teaching module, based on the 4D model was validated by experts and found to be highly feasible in terms of content, structure, language, and design. Its implementation significantly reduced students' misconceptions from 25,64% to 0,9% and increased conceptual understanding from 35,99% to 93,2%. These results highlight the effectiveness of using a guided inquiry and conceptual change approach, supported by contextual materials and diagnostic tools. The module is suitable for use in Islamic high school settings and provides a strong model for addressing complex science topics in a culturally sensitive and scientifically accurate manner.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to Tidar University for supporting the implementation of this research.

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