



# Designing Mobile Applications for Inquiry-Based Learning in Environmental Science in Madrasah Environment

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## ABSTRACT

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This study aims to analyze the limitations of contextual learning models in environmental science education in madrasahs, explore the potential and challenges of developing mobile applications for inquiry-based learning, and examine students' responses to using inquiry-based digital media in understanding environmental issues. This study uses a qualitative approach with a case study design. Data collection techniques were carried out through in-depth interviews, participatory observation, and documentation, which were analyzed using data reduction techniques, data display, and verification of findings. The study results indicate that conventional methods still dominate science learning in madrasahs and have not utilized contextual learning optimally. Teachers face challenges in the form of limited infrastructure, digital media, and low technological literacy. However, students responded positively to the interactive mobile application-based approach that supports the inquiry process. The implications of these findings emphasize the need to develop learning applications relevant to the local context and can increase students' active involvement in understanding environmental issues. This study contributes to the innovation of technology-based science learning models in madrasah environments and as a reference for developing digital-based curricula oriented towards ecological literacy.

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## INTRODUCTION

Science education in several environments is becoming increasingly urgently needed to be strengthened in the world of education, including in Islamic educational institutions such as madrasahs. Climate change,

environmental pollution, and degradation of local ecosystems are issues that the world of education can no longer ignore (Pedaste, Mitt, & Jürivete, 2020; Salas-Pilco, Xiao, & Hu, 2023). This phenomenon demands the integration of ecological care values into the learning process, mainly through an approach that can foster critical awareness of students. Unfortunately, environmental education in madrasas still tends to be textual, theoretical, and less related to local realities with contextual learning (Müssig et al., 2020; Lo et al., 2021; Muali et al., 2021).

This urgency is reinforced by the increasingly massive use of digital technology devices among students, including madrasa students. Based on data from the Indonesian Internet Service Providers Association (APJII) in 2023, more than 78% of students in Indonesia have accessed the internet via mobile devices (Ekici & Erdem, 2020; Lim & Lim, 2020; Zain & Bowles, 2021). However, digital devices in madrasas are more often used as a means of communication or entertainment, not as the main instrument for interactive environmental science-based learning. This is where the relevance and urgency of the design of mobile applications based on inquiry-based learning (IBL) lies, which brings students closer to environmental issues contextually and utilizes digital technology productively and educationally.

The main problem in this context lies in the limitations of learning media that can combine the inquiry approach and environmental issues with religious values typical of madrasas. Many learning media are generic and do not consider the characteristics of madrasa students, both in terms of language, local context, and students' spiritual needs. This causes the environmental science learning process to not touch students' affective and social aspects. In addition, the absence of an application model specifically designed to support inquiry learning in madrasas means that integrating technology and the environment is still partial and less than optimal.

Previous research has shown the great potential of mobile applications in inquiry-based learning. Khaokhajorn et al (2020) emphasized the role of mobile learning in STEM education, but their studies were generally limited to the context of higher education and developed countries. (Zain & Bowles, 2021) emphasized that Mobile-Assisted Language Learning supports flexible learning, especially in the context of EFL/ESL, and can be applied in other formal education. Meanwhile, Inel-Ekici & Ekici (2022) found that mobile inquiry in science learning improves students' conceptual understanding and positive attitudes but faces challenges such as low teacher digital literacy and the need for contextual applications. These three studies show the effectiveness of inquiry-based mobile learning, but none have specifically examined its application in madrasas. Therefore, this study fills this gap by designing a mobile-based inquiry-based learning application model based on madrasas' environmental learning characteristics. However, a significant research gap can be found from the three studies in the three studies. First, no research has explicitly developed a mobile inquiry application for the madrasah context, which is characterized by

a religious curriculum and values. Second, not much research has linked the use of IBL-based applications with the local context of the madrasah environment, even though this is important for building applicable and transformative understanding in students. Third, the existing literature has not explicitly examined the integration between environmental learning, inquiry approaches, and mobile technology within the framework of Islamic education.

It is known that this study, a novelty, shows the development of a mobile inquiry application design that emphasizes scientific aspects and integrates Islamic values and the local context of the madrasah. The application developed will contain interactive features such as digital field journals, location-based observations (geo-tagged observations), and reflections on Islamic values on environmental issues. With this approach, students learn to scientifically understand ecosystems and environmental problems and are invited to reflect on ecological responsibility as part of religious teachings. This is the uniqueness and strength of the novelty of this study, which is not found in previous literature.

Based on this description, the main objective of this study is to design and develop a prototype of a contextual inquiry-based learning mobile application for environmental science learning in the madrasah environment. This research will focus on one main problem: the lack of digital learning media that integrates the inquiry approach, local environmental context, and Islamic values in the science learning process in madrasahs. This research is expected to provide practical contributions for madrasah teachers in developing more participatory and meaningful science learning innovations and theoretical contributions in developing inquiry-based contextual learning media.

## RESEARCH METHOD

This study uses a qualitative approach with a case study design that aims to describe and deeply understand the process of designing a mobile application based on inquiry-based learning in environmental science learning in a madrasah environment. The unit of analysis in this study is Madrasah Tsanawiyah (MTs) Al-Mustaqim, which has tried to integrate ecological learning into its local curriculum. The selection of this location is based on the consideration that the madrasah already has an internal policy related to environmental education and is open to innovations in learning technology. This case study will explore the practices, challenges, and responses of educators and students to the development of mobile application-based learning media based on an inquiry approach. The research focuses not only on the final results of application development but also on the dynamics of the process and contextualization of implementation in the reality of the madrasah.

**Table 1. Informant Data**

	Gender	Amount	Education	Subjects
<b>Position</b>				
<b>Head of Madrasah</b>	Man	1	S2	Educational Management

<b>Science Teacher</b>	Woman	1	S1	Natural Sciences (IPA)
<b>Science Teacher</b>	Man	1	S1	Natural Sciences (IPA)
<b>Class VIII Students</b>	Man&Woman	3	-	Application user subject
<b>Class IX Students</b>	Woman	3	-	Application user subject
<b>Educational Technology Practitioner</b>	Man	1	S2	Mobile Learning Application Development

Data was collected through three main techniques: in-depth interviews, participant observation, and documentation. Interviews were conducted with teachers and madrasah principals to explore their perceptions, expectations, and experiences in integrating environmental learning with digital media. Observations were conducted during the learning process, especially when using inquiry-based mobile applications, to see students' responses, involvement, and interactions. Documentation was used to collect physical evidence such as syllabi, lesson plans, photos of class activities, and screenshots of application use. The data obtained were then analyzed using the Miles and Huberman analysis technique, which includes three stages: data reduction (filtering relevant data), data presentation (in the form of descriptive narratives and simple visualizations), and verification or drawing conclusions (finding patterns and meanings). This approach was chosen because it is appropriate for understanding phenomena holistically in the context of value-based and technology-based education.

## RESULT AND DISCUSSION

### Result

#### Limitations of Contextual Learning Models in Environmental Science Education in Madrasahs

The results of in-depth interviews with science teachers at Madrasah Tsanawiyah Al-Mustaqim show that environmental science learning is still dominated by lecture and memorization methods. Teachers admit that the limitations of learning media and a dense curriculum are the main reasons for the difficulty of implementing contextual learning. One teacher said, "We don't have enough time and media to invite students to learn directly in the surrounding environment." In addition, some teachers feel they are not yet sufficiently trained in implementing an inquiry-based approach that requires creativity and more flexible time management. From the student's perspective, they tend to consider science an abstract and challenging subject because it is not connected to real life. This shows a large gap between the environmental education goals, which are applicative, and the learning approach, which is still rigid and centered on the teacher.

The following is a visualization of the results of interviews with teachers and madrasah principals regarding the environmental science learning model currently used:

**Table 2. Visualization**

<b>Informant</b>	<b>Dominant Learning Methods</b>	<b>Main Obstacles</b>	<b>Readiness for Inquiry Implementation</b>
<b>Science Teacher (Female)</b>	Lectures, Discussions	Limited time, dense curriculum	Low
<b>Science Teacher (Male)</b>	Lecture, Q&A	Lack of media and training	Currently
<b>Head of Madrasah</b>	General supervision	School infrastructure and culture	Low
<b>Math teacher</b>	Practice questions, lectures	Focus on exam scores, minimal practice	Low
<b>Deputy Head of Curriculum Indonesian</b>	Academic supervision	The curriculum is not flexible	Low
<b>Language Teacher</b>	Text discussion, lecture	Science integration is not yet optimal	Currently

This table reinforces the initial findings that a significant obstacle is a lack of systematic support for implementing contextual learning. Not only limited time and media but also the low pedagogical readiness of teachers in implementing environmental-based inquiry strategies. The madrasah principal's response also indicated that no specific policy encourages environmental exploration as part of the active curriculum. The findings from the interviews make it clear that ecological science learning in madrasahs is still running conventionally and has not answered the needs of 21st-century education emphasizing environmental literacy. Teachers and madrasah principals have a uniform perception that the integration of contextual learning is still complex to implement due to limited time, media, and pedagogical training. The national curriculum that demands the achievement of specific academic targets makes teachers focus on delivering material quickly rather than on in-depth exploration. In addition, not all teachers have a strong background in the inquiry-based learning approach that emphasizes active student involvement.

### **Potential and Challenges of Developing Mobile Applications for Inquiry-Based Learning**

Direct observations conducted in the classrooms and laboratories of Madrasah Tsanawiyah Al-Mustaqim showed that most learning activities were still one-way, with the dominant use of blackboards and printed books as the main media. Teachers rarely use digital devices in science learning except for administrative purposes or end-of-semester evaluations. However, it was found that students are highly interested in technology-based activities, such as searching for information via smartphones and watching educational videos. This potential has not been utilized optimally in formal learning designs. Several teachers said they wanted to use learning applications but did not have the technical knowledge and supporting software. On the other hand, madrasahs still

face limited facilities, such as limited internet connections and projector devices.

The following is a visualization of the results of observations conducted in the classroom and learning environment of Madrasah Tsanawiyah Al-Mustaqim regarding the use of technology in science learning:

**Table 3. Utilization of Technolog**

<b>Observed Aspects</b>	<b>Field Findings</b>	<b>Quantitative Indicators / Real Evidence</b>
<b>Instructional Media</b>	Dominant use of blackboards and textbooks; digital devices are rarely used in the daily learning process.	Only 1 in 8 science teachers (12.5%) have used digital media in the last semester.
<b>Student Activities</b>	Students actively use smartphones independently outside the classroom to search for information, but are not directed in a formal learning context.	Of the 30 students observed, 23 ( $\pm 76\%$ ) actively searched for science information via YouTube/Google, but without learning guidance.
<b>The Role of Teachers</b>	Teachers are not yet accustomed to integrating technology into learning; they are more comfortable using conventional methods such as lectures.	5 out of 6 teachers stated that they had never attended ICT training in the last two years.
<b>Facilities and infrastructure</b>	Limited internet access; only one projector is available for the entire madrasah; there is no digital laboratory.	Projectors must be rotated between classes, and the Wi-Fi signal is only active in the teachers' lounge.
<b>Technology Potential</b>	Students were very responsive to educational videos and applications when introduced in demonstration sessions.	During the trial session, 26 out of 30 students (87%) showed high enthusiasm and completed the application exploration.
<b>Barriers to IT Usage</b>	Teachers have not received technical training on digital-based learning applications and there are no SOPs for ICT implementation.	There are no SOP/ICT documents in the madrasah; the last training recorded in 2020, was general in nature (not application development).

This table illustrates the gap between students' interest in technology and madrasahs' readiness to facilitate digital-based learning. This condition shows that the need for inquiry-based mobile applications is relevant and urgent to bridge potential and reality.

The observation results revealed that science learning in madrasahs is still taking place with a traditional approach that is very limited in the use of digital technology. Teachers prefer text-based lecture and discussion methods due to limited facilities and low digital competence. Students are highly interested in using technology, such as educational videos, and searching for information via mobile devices. This potential has not been accommodated in a structured manner in learning activities. In addition, madrasahs do not have adequate infrastructure, such as a stable internet connection and sufficient projector devices, so teachers have difficulty accessing or implementing digital media. This

finding confirms an excellent opportunity to develop inquiry based learning mobile applications to solve existing obstacles.

### Positive Student Responses to Digital Inquiry Application-Based Environmental Learning

Documentation of learning activities based on digital inquiry applications that were tested on a limited basis in one of the VIII grades of Madrasah Tsanawiyah Al-Mustaqim showed a very positive response from students. During the use of the application, students appeared enthusiastic, actively answered questions, and were involved in exploring the material presented interactively. The teacher noted that students who were usually passive in science lessons became more courageous in asking questions and discussing when using the application. This application presents simple simulations related to water pollution, waste recycling, and climate change, which enable students to connect theories with the environmental conditions around them. In addition, the results of teacher assessment records showed an increase in participation and understanding of concepts. Documentation in the form of photos of activities, student work results, and daily reflections showed that the use of appropriate technology can increase student motivation, creativity, and involvement in environmental science learning. The following is a summary of the visualization of the documentation of the results of the implementation of inquiry-based mobile applications in science learning:

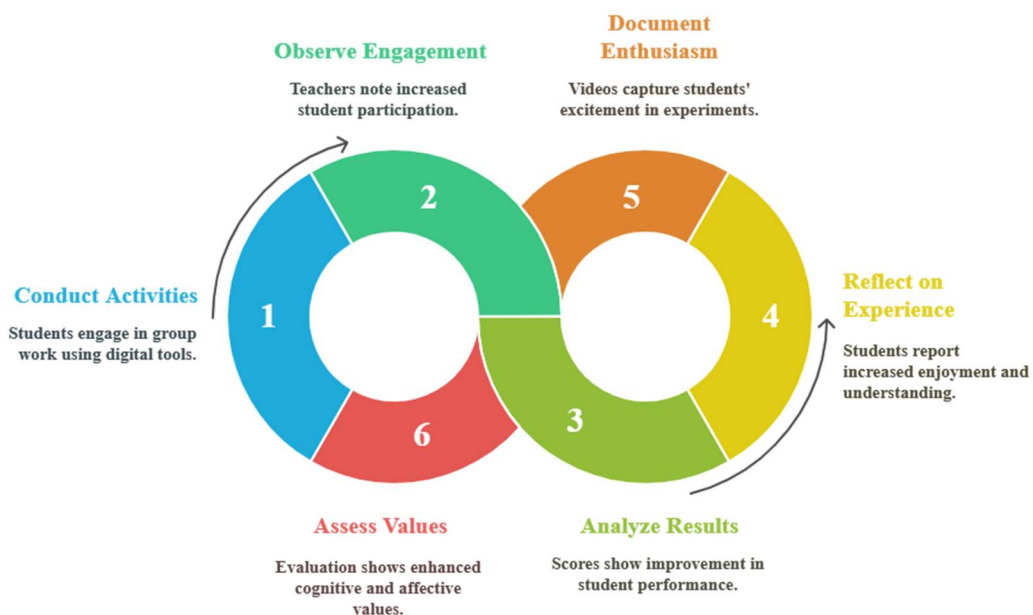


Figure.1 Cycle of Digital Inquiry-Based Learning

This visualization shows that even though it is only done on a limited basis, digital inquiry-based learning can create a more active, meaningful, and relevant learning atmosphere in the context of students' lives. Technological support strengthens learning outcomes that have been difficult to achieve with

conventional approaches.

Documentation of digital inquiry-based learning provides concrete evidence that this approach can encourage significant changes in students' learning behavior. The recorded activities show that students not only become more enthusiastic but also show an increase in conceptual understanding and active questioning. The learning process that previously tended to be passive and focused on memorization began to change into a more investigative and participatory process. In addition, applications with attractive visualizations and direct interactions increased students' interest in environmental issues, which they previously considered complicated. This is a strong signal that madrasas need to open themselves to educational technology to improve the quality and relevance of environmental science learning.

## **Discussion**

### **Limitations of the Contextual Learning Model in Environmental Science Education in Madrasas**

The limitations of the contextual learning model in environmental science education in madrasas have profound implications for students' low ecological awareness and literacy. When learning is still trapped in lecture and memorization methods, students do not get the opportunity to relate the material to the reality they experience every day. The implication is that environmental education becomes limited to theory without practical meaning, thus failing to form a strong ecological attitude (Siwawetkul & Koraneekij, 2020; Christopoulos et al., 2023; Liu et al., 2023). Furthermore, this also affects the achievement of the Pancasila Student Profile, which emphasizes environmental concern and 21st-century skills. Learning becomes monotonous and irrelevant without a contextual approach, making students quickly bored and not developing critical thinking skills. Therefore, this limitation is not only a matter of method but concerns the quality of the education process, including its contribution to character building and students' social responsibility in protecting the environment. The limitations of applying contextual learning are closely related to several fundamental factors, such as a dense curriculum, limited media, and minimal pedagogical training. Teachers tend to choose the lecture method because it is considered efficient for completing material targets in a short time.

On the other hand, not all teachers can design contextual learning based on the environment and has an inquiry-based weight. Low support from madrasah management and the absence of specific policies that encourage a contextual approach also exacerbate this condition (Mahmud et al., 2021; Chookaew & Panjaburee, 2022; Xie, Wu, & Xie, 2024). The correlation between structural factors (curriculum and policies) and personal factors (teacher competence) shows this problem is systemic. Therefore, fixing only one side, such as blaming teachers, will not be effective without strengthening policies, training, and providing learning facilities that support real and virtual

environmental exploration.

### **Potential and Challenges of Developing Mobile Applications for Inquiry-Based Learning**

The potential and challenges in developing mobile applications for inquiry-based learning in madrasas open up opportunities and threats in the digital transformation of education. The potential of enthusiastic students about technology is not immediately facilitated through relevant learning media. In that case, madrasas will be left behind in forming a generation that is adaptive to the development of the times (Ramdlani et al., 2021; Dakir et al., 2021; Munawwaroh et al., 2024). Conversely, if this application is successfully developed and implemented effectively, madrasas can become pioneers in contextual, interactive learning innovations that are by the characteristics of today's students. However, the challenges are very real, from limited devices and low digital competence of teachers to minimal supporting infrastructure. Therefore, it is essential for madrasas and Islamic education policymakers to immediately prepare a comprehensive digitalization strategy for learning so that this opportunity is not lost in a pile of limitations.

The correlation between the potential and challenges of developing mobile applications in inquiry-based learning is very close to the readiness of the education ecosystem in Madrasas. On the one hand, students already have a closeness to digital technology and show a high interest in interactive learning activities (Adanali, 2021; Afikah, Astuti, Suyanta, Jumadi, & Rohaeti, 2022; Peña-Acuña & Martínez-Sala, 2022). However, teachers are not fully prepared to facilitate this process due to limited technical skills, lack of training, and the unavailability of adequate supporting devices. This situation indicates a digital divide between students and educators. This correlation is a strong signal that the success of digital education innovation is not only determined by the technology itself but by the ability of the education system to accommodate and support these changes comprehensively (Alqaidi, Alharbi, & Almatrafi, 2021; Santana et al., 2022). Therefore, continuous training, development of teacher-friendly learning tools, and investment in long-term digital infrastructure are needed.

### **Positive Student Responses to Environmental Learning Based on Digital Inquiry Applications**

The positive responses of students to environmental learning based on digital inquiry applications indicate that this approach has transformative potential for the quality of science education in madrasas. When students feel happy, active, and involved in the learning process, learning outcomes also increase in cognitive, affective, and psychomotor. The implication is that digital applications can bridge abstract scientific concepts and meaningful real experiences. Furthermore, using applications that integrate technology and

environmental issues directly strengthens the achievement of the Sustainable Development Goals (SDGs) in education and the environment. If implemented massively, this method can encourage madrasah students to become a generation of active learners who are aware of environmental issues and can think critically about ecological problems. Therefore, this positive response should be the basis for developing madrasah policies and programs that support technology integration in contextual learning.

Students' positive response to using digital inquiry applications in environmental science learning correlates with the characteristics of the digital-native generation, who are accustomed to technology-based interactions (Fatimah, Santiana, & Sulastri, 2021; Situmorang et al., 2024). When learning utilizes interactive applications, students feel closer to the material because it is delivered with a visual, simulative, and exploration based approach. In addition, the principle of inquiry-based learning that places students as active subjects is also by their more independent and collaborative learning styles (El Iq Bali et al., 2020; Hidayah et al., 2024; Onia, 2024). Students' intrinsic motivation factor also supports this correlation, which increases because learning feels fun and challenging. Thus, the success of this application cannot be separated from the pedagogical approach's suitability, students' needs, and the use of appropriate media. Therefore, this success provides empirical evidence that educational technology is not just a tool but an integral component in creating a holistic and meaningful learning experience in madrasahs.

This research's contribution is significant because it introduces innovative digital learning media based on mobile applications specifically designed for environmental science learning in madrasahs. This research confirms that inquiry-based applications not only increase student participation and understanding but also integrate Islamic values and local contexts into a more contextual and interactive learning process. These findings support the development of a digital curriculum relevant to 21st-century needs and ecoliteracy-based education.

## CONCLUSION

This study provides the wisdom that integrating digital technology, especially inquiry-based mobile applications, is very relevant in overcoming the limitations of contextual learning models in environmental science education in madrasahs. The main conclusion that can be drawn is that science learning, which is still conventional, has minimal student involvement, and is not directly connected to the reality of the surrounding environment, requires a new approach that is more participatory and technology-based. The findings show that teachers have limitations in implementing innovative learning models due to infrastructure constraints, digital competence, and a dense curriculum. However, students' enthusiasm for the application-based approach shows great opportunities for learning transformation. An essential contribution of this study is to provide a conceptual and empirical basis for developing inquiry-based

learning applications that are contextual, adaptive, and relevant to the needs of madrasahs. However, this study has weaknesses in its scope, which is still limited, and has not tested the direct impact of the application on student learning outcomes quantitatively. Therefore, recommendations for further research are to expand research locations in diverse madrasahs, involve teachers and students directly in application development, and conduct experimental trials to measure the effectiveness of this model on improving environmental literacy and science learning outcomes

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