Integration of the STEAM Approach Based on Islamic Values in Pesantren Education: An Exploratory Case Study Grounded in Project-Based Learning and the Principles of *Ta'dib*

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ABSTRACT

Purpose – This study aims to explore the implementation of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach based on Islamic values in pesantren, as a response to the need for integrating modern scientific knowledge and Islamic spirituality in addressing 21st-century challenges. The focus of the study is to identify contextual strategies for implementing STEAM, analyze students' responses to the integration of Islamic values within STEAM learning, and formulate a conceptual framework for STEAM integration grounded in the principles of Islamic education (ta'dib).

Design/methods/approach – This study employs a qualitative approach through an exploratory case study design at Pondok Pesantren Tahfidzul Qur'an Al Husna Bukit Rajawali. Data were collected through participatory observation, semi-structured interviews with five key informants (teachers, pesantren leaders, students), and document analysis conducted during March 2025. Data analysis was carried out thematically using triangulation techniques to validate the findings.

Findings – The results indicate that STEAM was implemented through project-based learning, including projects such as constructing a natural water filter, producing educational videos, and creating Islamic geometry-based calligraphy. The integration of Islamic values was carried out substantively, with explicit connections between STEAM activities and Qur'anic verses and hadiths, significantly enhancing students' enthusiasm and active engagement. Identified challenges include limited learning facilities and teachers' competencies in applying interdisciplinary learning.

Research implications – Practically, this study recommends that pesantren improve teachers' pedagogical competencies through regular training in STEAM methodologies and invest in simple laboratory facilities or collaborative learning spaces. This integration model can be implemented in other pesantren with similar characteristics to enhance the quality of Islamic education in preparing a generation that is characterized, religious, and capable of addressing global challenges.

1. Introduction

Twenty-first century education demands learning models that can bridge the mastery of modern scientific knowledge with the formation of spiritual and social character. Amid the dynamics of globalization, digitalization, and socio-ecological complexity, pesantren—as the oldest Islamic educational institutions in Indonesia—face the challenge of curriculum transformation that must not only adapt to contemporary changes but also remain firmly rooted in Islamic values (Fauzi & Fajrin, 2022; Susanti et al., 2024). The STEAM (Science, Technology, Engineering, Arts, and Mathematics)

approach has gained increasing attention, particularly for its capacity to foster critical, collaborative, creative, and problem-solving skills essential in the disruption era (Sampurna & Susanto, 2025). In the context of pesantren, STEAM integration is not merely a technical innovation, but a systematic effort to synthesize Islamic epistemology with modern scientific approaches (Novitasari, 2023).

Historically, pesantren have been known for their tradition of teaching *kitab kuning*, *fiqh*, *tauhid*, and *tafsir*. However, the demands of the era urge pesantren to develop holistic and contextual learning models that not only produce *ulama* and Muslim scholars but also generations who are adaptive and contributive to the global society (Khoiri, 2025). The STEAM approach, if appropriately integrated, allows for a synergy between Islamic values and modern knowledge, as demonstrated in STEAM-based ecopedagogical models within pesantren environments that emphasize the principles of *khalifah*, *mizan*, and *hifdz al-biah* (Sheik Mohamed et al., 2024). In practice, activities such as coding, robotics, and simple ecological projects have been contextualized through Islamic spirituality and local wisdom, rendering the learning process more meaningful (Marwiyah, 2022; Sampurna & Susanto, 2025).

Several studies have demonstrated the effectiveness of the STEAM approach in enhancing students' participation, learning outcomes, and 21st-century skills. A local wisdom-based experimental study found that students learning through the STEAM model experienced significant improvements in cognitive, affective, and psychomotor aspects. Project-based learning activities such as waste processing and basic irrigation, when combined with pesantren values like mutual cooperation and social responsibility, fostered a strong connection between scientific content and real-life contexts (Sampurna & Susanto, 2025). Another study emphasized the importance of community involvement and the close relationship between kiai and students as transformative forces in STEAM-based environmental education (Sheik Mohamed et al., 2024). Furthermore, these models indirectly contribute to achieving the Sustainable Development Goals (SDGs), particularly SDG 4 (quality education) and SDG 13 (climate action) (Sheik Mohamed et al., 2024).

In the context of character and civic education, integrative approaches that combine Islamic curricula and the values of civil society have also proven effective in several Islamic schools. Islamic schools can serve as agents for shaping democratic and just leadership through the integration of value education, interactive discussions, and extracurricular activities such as debates and student organizations (Susanti et al., 2024). The same principle can be applied to pesantren, where STEAM integration must be designed not only to develop technological competencies but also to strengthen civic values, spirituality, and students' social leadership.

Nevertheless, various challenges persist in implementing STEAM curricula in pesantren. The still-dominant traditional curriculum structure, limited laboratory and learning facilities, and insufficient teacher training in interdisciplinary approaches constitute major barriers to implementation (Mu'minah, 2021; Sheik Mohamed et al., 2024). In addition, the transformation of teachers' roles from content deliverers to facilitators of value- and project-based learning has not been fully internalized (Sampurna & Susanto, 2025). In many cases, epistemological tensions arise between the secular and positivistic tendencies of Western scientific approaches and the Islamic view that positions knowledge as a spiritual trust. When Islamic values are merely attached symbolically without processes of reinterpretation and Islamization of knowledge, the curriculum risks losing its spiritual depth.

Within this framework, the theory of ta'dib is chosen as the main theoretical foundation because it offers a concept of Islamic education that encompasses not only the transfer of knowledge but also the formation of adab, ethics, and morals integrated with intellectual achievement (Al-Attas, 1988). In contrast to the *tarbiyah* approach, which is more oriented toward moral development, or *ta'lim*, which tends to focus on content delivery, *ta'dib* emphasizes the integration of the three: knowledge (*'ilm*), instruction (*ta'lim*), and character formation (*tarbiyah*) as a mutually reinforcing unity. This approach

enables a more profound evaluation of the extent to which STEAM elements can be adapted and interpreted within a substantive Islamic value framework.

Although a number of studies have indicated the potential for STEAM integration in pesantren, significant research gaps remain. First, a theoretical gap persists in the systematic development of a framework for Islamizing knowledge within the context of the STEAM curriculum. Second, an empirical gap is evident in the lack of documentation of best practices and longitudinal data regarding the impact of STEAM learning on students' character and scientific literacy (Sampurna & Susanto, 2025; Sheik Mohamed et al., 2024). Third, a practical–knowledge conflict gap arises from the absence of pedagogical guidelines that substantively integrate spiritual values with scientific approaches.

This study aims to: (1) identify strategies for implementing the STEAM curriculum in accordance with the characteristics of pesantren; (2) analyze students' responses to the integration of Islamic values within STEAM learning; and (3) formulate a conceptual framework for integrating STEAM with the principles of *tarbiyah Islamiyah*. The focus of the study is directed toward strategies that are contextual and rooted in pesantren values—epistemologically, pedagogically, and socio-culturally.

As the study site, Pondok Pesantren Tahfidzul Qur'an Al Husna Bukit Rajawali was selected for its representation of the modern *salafiyah* pesantren typology that has begun to adopt science and technology learning approaches selectively. This pesantren is also actively engaged in project-based learning and digital *dakwah*, making it an appropriate social laboratory to observe the dynamics of integrating Islamic values with the STEAM approach.

The original contribution of this study lies in the development of a STEAM curriculum integration model based on Islamic values within the pesantren environment. This model is expected to enrich the discourse of contemporary Islamic education by presenting an epistemological synthesis between tradition and modernity, spirituality and science, and by strengthening the position of pesantren as competitive educational institutions both nationally and globally. Through this approach, pesantren are envisioned not only to produce intellectually capable students, but also individuals with ecological awareness, social leadership, and strong moral commitment—an ideal profile of *insan kamil* in the era of civil society (Susanti et al., 2024).

2. Methods

2.1. Research Design

This study employed a qualitative approach with an exploratory case study design to gain an in-depth understanding of the effectiveness of STEAM curriculum implementation within the context of pesantren education based on Islamic values. This design was selected in alignment with the research objective to explore the complexity of integrating Islamic values into the domains of science, technology, engineering, arts, and mathematics (STEAM), as well as stakeholders' perceptions regarding the challenges and opportunities in implementing such a curriculum. The study was conducted over five days, from 15–19 March 2025, at Pondok Pesantren Tahfidzul Qur'an Al Husna Bukit Rajawali, focusing on direct observation, exploration of pedagogical practices, and participatory interaction among teachers, pesantren leaders, and students.

2.2. Participants and Research Context

The research was conducted at Pondok Pesantren Tahfidzul Qur'an Al Husna Bukit Rajawali, a modern pesantren that has incorporated the STEAM approach into its educational practices. Respondents were purposively selected to represent key actors in the curriculum's implementation, comprising three STEAM-subject teachers, one pesantren leader, and one senior student. The selection considered diversity in educational background, experience in teaching or

participating in STEAM programs, and direct involvement in project-based learning activities. This purposive sampling strategy is commonly used in qualitative research to obtain rich data from informants with relevant knowledge and experience.

Table 1. Characteristics of Research Respondents

No	Respondent Initial	Gender	Role in Pesantren	Educational Background	STEAM Teaching/Learning Experience
1	R1	Male	Science & Technology Teacher	B.Ed. in Physics Education	3 years
2	R2	Female	Mathematics & Arts Teacher	B.Sc. in Mathematics & Arts Training	2 years
3	R3	Male	Pesantren Leader	M.Ed. in Islamic Education	5 years (curriculum development)
4	R4	Female	English & IT Teacher	B.A. in English	1 year
5	R5	Male	Senior Student	Final-year Islamic Senior High School	1 year (involved in STEAM projects)

The composition of participants reflects cross-functional representation within the pesantren's STEAM-based learning system, encompassing perspectives from teachers of core disciplines, institutional leadership, and students actively engaged in field practices. This approach was intended to ensure both depth and diversity of data in examining curriculum implementation holistically.

2.3. Data Collection Techniques and Procedures

Data were collected through three primary methods: participatory observation, semi-structured interviews, and documentation. Observations focused on classroom learning activities and interdisciplinary project implementation, with systematic field notes to capture the dynamics of Islamic value integration in STEAM practices. Interviews were conducted individually with each respondent, lasting between 45 to 60 minutes, and were audio-recorded using digital devices to ensure transcription accuracy. The interview guide included key themes such as strategies for integrating Islamic values, challenges in curriculum implementation, and student responses to project-based learning. Documentation was obtained from a variety of sources, including syllabi, learning modules, project plans, student works, and learning evaluations, to enrich data triangulation (Creswell & Poth, 2018).

2.4. Data Analysis Technique

Data were analyzed thematically using manual open coding. The analytical process began with data reduction, followed by categorization into key themes, and narrative interpretation to identify patterns of Islamic value integration in STEAM learning. These steps were aligned with the qualitative analysis model that emphasizes a cycle of data reduction, data display, and conclusion drawing/verification (Miles et al., 2014). The validity of the findings was ensured through member checking, whereby respondents were asked to clarify and confirm the researcher's interpretations.

2.5. Ethical Considerations

This study obtained formal approval from the authorities of Pondok Pesantren Tahfidzul Qur'an Al Husna Bukit Rajawali as the research site. All participants were provided with a clear explanation of the study's aims and procedures and gave their voluntary consent to participate through verbal informed consent. To protect privacy and confidentiality, all respondent identities were anonymized using coded initials.

3. Results

This study aimed to:
a. Identify strategies for implementing a STEAM curriculum in accordance with the characteristics of pesantren;
b. Analyze students' responses to the integration of Islamic values within STEAM learning; and
c. Formulate a conceptual framework for STEAM integration based on the principles of *tarbiyah Islamiyah*.

The study employed a qualitative approach with an exploratory case study method. Data were collected through in-depth interviews, participatory observation, and documentation during 15 January–19 May 2025 at Pondok Pesantren Tahfidzul Qur'an Al Husna Bukit Rajawali, and were analyzed thematically.

3.1. STEAM Curriculum Implementation Strategies through Project-Based Learning

a. Learning Methods Applied

Observations recorded that the primary strategy in implementing STEAM was project-based learning. Activities included:
- Construction of simple technological devices (water filtration system),
- Production of educational videos,
- Calligraphy through geometric approaches.

Students were actively involved in hands-on practice. Observation on 16 March 2025 noted students constructing a basic water filter using natural materials such as sand, charcoal, and cotton.

b. Teachers' Role in STEAM Implementation

During observation (17 March 2025), teachers were observed primarily acting as facilitators rather than mere transmitters of content. They guided scientific exploration processes, provided direction, and encouraged peer discussions among students.

"Teachers act more as discussion facilitators. They give us the freedom to explore, but still direct us so we stay within context." (R5, personal interview)

c. Student Activities and Participation

Observations documented high levels of student engagement throughout project activities, with students actively discussing, conducting experiments, and demonstrating enthusiasm for new technologies.

"Previously, learning physics was just theory. Now I can create a simple tool and understand its function." (R5, personal inRterview)

3.2. Patterns of Islamic Value Integration in STEAM Learning

a. Contextual Integration of Qur'anic Verses and Hadiths

Teachers explicitly connected each STEAM learning activity to verses from the Qur'an and hadiths. For instance, during the water filtration activity, the science teacher cited QS. Al-Anbiya:30 regarding water as a source of life (Observation, 16 March 2025).

"I usually link experiments with verses or hadiths so that students don't just learn science, but also strengthen their faith." (R1, personal interview)

b. STEAM as a Medium for Islamic Spiritual Reflection

In the Islamic geometric calligraphy activity, the mathematics and arts teacher explained how STEAM served as a medium for students' spiritual reflection.

"We encouraged students to create calligraphy using Islamic geometric concepts. They not only drew but also learned about symmetry, patterns, and the philosophy of beauty in Islam." (R2, personal interview)

Observation of the art class (17 March 2025) showed that students were not merely producing artworks but also engaging in active discussion about the philosophical meanings of their creations.

3.3. Stakeholder Responses to STEAM Curriculum Implementation

a. Positive Perceptions of STEAM Benefits

Interview data consistently indicated that all respondents held positive views regarding the benefits of STEAM in the pesantren context.

"STEAM helps students think logically and scientifically, while still being religious." (R1, personal interview)

b. Student Enthusiasm Toward Technology-Based STEAM

Students responded positively to the integration of technology within STEAM, perceiving it as a more meaningful and engaging alternative to conventional methods.

"I'm really happy. We're getting new things in class. In the past, people used to call our pesantren outdated, but now we can also connect to the outside world through technology." (R5, personal interview)

Observation (18 March 2025) of an English lesson involving the production of educational videos showed high enthusiasm, evidenced by students independently editing videos outside class hours.

c. Challenges in Implementing STEAM

Interviews revealed two primary challenges in STEAM implementation: limited facilities and the need to improve teacher competencies.

"We're still in a transition phase. Many teachers are not yet familiar, and we also face budget constraints." (R3, personal interview)

Teachers also expressed the need for further training to implement STEAM integration more effectively.

"I feel I need to learn more. Integrating science with art or religion is not an easy task." (R1, personal interview)

Empirical data from interviews and observations revealed several substantive elements with potential for development into a conceptual framework for STEAM integration based on *tarbiyah Islamiyah* principles:

*   Project-based learning activities that combine modern knowledge (STEAM) with reflective Islamic spirituality,
*   Teachers serving as facilitators guiding students to understand the interconnection between modern knowledge and Islamic values,
*   Active student participation in learning, not only cognitively but also spiritually and affectively.

The results of this study reveal the strategies used for implementing STEAM in pesantren, the patterns of Islamic value integration, and the positive responses from students and teachers. Challenges such as limited facilities and the need for improved teacher competencies remain critical considerations. These findings directly address the study's objectives and research

questions without over-interpretation, while also providing a robust empirical basis for the conceptual development of STEAM integration grounded in *tarbiyah Islamiyah* principles.

4. Discussion

This study aimed to identify strategies for implementing a STEAM curriculum suited to the characteristics of pesantren, analyze students' responses to the integration of Islamic values in STEAM learning, and formulate a conceptual framework for STEAM integration based on the principles of tarbiyah Islamiyah. The findings indicate that the project-based STEAM approach at Pondok Pesantren Tahfidzul Qur'an Al Husna successfully fostered students' active participation, enhanced integrative understanding between modern science and Islamic values, and provided a spiritually and intellectually meaningful learning experience. These results align with the research objectives by offering empirical evidence of the effectiveness of an integrated STEAM model in the pesantren context.

The principal finding demonstrates that project-based STEAM implementation strategies were highly effective in increasing student engagement and rendering the learning process more contextual. The success of this project-based approach aligns with previous research emphasizing that STEM or STEAM approaches, especially those integrated with Islamic values, significantly enhance students' scientific literacy, problem-solving skills, and critical thinking abilities (Prihatiningtyas et al., 2025; Wahyuningtyas & Widiyono, 2023; Wildani & Budiyono, 2022). In contrast to traditional learning, which emphasizes memorization and theoretical instruction, this approach encourages critical, creative, and collaborative thinking (Febriansari et al., 2022), with demonstrated improvements in students' performance and motivation (Wahyuningtyas & Widiyono, 2023; Wildani & Budiyono, 2022).

Furthermore, the integration of Islamic values within STEAM learning was found to be highly contextual and substantive rather than merely symbolic. This is consistent with findings that interdisciplinary approaches such as Re-STEAM and STEM-based storytelling effectively embed Islamic values and character education into learning contexts, thereby harmonizing science and religion substantively (Adiyono et al., 2024; Masud et al., 2023). The current study similarly observed that teachers explicitly linked STEAM content with Qur'anic verses and hadiths, thus deepening the spiritual significance of learning. This reflects a successful alignment of Islamic epistemology with modern science, supporting the concept of substantive integration, which regards ta'dib as the holistic integration of knowledge, teaching, and character formation (Al-Attas, 1988).

Students' positive responses to the STEAM approach reflect its relevance to 21st-century educational demands, where technological literacy, collaboration, and critical reflection are essential competencies (Khoiri, 2025; Wahyuningtyas & Widiyono, 2023). The study found students to be more motivated when learning was connected to real-life contexts, such as the water filtration project, educational video production, and Islamic geometric calligraphy. These findings support previous studies that emphasize STEAM learning's effectiveness when connected with Islamic values and local wisdom, contributing indirectly to achieving Sustainable Development Goals (SDGs), particularly Goals 4 and 13 (Marwiyah, 2022; Sheik Mohamed et al., 2024).

From a theoretical perspective, this study reinforces that STEAM integration within Islamic education can effectively be achieved through a ta'dib-based substantive approach (Adiyono et al., 2024; Al-Attas, 1988). This perspective contributes to the development of Islamic educational theory by underscoring the importance of integrating spiritual, intellectual, and practical dimensions in STEAM learning. The resulting integration model enriches the discourse on Islamization of knowledge by offering an operational and contextually grounded conceptual framework, addressing the fragmentation issue between religious and secular knowledge noted in previous studies (Adiyono et al., 2024).

Practically, this study recommends pesantren to actively adopt project-based learning approaches in their STEAM curricula, emphasizing the substantive integration of Islamic values. It

advises regular training for teachers to enhance their pedagogical competencies, as supported by findings that highlight the necessity of teacher training and technological resource improvement (Wildani & Budiyono, 2022). Additionally, investment in learning facilities, such as simple laboratories or collaborative spaces, is recommended to better support STEAM-based projects.

Nevertheless, this study acknowledges several limitations. First, the research's short duration (five days) may not fully capture the long-term dynamics of STEAM implementation (Prihatiningtyas et al., 2025). Second, the limited participant number and qualitative approach restrict the generalizability of the findings. Third, the study does not fully resolve epistemological tensions between Western scientific paradigms and Islamic worldviews (Adiyono et al., 2024).

Future research should conduct longitudinal studies to assess the long-term impact of STEAM integration on character development, scientific literacy, and academic performance. Additional research could also develop detailed pedagogical guidelines for reconciling Western scientific methods with Islamic epistemology within STEAM curricula and explore systematically structured teacher training programs (Adiyono et al., 2024; Wildani & Budiyono, 2022).

This study confirms that the integrative, project-based STEAM approach in pesantren positively impacts students' participation and deepens their understanding of the relationship between modern knowledge and Islamic values. The key contribution lies in formulating a conceptual framework for STEAM integration based on the principles of ta'dib, bridging Islamic epistemology with 21st-century educational demands. Despite its limitations, this study significantly advances Islamic educational theory and practice, underscoring pesantren's adaptability and innovation rooted deeply in Islamic spirituality amid globalization and educational modernization.

5. Conclusion

This study identified strategies for implementing the STEAM curriculum at Pondok Pesantren Tahfidzul Qur'an Al Husna Bukit Rajawali and explored the patterns of integration between Islamic values and the components of STEAM learning. Overall, the findings addressed the research objectives by demonstrating the effectiveness of project-based learning in enhancing students' active participation, developing 21st-century skills, and achieving substantive integration between Islamic epistemology and modern scientific knowledge. Empirical findings consistently indicated that the integrative approach adopted in the pesantren was capable of generating intellectually, spiritually, and socially meaningful learning experiences for students.

Practically, this research affirms that integrating the STEAM curriculum into pesantren education has a positive impact not only on students' cognitive development but also on their spiritual and social character formation. Teachers successfully assumed the role of facilitators who directly linked STEAM content with Qur'anic verses and hadiths, making STEAM learning more aligned with the Islamic educational vision grounded in ta'dib. The project-based learning model implemented in the pesantren served as an effective platform for cultivating critical thinking, collaboration, creativity, and socio-ecological awareness—all of which are essential competencies in the 21st century. Therefore, this approach holds significant potential for broader application in other pesantren with similar typologies.

Despite these promising findings, the study has several limitations. First, the research was conducted over a relatively short period of five days, which may not fully capture the long-term impact of implementation. Second, the limited number of informants restricts the generalizability of the results to all types of pesantren. Third, the study has not fully resolved the epistemological tension between secular-positivist modern science and the religious epistemology of Islam.

The primary theoretical implication of this study is the importance of developing Islamic educational models that are not merely symbolic, but substantive—harmoniously integrating modern scientific knowledge with Islamic spiritual values within the *ta'dib* framework. Practically, pesantren are

encouraged to enhance teachers' pedagogical competence through regular training and workshops on the STEAM approach, and to improve the availability of learning facilities to optimally support interdisciplinary project implementation.

For future research, longitudinal studies are needed to assess the impact of STEAM curriculum integration on students' spiritual, social character, and scientific literacy development in a more systematic manner. Moreover, the development of specific pedagogical guidelines for explicitly reconciling Islamic epistemology with modern scientific approaches should be prioritized in subsequent studies.

In conclusion, this study makes a tangible contribution to the advancement of theory and practice in contemporary Islamic education. The resulting model of STEAM integration grounded in Islamic values not only enriches scholarly discourse on the Islamization of knowledge but also reinforces the position of pesantren as educational institutions that are both responsive to the changing times and firmly rooted in Islamic principles—equipping younger generations to face global challenges in the era of disruption.

Declarations

Author contribution statement

Dini Pepilina served as the main and corresponding author, leading the conceptualization, research design, and manuscript writing. Fauzi contributed to the development of methodological instruments and provided technical assistance during data processing. Ani Safitri contributed to data collection, analysis, and assisted in the revision and final editing of the manuscript. Muh. Dzihab Aminudin S. supported the fieldwork coordination and ensured consistency in research documentation. Selly Nurlela Sari provided critical input during the data interpretation phase and supported the refinement of the theoretical framework and discussion section.

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Data availability statement

The datasets generated during and analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of Interest's statement

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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