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Integrating Science and Islamic Religious Education in Pesantren: A Literature Review on Character Development and Academic Culture

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Abstract

Purpose of the study: This study examines how science and Islamic religious education are conceptually connected and how these connections may support character development and academic culture. It distinguishes substantive integration from the coexistence of subjects within a curriculum. Method: A narrative literature review was conducted through critical reading, thematic categorization, comparative analysis, and interpretive synthesis. The search focused on contemporary publications from 2020 to 2026, supplemented by earlier conceptual and methodological references. Empirical findings were distinguished from theoretical arguments, and evidence from different educational settings was interpreted cautiously. Main findings: The synthesis identifies three complementary analytical dimensions: curricular integration, involving connections among objectives, content, activities, and assessment; epistemic integration, connecting scientific inquiry with Islamic ethical commitments while preserving disciplinary standards of justification; and cultural integration, involving shared practices of reasoned discussion, accurate reporting, and openness to correction. These dimensions suggest potential relationships with intellectual honesty, responsibility, and collaborative learning. However, the evidence does not establish independent causal effects or automatic transfer from memorization and religious discussion to scientific competence. Teacher preparation, guidance, resources, and curricular workload emerge as important considerations. Novelty/Originality of this study: The study brings curricular, epistemic, and cultural perspectives together within a framework that distinguishes intended connections, potential mechanisms, and demonstrated outcomes. It challenges assumptions that administrative coordination or religious references alone constitute substantive integration. Contributions of this study: The framework informs curriculum planning, collaborative teacher development, and assessment that differentiates scientific understanding from ethical reflection. It also identifies priorities for comparative and longitudinal research using diverse samples and validated measures. The conclusions remain limited by heterogeneous sources, indirect evidence, and the absence of field verification.

Keywords: Science and religion integration; Islamic religious education; character development; academic culture; epistemic integration; narrative literature review.

Introduction

Integrating science and Islamic religious education raises important questions about how educational institutions connect disciplinary knowledge, ethical commitments, and everyday learning practices. In Indonesia, pesantren—Islamic boarding schools—provide a distinctive setting for examining these relationships because religious instruction can coexist with formal schooling and residential education. Discussions of multidisciplinary Islamic education and integrative curriculum development offer conceptual resources for connecting these domains (Muhsan & Haris, 2022; Junus, 2024). However, the presence of religious and scientific subjects within the same institution does not, by itself, demonstrate substantive integration. Such integration requires attention to the relationships among learning objectives, teaching practices, standards of justification, and educational values.

These questions are situated within the broader challenges facing contemporary pesantren. Isbah and Sakhiyya (2023) examine how these institutions negotiate educational equity and market demands while maintaining their religious traditions. A recent review of pesantren learning models also describes movement toward hybrid and digitally supported approaches, alongside uneven infrastructure and tensions between preserving established practices and adopting educational innovations (Suresman et al., 2025). These developments suggest that integration should be examined in relation to institutional diversity rather than treated as a uniform characteristic of pesantren. The present review therefore focuses on pesantren that combine Islamic learning with formal primary or secondary education, while distinguishing evidence from other educational settings.

The importance of science education is reinforced by Indonesia's broader educational context. According to the Programme for International Student Assessment (PISA) 2022, 34% of students in Indonesia attained at least Level 2 proficiency in science, compared with an OECD average of 76% (Organisation for Economic Co-operation and Development [OECD], 2023). These national findings provide a rationale for strengthening science education, but they do not establish the proficiency of pesantren students specifically. Research on curriculum management in an integrated Islamic elementary school offers a related institutional perspective on educational quality (Faizah, 2023), although its findings should not be generalized directly to pesantren. National assessment results and research from other Islamic educational institutions must therefore be distinguished from evidence concerning science learning within pesantren.

The conceptual foundations of integration include debates about the Islamization of knowledge and the relationship between knowledge, worldview, and educational purpose. Contemporary discussions of al-Faruqi and al-Attas provide different perspectives on these issues (Atmaja & Mustopa, 2020; Edison et al., 2022). Al-Faruqi's approach emphasizes engaging modern disciplines and Islamic intellectual resources in the reconstruction of knowledge, whereas al-Attas's perspective places greater emphasis on the

worldview and foundational concepts through which knowledge is understood. These perspectives can inform the analysis of educational integration without assuming that one simply superseded or completed the other. Their relevance to pesantren depends on how philosophical commitments are translated into age-appropriate curricula, teaching practices, and opportunities for inquiry.

An important consideration is whether integration helps learners understand the relationships and distinctions between different forms of knowledge. Billingsley et al. (2018) propose an epistemic insight framework that addresses the nature of science, interactions among ways of knowing, and relationships between science and religion. Although developed for schooling in England, the framework offers a useful comparative perspective for examining disciplinary boundaries. Its application to pesantren nevertheless requires contextual adaptation. In this review, integration is understood as connecting scientific learning with Islamic ethical and educational commitments while retaining the role of empirical evidence in evaluating scientific explanations. Religious reflection should not be treated as a substitute for observation, investigation, or critical assessment.

Pesantren are also relevant because learning takes place through both organized instruction and community life. Discussions of religious–scientific integration emphasize the role of Islamic values in shaping educational purposes and understandings of knowledge (Daulay & Salminawati, 2022; Fakhrurrazi et al., 2023). These perspectives provide a basis for examining whether and how curricular connections are supported by residential practices, teacher–student relationships, and collective learning. However, practices such as textual discussion, religious instruction, and scientific investigation should not be assumed to employ identical standards of justification. Their possible relationships with intellectual honesty, responsibility, openness to correction, and reasoned discussion remain questions for analysis rather than predetermined outcomes.

Existing studies provide several complementary strands of evidence. Mundungningtias (2022) examines the management of pesantren and national curriculum integration, while Munir and Nor (2021) investigate the preservation of salafiyah educational traditions in Indonesia and Malaysia. Research by Alqudsi et al. (2023) and Arifin et al. (2022) addresses character education through the internalization of Islamic values and institutional culture. Meanwhile, Muhtadi et al. (2023) discuss curriculum, information literacy, and critical literacy in Indonesia's digital educational context. The latter provides a broader comparative perspective rather than direct evidence of science literacy among santri. Together, these studies identify relevant curricular, cultural, and literacy concerns, but their different settings and research designs limit the conclusions that can be drawn about the specific contribution of science–religion integration.

The analytical problem addressed here is how these strands can be brought together without conflating their concepts or overstating their findings. Character development concerns dispositions and practices such as

honesty, responsibility, and intellectual humility. Academic culture refers to shared practices through which a learning community seeks knowledge, evaluates arguments, uses references, and responds to correction. Science literacy, although potentially supported by reading and information literacy, requires distinct attention to scientific explanations and evidence. A literature review can clarify these relationships by comparing concepts, contexts, and findings rather than merely assembling favorable accounts of integration. This approach is consistent with Snyder's (2019) emphasis on literature reviews as a means of synthesizing knowledge and developing conceptual understanding.

Accordingly, this review organizes the literature through three analytical dimensions: curricular integration, concerning connections among objectives, content, learning activities, and assessment; epistemic integration, concerning relationships between scientific inquiry and Islamic understandings of knowledge and educational purpose; and cultural integration, concerning the everyday practices through which learning and intellectual responsibility are sustained. These dimensions are used as interpretive categories, not as empirically validated causal mechanisms. Their value lies in helping identify where reported practices align, where evidence remains indirect, and where further research is needed.

The study therefore aims to clarify how science and Islamic religious education are conceptualized and connected in pesantren, examine the evidence relating these connections to character development and academic culture, and identify enabling conditions, limitations, and research priorities. It also considers the relevance of these findings to curriculum development, including discussions associated with Kurikulum Merdeka, while recognizing differences among schools, madrasahs, and pesantren educational arrangements. The contribution is a context-sensitive synthesis of potential relationships and the evidence supporting them, rather than an estimate of causal impact.

Method

Research Design

This study employed a narrative literature review with a conceptual and thematic orientation to examine the integration of science and Islamic religious education in pesantren. The review drew on published literature rather than primary field data. Its purpose was to clarify concepts, compare reported educational practices, and synthesize potential relationships between integration, character development, and academic culture. It did not seek to estimate causal effects or test hypotheses within a particular pesantren.

A narrative review was appropriate for bringing together empirical studies and conceptual discussions addressing different aspects of the research problem. Its analytical value rests on the critical comparison and interpretation of existing knowledge rather than the accumulation of

supporting references alone (Snyder, 2019). The review focused on three questions: how integration is conceptualized, how it is described in educational practices, and what evidence supports its proposed relationships with character development and academic culture.

Literature Sources and Search Focus

The literature search focused on publications from 2020 to 2026 identified through Google Scholar, the Directory of Open Access Journals (DOAJ), Crossref, and relevant journal websites, including national journals listed in SINTA. These resources served different functions. Google Scholar supported literature discovery, DOAJ facilitated the identification of open-access journal articles, Crossref supported bibliographic verification, and journal websites provided publication information and access to available texts. Their use did not imply that all retrieved publications were indexed in Scopus.

The reported search terms included combinations of "integrasi sains dan agama," "islamisasi ilmu pengetahuan," "pendidikan karakter santri," "budaya akademik pesantren," "bahtsul masail," and "kurikulum merdeka pesantren." These terms addressed science–religion integration, Islamic perspectives on knowledge, character education, academic practices, and curriculum development. The review drew primarily on journal articles, supplemented by academic book chapters relevant to its conceptual and institutional context.

The publication window applied to the contemporary literature under discussion. Earlier methodological references were used to support the review approach and were distinguished from the substantive literature concerning pesantren education. Accordingly, the publication dates of methodological references did not extend the stated coverage of the contemporary review corpus.

Scope and Interpretation of Sources

The original source selection considered the availability of identifiable authorship, publication year, journal or publisher information, and bibliographic details. These features supported the traceability of references but were not treated as sufficient evidence of methodological quality.

The central context of interpretation was pesantren education, particularly settings in which Islamic learning coexists with formal primary or secondary education. Sources addressing other Islamic educational institutions, higher education, or literacy more broadly provided comparative or conceptual perspectives. Their findings could inform the discussion, but they did not constitute direct evidence of educational outcomes among pesantren students.

The distinction between empirical and conceptual sources was important to the interpretation of the literature. Empirical findings were understood in relation to the settings and research designs reported by the original studies. Conceptual sources informed definitions and possible

explanations without being treated as demonstrations of effectiveness. Likewise, findings concerning reading, information, or digital literacy were not equated with measured improvements in science literacy.

Analytical Procedure

The analysis followed the three stages described in the original review: thematic categorization, critical comparison, and interpretive synthesis.

First, the literature was organized according to its substantive focus, including concepts of integration, curricular implementation, character development, and academic culture. These categories provided an initial structure for examining the relationships among philosophical perspectives, educational arrangements, and everyday learning practices.

Second, studies were compared critically to identify similarities, differences, and unresolved questions. Particular attention was given to whether a source addressed pesantren directly or another educational setting, and whether its argument was supported by empirical findings or conceptual reasoning. Differences in institutional context and research design were considered when interpreting the relevance of findings to the review questions.

Third, the findings and arguments were synthesized into an interpretive account organized around curricular, epistemic, and cultural integration. Curricular integration concerned connections among educational content and learning arrangements. Epistemic integration concerned relationships between scientific inquiry and Islamic understandings of knowledge and educational purpose. Cultural integration concerned community practices through which learning, responsibility, and intellectual engagement were sustained.

These dimensions functioned as analytical categories rather than validated causal mechanisms. The synthesis sought to connect recurring ideas across sources while preserving the distinction between what individual studies reported and what the review inferred. This distinction is consistent with the methodological emphasis on maintaining a transparent relationship between source findings and higher-level interpretation in thematic synthesis (Thomas & Harden, 2008). Their work informed this principle without implying that the present review implemented their complete systematic-review procedure.

Interpretive Rigor and Limitations

Where the available literature permitted, arguments were considered in relation to more than one source. However, convergence across publications was not treated as proof of causality or as a substitute for evaluating the relevance of their evidence. Interpretive statements were distinguished from reported findings, and recommendations for educational practice were presented as implications rather than established outcomes.

The review was limited by the heterogeneity of its sources and the absence of field-based verification. It did not establish that integration

independently caused improvements in character, academic culture, or science literacy. Its conclusions therefore concern conceptual relationships, reported practices, and potential mechanisms that require further empirical investigation. The review also does not claim exhaustive coverage of all relevant publications or a formal risk-of-bias assessment.

Results and Discussion

Conceptual Foundations of Science and Islamic Religious Education Integration

The literature provides a basis for distinguishing the institutional coexistence of science and religious education from their substantive integration. Fakhrurrazi et al. (2023) discuss relationships between scientific knowledge and faith, while Daulay and Salminawati (2022) address the integration of religious knowledge and science in education. Muhsan and Haris (2022) contribute a multidisciplinary perspective on Islamic religious education. Together, these discussions suggest that integration involves more than accommodating different subjects within a common institutional structure.

Administrative integration concerns arrangements such as timetables, organizational responsibilities, and the inclusion of religious and scientific subjects in the curriculum. These arrangements may be necessary, but they do not demonstrate that students understand relationships between the subjects. Substantive integration requires deliberate connections among educational purposes, learning activities, and the ways in which knowledge claims are justified. A pesantren may therefore offer both religious instruction and science classes while leaving their conceptual and pedagogical relationships largely unexplored.

Within Islamic educational discourse, *tawhid*, or the oneness of God, provides an orientation through which learning can be associated with ethical responsibility and a broader understanding of human purpose. Daulay and Salminawati (2022) provide a conceptual basis for examining this orientation, while Hafiz (2022) discusses integration in relation to moral development. However, a theological rationale should be distinguished from evidence of educational effectiveness. The proposition that knowledge entails responsibility does not establish that a particular curriculum produces honesty, humility, or improved scientific reasoning.

Epistemic integration also requires attention to disciplinary differences. Scientific inquiry evaluates explanations through observation, measurement, argument, and the assessment of evidence. Religious education includes interpretive, theological, and ethical questions whose justification may involve different intellectual traditions. Integration becomes analytically clearer when it explains how these domains interact without assuming that their methods are interchangeable.

Billingsley et al. (2018) provide a comparative framework through epistemic insight, which concerns understanding disciplinary knowledge and relationships among ways of knowing. Applied cautiously to pesantren, this perspective suggests asking students to distinguish the empirical question of how a phenomenon occurs from ethical questions about how people should respond to it.

For example, a lesson on water quality could connect measurement and interpretation of results with reflection on communal responsibility. The scientific conclusion would depend on the investigation, while the ethical discussion would address the use and implications of that knowledge. This is a proposed pedagogical connection rather than evidence that such integration has already produced particular outcomes in the reviewed institutions.

Intellectual Perspectives on the Islamization of Knowledge

The Islamization of knowledge provides an important intellectual context for understanding contemporary integration debates. Edison et al. (2022) examine al-Faruqi's approach in relation to educational challenges, while Atmaja and Mustopa (2020) discuss metaphysical and epistemological questions within Islamic and Western philosophical traditions. Bistara (2021) considers al-Attas's contribution to the Islamization of knowledge.

These perspectives should not be presented as a simple sequence in which one thinker completed or corrected the other. Al-Faruqi's emphasis on engaging modern disciplines and Islamic intellectual resources differs from al-Attas's attention to the worldview and foundational concepts through which knowledge is understood. Their relationship can be examined comparatively, but claims about direct intellectual influence or chronological responses require historical evidence.

For pesantren education, the significance of these perspectives lies in their translation into educational decisions. A philosophical commitment becomes pedagogically meaningful when it informs the selection of learning objectives, the organization of subject relationships, and the evaluation of student understanding. Without such translation, integration may remain a statement of institutional aspiration.

Abdurrohim et al. (2023) offer a historical discussion of faith education in the early Muslim community. Their contribution can contextualize the educational importance of belief and religious formation. It should not, however, be treated as proof that contemporary experimental science is a direct continuation of early religious instruction. Historical connections require attention to differences in institutions, knowledge practices, and educational purposes.

Fuady and Bistara (2022), Nugraha (2020), and Nyak Mustakim (2021) provide further perspectives on Islamic knowledge and institutional applications. Read together, these sources invite distinctions among Islamization, integration, and interconnection. The terms may overlap, but

they need not imply identical relationships between religious authority and disciplinary inquiry.

The present synthesis therefore interprets these intellectual perspectives as resources for examining educational purposes rather than as established models of classroom effectiveness. Their practical relevance depends on whether learners gain opportunities to understand scientific explanations, evaluate evidence, and reflect on ethical responsibility without confusing these activities.

Curricular Integration in Diverse Pesantren Settings

Curricular integration must be examined within the diversity of pesantren. Institutions differ in their relationships with formal schooling, the place of classical texts, their educational levels, and their available resources. Isbah and Sakhiyya (2023) situate contemporary pesantren within negotiations involving equity and market demands. These institutional conditions shape the possibilities for integration.

Mundungningtias (2022) addresses the management of pesantren and national curricula. Curriculum coordination provides an important organizational foundation, but its educational significance depends on what follows from coordination. Scheduling related topics close together may create opportunities for conceptual connections, yet the connections cannot be assumed to emerge automatically.

Three questions help assess whether coordination becomes substantive integration. First, are relationships between subjects made explicit in learning objectives? Second, do activities require students to use knowledge across subjects? Third, does assessment examine whether students understand the relationship? These questions shift attention from curriculum documents to the learning experiences they support.

As a proposed example, an environmental unit could connect scientific investigation, written reporting, and Islamic ethical reflection. Students might collect observations, evaluate the reliability of their data, and discuss responsibilities associated with the findings. The quality of integration would depend on whether each component contributes meaningfully to the shared educational purpose.

Munir and Nor (2021) examine the preservation of salafiyah traditions, including leadership and established educational practices. Their findings support attention to institutional continuity, but they do not establish that a particular leadership profile independently determines successful science integration.

Suresman et al. (2025) describe changing pesantren learning models, including hybrid and digitally supported approaches. This broader perspective suggests that adaptation does not necessarily require abandoning established practices. The analytical question is whether changes preserve relevant educational strengths while improving opportunities for disciplinary learning.

Integration should consequently be evaluated within specific institutional arrangements rather than treated as a universal developmental stage.

Connecting Classical Texts, Tahfiz, and Scientific Inquiry

Classical text study, Qur'anic memorization, and scientific investigation involve different learning demands. Their coexistence within pesantren provides opportunities for connection, but it does not demonstrate automatic transfer of competencies.

Fakhrurrazi et al. (2023) provide a conceptual context for considering relationships between Islamic knowledge and science. One possible instructional connection concerns astronomy, where religious purposes can be associated with observation, mathematical calculation, and evaluation of measurement. However, whether a particular lesson develops these competencies depends on the tasks students perform and the explanations they construct.

The same caution applies to tahfiz. Alqudsi et al. (2023) address Islamic values and character development in a tahfiz pesantren. Regular memorization may provide a context for discussing discipline and responsibility, but evidence of disciplined participation does not demonstrate improvements in working memory or science achievement.

Sala and Gobet (2020) provide a relevant methodological caution through their analysis of working memory training. Their research concerns cognitive training rather than tahfiz, so it should not be used to evaluate Qur'anic memorization directly. Its relevance is the distinction between improvement in practiced tasks and transfer to other outcomes. Claims that tahfiz supports science learning therefore require direct assessment of the proposed connection.

Science learning also involves more than remembering formulas or procedures. Hodson (2014) distinguishes learning scientific knowledge, understanding science, engaging in inquiry, and addressing socioscientific issues. These goals require different educational activities. A laboratory lesson that follows instructions successfully may not demonstrate that students can formulate a researchable question or explain why a method is appropriate.

Ramadhan and Sentosa (2023) discuss Islamic values in primary school IPAS learning. Their contribution offers a comparative pedagogical perspective, but adaptation to pesantren requires consideration of student age, curricular organization, teacher preparation, and available resources.

Lazonder and Harmsen (2016) further highlight the importance of guidance in inquiry learning. For pesantren, this suggests designing investigations with appropriate support rather than assuming that practical activity alone produces scientific understanding. The potential connection among classical learning, religious reflection, and science becomes stronger when teachers explicitly identify the competencies involved and assess whether students apply them.

Academic Culture and Intellectual Accountability

Academic culture concerns the shared expectations and practices through which a community engages with knowledge. It includes how questions are welcomed, how sources are used, how disagreements are handled, and how conclusions are revised. This concept should be distinguished from individual character, although the two can interact.

Munir and Nor (2021) provide a context for considering collective learning and the continuity of pesantren traditions. Bahtsul masail and musyawarah can be examined as settings for consulting references, comparing interpretations, and presenting reasons. These activities have possible relevance to academic argumentation, but their relationship with scientific reasoning requires careful analysis.

Jurisprudential discussion and experimental science may share activities such as problem formulation and comparison of claims. However, they can differ in their sources, objects of inquiry, and standards of justification. The presence of structured discussion does not establish competence in experimental design, measurement, or causal inference.

The pedagogical opportunity lies in making these differences explicit. A teacher could ask students to compare how a jurisprudential position is supported with how a scientific explanation is evaluated. Such comparison may develop awareness of disciplinary reasoning without treating one method as a substitute for another. Billingsley et al. (2018) provide a comparative conceptual basis for this approach.

Sanad and talaqqi should likewise be interpreted within their own intellectual functions. They involve relationships of transmission and accountability, but they are not equivalent to scientific replication or journal peer review. The relevant connection is a concern for responsible knowledge practices, while the procedures used to establish credibility remain distinct.

A substantive academic culture would require observable opportunities for correction and questioning. Possible indicators include whether students identify sources accurately, explain the reasons for their conclusions, engage with counterarguments, and acknowledge uncertainty. These indicators are proposed for analysis and future assessment. They are not findings that this review has measured.

Character Development and the Specific Contribution of Integration

The literature on pesantren character education emphasizes institutional practices and social relationships. Arifin et al. (2022) address culture-based character education, while Alqudsi et al. (2023) examine the internalization of Islamic values. Afif and Sariman (2022) discuss community service, and Alfi et al. (2023) examine social interaction among santri.

These contributions support the view that character formation should be studied within lived educational environments. However, they do not establish that integration of science and religion independently causes

character development. The specific contribution of integration must be separated from the influence of established routines, relationships, and institutional expectations.

One potential mechanism concerns the alignment of moral expectations with scientific practice. An expectation of honesty can be connected with accurate reporting of observations. Responsibility can be practiced through appropriate handling of materials and completion of shared tasks. Intellectual humility can be associated with recognizing uncertainty and revising an explanation when evidence changes. These are proposed mechanisms whose operation requires empirical investigation.

Sukari et al. (2023) discuss senior santri and character formation, while Ahmad Nur and Widodo (2023) examine extracurricular activities and Islamic values. These sources provide perspectives on mentoring and participation. Applying mentoring to science activities is a possible educational development, but it should not be attributed to the sources as a tested science intervention unless their findings support that claim.

Amin (2021) contributes to discussion of multicultural character, and Ali et al. (2023) address Islamic educational philosophy and emotional intelligence. Amirudin (2023) examines worldview and radicalism prevention among university students. These outcomes and populations differ, so their findings should not be combined into a general claim that science integration produces tolerance or emotional maturity among santri.

Evaluation should therefore focus on specific practices rather than broad moral labels. For example, honesty in a science project could be examined through consistency between recorded observations and the final report. Openness to correction could be investigated through responses to feedback. Such assessment would provide clearer evidence than assuming character development from participation alone.

Science Literacy and Its Supporting Conditions

Science literacy should be distinguished from reading, information, and digital literacy. The latter can support scientific learning, but they do not provide equivalent evidence of scientific competence.

Muhtadi et al. (2023) discuss information and critical literacy, Helmanda and Yani (2023) address reading and writing among santri, and Sya'roni (2023) examines digital literacy within a pesantren writing community. These studies offer perspectives on practices relevant to accessing and communicating knowledge. Their findings should be interpreted as indirect support rather than demonstrations of science literacy gains.

Several possible connections can nevertheless be identified. Reading can support comprehension of scientific explanations. Information literacy can assist in evaluating the relevance and credibility of sources. Writing can help students make their reasoning visible. These connections require instructional attention because students may use each practice successfully without understanding the scientific concepts involved.

For example, selecting a credible source does not establish that a student can interpret a graph correctly. Producing a coherent report does not demonstrate understanding of experimental controls. Scientific learning requires disciplinary knowledge and opportunities to examine the relationship between evidence and explanation.

Hodson's (2014) distinctions clarify the need for assessment that matches educational goals. If the goal is conceptual understanding, assessment should examine explanations. If the goal is inquiry, it should examine questions, methods, and interpretation of results. If the goal concerns socioscientific issues, it should consider how students use scientific information in evaluating possible decisions.

The literature therefore supports examining literacy practices as enabling conditions, while the claim of improved science literacy remains dependent on direct evidence. Future studies could combine written tasks, investigation-based assessments, and discussion analysis to identify which aspects of scientific understanding develop and under what conditions.

Implementation Challenges and Competing Explanations

Integration depends on conditions that can vary substantially across institutions. Isbah and Sakhiyya (2023) provide a perspective on institutional pressures and equity, while Suresman et al. (2025) discuss changing learning models and infrastructural differences. These contributions justify attention to context without establishing that every pesantren experiences the same barriers.

Teacher preparation is one potential condition. Science teachers need to preserve the accuracy of scientific explanations, while religious educators contribute expertise in ethical and interpretive traditions. Collaboration can connect these responsibilities without requiring identical expertise. Billingsley et al. (2018) offer a comparative rationale for examining teachers' understanding of disciplinary relationships.

Resources are another condition, but their significance should not be reduced to equipment availability. A laboratory can support investigations, yet learning also depends on task design and guidance. Lazonder and Harmsen (2016) indicate that support is important in inquiry learning. Institutions with limited facilities may therefore need to prioritize purposeful activities and teacher preparation alongside investment in equipment.

Curricular workload creates a further analytical concern. Integration may become an additional burden if it is implemented by adding activities without reconsidering existing objectives. A more coherent approach would identify where subjects can contribute to shared tasks while retaining essential disciplinary content.

Potential risks include symbolic integration, inaccurate associations between religious texts and scientific concepts, and restricted opportunities to question explanations. These are concerns for investigation rather than documented characteristics of all pesantren.

Competing explanations must also be considered. Better outcomes in an institution using integration may reflect teacher quality, student selection, prior achievement, funding, or established organizational culture. Without attention to these factors, positive outcomes cannot confidently be attributed to integration itself. This limitation is central to interpreting the literature and designing future empirical research.

Curriculum Development and Contextual Learning

Salindry et al. (2025) discuss pesantren curricula and character formation, while Ramadhan and Sentosa (2023) examine Islamic values in IPAS learning under Kurikulum Merdeka. These contributions provide starting points for curriculum development, but a shared commitment to character education does not automatically ensure alignment in practice.

Policy relevance requires attention to time and institutional jurisdiction. P5 is relevant to earlier implementation of Kurikulum Merdeka. Official explanations of the 2025 adjustments describe changes toward the graduate profile and more flexible co-curricular arrangements (Kementerian Pendidikan Dasar dan Menengah, 2025). Educational proposals should therefore identify the applicable policy period and distinguish schools, madrasahs, and pesantren programs.

Contextual environmental projects illustrate how integration might be designed. A waste-management project could begin with a scientific question, such as comparing changes in organic waste under different treatment conditions. Students could record measurements, explain methodological choices, and evaluate uncertainty. Religious education could contribute discussion of responsibility, stewardship, and the ethical implications of communal practices.

The connection becomes substantive when scientific and ethical learning both contribute to the project. It remains superficial if religious quotations are added after an investigation without influencing reflection or responsible conduct. Assessment should therefore distinguish scientific reasoning from ethical engagement while examining how students connect them.

Such projects are proposals, not verified interventions in the reviewed institutions. Their implementation would require attention to feasibility, teacher guidance, and the quality of student evidence.

Partnerships among pesantren or with higher education institutions could support development through shared facilities, collaborative planning, and teacher learning. However, partnerships should be evaluated for accessibility and sustainability. A model dependent on extensive external funding may be difficult to maintain or transfer to institutions with fewer resources.

Integrated Interpretation and Research Implications

The synthesis organizes the discussion through curricular, epistemic, and cultural integration. These dimensions clarify where connections are intended to occur and what evidence would be needed to evaluate them. Their analytical relationships are summarized in Table 1.

Table 1. Analytical Dimensions of Integration and Evidence Required to Assess Their Educational Contribution

Dimension	Analytical focus	Proposed educational mechanism	Possible evidence	Boundary of interpretation
Curricular integration	Connections among objectives, content, activities, and assessment	Students encounter and apply relationships across subjects through explicitly connected tasks	Curriculum documents, lesson plans, assignments, and assessed student work	Shared timetables or subject availability do not demonstrate substantive integration
Epistemic integration	Relationships between scientific inquiry and Islamic educational commitments	Students distinguish forms of justification while connecting inquiry with ethical responsibility	Explanations, disciplinary comparisons, interpretation of data, and reflective discussion	Theological affirmation cannot replace empirical evidence
Cultural integration	Shared practices of learning and intellectual accountability	Community expectations support source use, reasoned disagreement, correction, and responsible conduct	Observation of discussion, feedback practices, reports, and responses to correction	Participation in communal activities does not establish cognitive transfer
Relationships with character and academic culture	Connections between integration and individual or collective educational practices	Intended values are practiced within tasks and sustained through institutional expectations	Repeated observations, student work, interviews, and comparisons across settings	Associations may reflect other institutional or participant characteristics

Note. The dimensions and indicators are an interpretive framework developed in this review. They are not a validated measurement instrument or evidence of causal effects. Character and academic culture are treated as related outcomes rather than additional dimensions of integration.

The framework helps avoid treating every connection between religion and science as the same educational practice. It also distinguishes intended mechanisms from observed outcomes. An institution may show curricular connections without evidence of epistemic understanding, or a supportive academic culture without explicit coordination between subjects.

The strongest conceptual contribution of the review is therefore the clarification of relationships that require investigation. Integration may create conditions for responsible inquiry, but its contribution depends on implementation and cannot be inferred solely from institutional identity.

For practice, the implications concern explicit planning, teacher collaboration, and assessment aligned with educational goals. For research, the priorities include documenting implementation, examining variation, and assessing proposed mechanisms directly.

Comparative studies could investigate how different forms of integration relate to student work while considering teacher preparation, resources, and prior achievement. Longitudinal studies could examine whether intellectual practices are sustained over time. Transfer studies could test whether competencies practiced in religious learning are applied to science tasks and whether explicit instructional connections make a difference.

The distinction among character development, academic culture, and science literacy should remain central. These outcomes require different evidence and may develop at different rates. Improvements in one cannot be assumed to demonstrate improvements in the others.

Overall, the literature supports a context-sensitive interpretation of integration as a set of educational possibilities. It does not justify a general causal claim that integrating science and Islamic religious education necessarily strengthens character, academic culture, or science literacy across pesantren.

Conclusion

This review identifies curricular, epistemic, and cultural integration as complementary analytical dimensions for understanding the relationships between science and Islamic religious education in pesantren. The synthesis suggests that integration extends beyond the coexistence of subjects to encompass connected learning activities, awareness of disciplinary differences, and shared practices of intellectual responsibility. These relationships challenge the assumption that timetable coordination or the inclusion of religious references in science lessons is sufficient to establish substantive integration. They also open further discussion about how

educational arrangements and community practices may support character development and academic culture. However, the reviewed evidence does not establish that integration independently causes improvements in these outcomes or in science literacy.

The study contributes to scholarly discussion by bringing previously separated curricular, philosophical, and cultural perspectives into a context-sensitive analytical framework. It supports earlier emphasis on institutional practices and social relationships in character education while questioning inferences that equate religious discussion with scientific inquiry or assume automatic transfer from memorization to broader academic competence. Its contribution lies in distinguishing intended educational connections, potential mechanisms, and demonstrated outcomes. This distinction clarifies how integration can connect Islamic ethical commitments with scientific learning while preserving the role of empirical evidence in evaluating scientific explanations. The framework also provides a basis for developing more explicit indicators of integration in future research.

The review is limited by the scope and heterogeneity of the available literature, including context-specific studies, indirect evidence from other educational settings, and the absence of primary field verification. These limitations restrict generalization across pesantren and prevent firm causal conclusions. Future research should involve larger and more diverse samples across institutions, validated assessments of science literacy and character-related practices, and comparative or longitudinal designs that account for teacher preparation, resources, and prior achievement. Studies should also test whether competencies developed through religious learning transfer to scientific tasks. In practice, pesantren are encouraged to prioritize collaborative teacher development, explicitly connected learning activities, and assessment that distinguishes scientific understanding from ethical reflection, with curriculum alignment adapted to applicable policies and institutional conditions.

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