

Chemistry Education in Indonesian Madrasahs: A Systematic Review of Challenges, Pedagogical Innovations, and Islamic Values Integration

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Abstract

Chemistry education in Indonesian madrasahs occupies a distinctive position because it is directed not only toward the mastery of scientific literacy but also toward the cultivation of Islamic values that shape students' ethical responsibility and spiritual awareness. Previous studies have reported recurring challenges, including student misconceptions, limited laboratory facilities, teachers' limited competence in integrating science with Islamic values, and a scarcity of contextual learning resources; however, this evidence remains scattered and has not been systematically synthesized. This study aims to synthesize empirical evidence on chemistry education in Indonesian madrasahs through a Systematic Literature Review (SLR) following the PRISMA 2020 protocol. Searches were conducted in Scopus, Web of Science, ERIC, and Dimensions for publications from January 2021 to June 2026, with the application of inclusion and exclusion criteria, quality appraisal using the Joanna Briggs Institute (JBI) instrument, and thematic synthesis based on Braun and Clarke's six-phase framework. Of the 428 articles identified, 52 met all criteria and were synthesized thematically. The synthesis yielded five dominant themes: learning challenges, pedagogical innovation, laboratory-based learning, digital technology integration, and Islamic values integration. The findings indicate that meaningful chemistry learning in madrasahs depends on a balance between scientific inquiry and contextualized Islamic perspectives, supported by stronger teacher pedagogical competence and institutional support. This study proposes a conceptual framework that integrates inquiry-based chemistry learning, digital pedagogy, contextual laboratory experiences, and Islamic character education, and it offers recommendations for teachers, curriculum developers, policymakers, and future researchers.

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INTRODUCTION

Chemistry is widely recognized as one of the most conceptually demanding disciplines in science education because it requires learners to understand observable phenomena, particle behavior at the microscopic level, and symbolic representations simultaneously. Johnstone (1991) argued that much of the difficulty in learning chemistry stems from the need to move dynamically among these three levels of representation, namely the macroscopic, submicroscopic, and symbolic. This multidimensional nature of chemistry often creates conceptual barriers for students, particularly when instruction relies on memorization rather than on the development of conceptual understanding (Ainsworth, 2021; Taber, 2022).

These challenges become more complex in the context of Indonesian madrasahs, where chemistry education is expected to fulfill not only scientific objectives but also a religious mission and

the formation of moral character (akhlak). Madrasahs constitute one of the largest educational systems in Indonesia, enrolling millions of students at the primary and secondary levels, with an educational philosophy that positions scientific knowledge as complementary to, rather than separate from, Islamic teachings. This philosophical foundation opens opportunities to contextualize chemical concepts through ethical reflection, environmental concern, and an appreciation of the order of creation. Nevertheless, translating these philosophical ideals into classroom practice remains difficult, as some teachers continue to apply instructional models designed for general schools without systematically integrating Islamic perspectives; consequently, religious integration is often limited to symbolic references.

International research has consistently shown that students tend to perceive chemistry as an abstract, mathematically intensive, and difficult subject (Treagust & Chandrasegaran, 2021). This perception lowers learning motivation, increases cognitive load, and contributes to low academic achievement. In the madrasah context, these difficulties are compounded by disparities in educational resources, limited laboratory infrastructure, and restricted access to up-to-date learning technologies, as reflected in widespread shortages of practical facilities, students' negative perceptions of chemistry, and the prevalence of teacher-centered instruction resulting from infrastructural constraints.

Another equally important issue concerns teacher competence. Effective chemistry teaching requires deep content knowledge, pedagogical expertise, technological literacy, and the ability to facilitate inquiry-based learning. In the madrasah context, an additional competence is required, namely the ability to integrate chemical concepts with authentic Islamic values without compromising scientific accuracy. Previous literature indicates that many chemistry teachers face a dilemma between disciplinary mastery and religious literacy, so that integration efforts often become symbolic rather than pedagogically meaningful.

Recent developments in science education show that innovative pedagogies, including inquiry-based learning, project-based learning, contextual learning, digital simulations, virtual laboratories, and blended learning, can significantly improve students' conceptual understanding (Zoller, 2022). These approaches emphasize the active construction of knowledge and enable learners to visualize abstract chemical phenomena through multiple representations (Gilbert & Treagust, 2009). In madrasah education, such pedagogical innovations also have the potential to bridge scientific inquiry and Islamic ethical principles, thereby strengthening learning outcomes in both the cognitive and affective domains.

The integration of Islamic values into chemistry learning should not be reduced to the insertion of Qur'anic verses into lesson plans. Meaningful integration requires connecting scientific inquiry with ethical responsibility, environmental sustainability, and an appreciation of natural phenomena as manifestations of divine order. This perspective is consistent with contemporary views of holistic education, which call for learners to be educated intellectually, socially, emotionally, and spiritually at the same time (Zoller, 2022; UNESCO, 2021).

Several previous studies have addressed the issues outlined above, but generally in a fragmented manner: some have highlighted laboratory limitations, while others have examined digital learning, contextual pedagogy, or religious integration separately (Ningrum & Nahadi, 2026; Damayanti et al., 2026; Rahmah & Widjajanti, 2026). These reviews have typically taken the form of narrative literature reviews that describe research findings in general terms without applying transparent and replicable procedures for identifying, screening, and appraising the quality of evidence. As a result, educators and policymakers still lack a comprehensive synthesis capable of mapping research trends, methodological characteristics, knowledge gaps, and evidence-based

recommendations specifically at the intersection of chemistry education and Islamic education in madrasahs.

A Systematic Literature Review (SLR) offers a more rigorous methodology for addressing this gap because it identifies, selects, appraises, and synthesizes empirical evidence transparently. Compared with narrative reviews, SLRs minimize selection bias, enhance methodological transparency, and generate more reliable evidence for educational decision-making. By following internationally recognized review procedures such as PRISMA 2020, this study seeks to build a stronger evidence base for curriculum development, teacher professional development, and future research agendas. The principal novelty of this study lies in the application of an explicit and replicable SLR protocol to the topic of chemistry learning in Indonesian madrasahs, as well as in its attempt to connect, at a theoretical level, the chemistry triplet of representation (Johnstone, 1991) with the epistemology of Islamic education, a linkage that has rarely been explored systematically in the existing literature.

Against this background, this review aims to synthesize recent evidence on chemistry learning in Indonesian madrasahs published between 2021 and 2026. Specifically, it aims to: (1) identify the dominant challenges affecting chemistry education in madrasahs; (2) examine the innovative pedagogical strategies implemented to improve the quality of learning; (3) analyze approaches to integrating Islamic values into chemistry learning; (4) evaluate methodological trends in the existing literature; and (5) develop an evidence-based conceptual framework to guide future research and practice in chemistry education within Islamic educational institutions.

The findings of this review are expected to make a theoretical contribution by consolidating previously fragmented literature into a coherent framework, as well as a practical contribution in the form of recommendations for chemistry teachers, curriculum developers, school leaders, education policymakers, and researchers seeking to strengthen the quality of chemistry education without neglecting the distinctive identity of madrasahs in Indonesia.

RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) approach to synthesize empirical evidence on chemistry learning in Indonesian madrasahs. Unlike conventional narrative reviews, an SLR applies explicit, transparent, and replicable procedures to identify, select, appraise, and synthesize relevant literature. The aim was to generate evidence-based conclusions regarding learning challenges, pedagogical innovation, laboratory implementation, the use of digital technology, and the integration of Islamic values in chemistry learning.

The review protocol followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) (Page et al., 2021) to ensure methodological transparency throughout the review process. The review addressed the following three research questions: RQ1. What are the main challenges reported in chemistry learning in Indonesian madrasahs? RQ2. What instructional innovations have been implemented to improve chemistry learning? RQ3. How are Islamic values integrated into chemistry education?

The search strategy was developed systematically prior to the identification of literature in order to minimize selection bias. The search string was constructed using Boolean operators as follows: ("chemistry education" OR "chemistry learning") AND (madrasah OR "Islamic school" OR "Islamic education") AND (Indonesia) AND (learning OR teaching OR pedagogy OR curriculum). Supplementary searches included the terms STEM Education, Science Education, Islamic Value Integration, Inquiry Learning, Contextual Learning, Laboratory Learning, Digital Learning, and

Chemistry Teaching. Backward and forward citation tracking was also conducted to identify additional relevant publications.

The literature search was conducted in four databases: Garuda, Scopus, Web of Science, ERIC, and Dimensions. Additional sources included Google Scholar (for cross-verification), publications of the Ministry of Religious Affairs of the Republic of Indonesia, and national curriculum documents. To maintain a consistent time frame throughout the manuscript, the search was limited to publications from January 2021 to June 2026. This period was selected to capture recent developments following the large-scale implementation of digital learning and the transition to the Merdeka Curriculum (Kurikulum Merdeka). It should be emphasized that the literature search for this review was completed in mid-2026; the end date of June 2026 therefore represents the actual point at which the search was concluded rather than a projection into the future, and the manuscript was subsequently prepared and revised in the second half of 2026. The inclusion and exclusion criteria were established prior to the screening process, as presented in Table 2.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Published between 2021 and 2026	Published before 2021
Peer-reviewed journal	Conference proceedings abstracts only
Written in English or Indonesian	Non-scholarly publications
Focused on chemistry education	Studies outside the field of chemistry
Addressing madrasahs or Islamic education	General education without an Islamic context
Empirical or review articles	Editorials or opinion pieces

Only studies that met all inclusion criteria proceeded to the quality appraisal stage. As a further check on the exclusion criteria, the review team specifically examined the literature review articles that had passed screening to ensure that no overlapping secondary SLRs were treated as primary data in the thematic synthesis. The four review articles listed in Table 4 were retained solely for contextual triangulation and were excluded from the count of substantive themes in the Results section to avoid duplication of evidence.

The screening process comprised four sequential stages in accordance with the PRISMA 2020 framework: identification, title and abstract screening, full-text eligibility assessment, and final eligibility determination. The selection flow is presented in Figure 1.

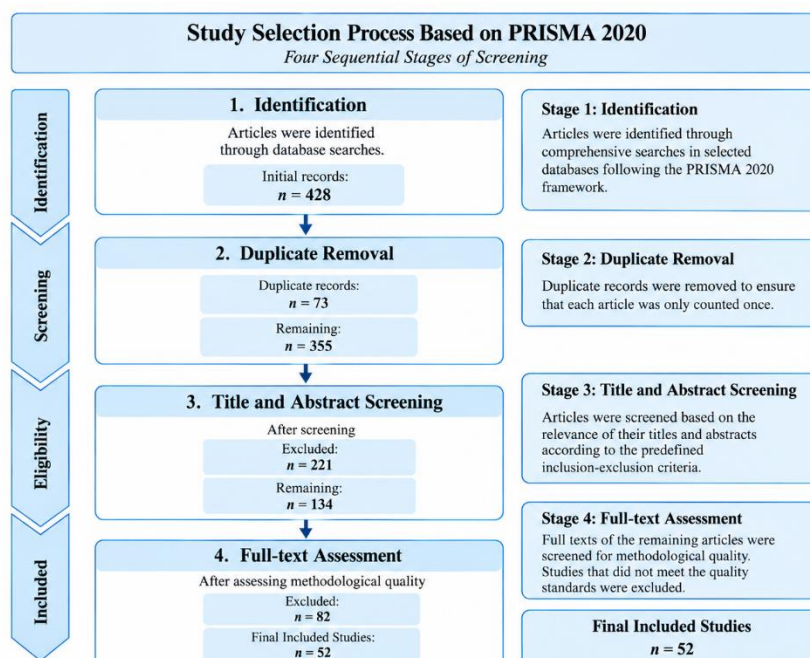


Figure 1. PRISMA 2020 Flow Diagram

To ensure methodological credibility, each eligible article underwent quality appraisal before thematic synthesis. The appraisal was adapted from the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for qualitative and mixed-methods studies and comprised eight indicators: (1) the research objective is clearly stated, (2) the methodology is appropriate, (3) the sampling procedure is transparent, (4) data collection is adequate, (5) data analysis is conducted rigorously, (6) the credibility of the findings is maintained, (7) the discussion is supported by evidence, and (8) the limitations of the study are explicitly stated. Each indicator was scored 1 (yes) or 0 (no). Quality scores were categorized as high (7–8), moderate (5–6), or low (<5). Only studies of moderate and high quality were retained for the synthesis.

A standardized data extraction form was developed before the selected studies were reviewed, covering author(s), year of publication, country, journal, research objective, research design, participants, learning topic, instructional strategy, form of Islamic values integration, main findings, and recommendations. Two reviewers extracted the data independently to ensure consistency; discrepancies were resolved through discussion until consensus was reached. The coding procedure illustrates how statements in the primary articles were translated into initial codes and subsequently grouped into themes. This matrix is provided to ensure the traceability and reproducibility of the qualitative analysis.

Table 2. Coding Matrix for Thematic Synthesis

Source Excerpt/Statement	Initial Code	Theme
Students struggle to connect abstract levels of chemical representation	Difficulty with the representational triplet	Learning Challenges
Teachers developed PhET simulations as a substitute for conventional practical work	Virtual laboratory substitution	Laboratory-Based Learning
The concept of chemical bonding is linked to the concepts of amanah and responsibility	Concept-value linkage	Islamic Values Integration
The use of an LMS increases student engagement in online discussions	Use of digital platforms	Digital Technology Integration

The extracted data were then synthesized using thematic analysis following the six-phase framework developed by Braun and Clarke (2021): (1) familiarization with the data through repeated reading of the full texts of all selected studies; (2) inductive initial coding of relevant statements, concepts, and empirical findings; (3) searching for themes by grouping codes with conceptual similarities; (4) reviewing themes to assess their coherence and consistency across studies; (5) defining themes to clearly delineate the conceptual scope of each theme; and (6) narrative synthesis to integrate all validated themes into a coherent, evidence-based narrative. Through this analytical process, five main themes were identified: Learning Challenges, Innovative Learning Strategies, Laboratory-Based Chemistry Learning, Digital Technology Integration, and Islamic Values Integration.

Four strategies were applied to enhance the credibility, dependability, and transparency of the review. First, methodological transparency was maintained by following the PRISMA 2020 guidelines at every stage of the review. Second, source triangulation was carried out by comparing evidence from four databases (Scopus, Web of Science, ERIC, and Dimensions) to reduce database bias. Third, an audit trail was maintained by documenting all screening decisions, the inclusion–exclusion process, coding procedures, and analytical steps. Fourth, peer debriefing was conducted through collaborative discussions among the reviewers to evaluate coding consistency, sharpen the interpretation of themes, and reduce potential interpretive bias.

RESULTS AND DISCUSSION

A total of 428 articles were identified from four international databases (Scopus, Web of Science, ERIC, and Dimensions). After the removal of duplicates, title and abstract screening, and eligibility assessment against the inclusion and exclusion criteria, 52 articles met all methodological requirements and were included in the thematic synthesis, as shown in the PRISMA flow diagram. The 52 articles analyzed were published in both accredited national journals and reputable international journals. Table 4 shows that most studies employed a qualitative approach (36.5%), followed by experimental research (26.9%), mixed methods (15.4%), quantitative surveys (13.5%), and literature reviews (7.7%).

Table 3. Research Design Characteristics of the Selected Studies

Characteristic	Number (n=52)	Percentage
Qualitative	19	36.5%
Experimental	14	26.9%
Mixed Methods	8	15.4%
Quantitative Survey	7	13.5%
Literature Review	4	7.7%

The predominance of qualitative and classroom-scale experimental designs indicates that research on chemistry learning in madrasahs remains centered on exploring learning experiences and on short-term trials of instructional models, whereas large-scale evaluative research, such as curriculum policy evaluations or longitudinal studies, remains very limited. This pattern is consistent with the small proportion of literature reviews identified (7.7%), which reinforces the novelty of this review as the first systematic synthesis to focus specifically on the intersection of chemistry education and Islamic education in madrasahs.

In terms of geographical distribution, Table 5 shows that 41 of the 52 studies (78.8%) originated from Indonesia, while the remainder came from Malaysia, Brunei Darussalam, Saudi Arabia, Pakistan, and Turkey. The predominance of studies from Indonesia (78.8%) confirms that the country is the center of research on chemistry learning in Islamic educational institutions, while also representing one of the limitations on the generalizability of the findings, which is discussed further

in the Research Limitations section. This distribution also explains why cross-country comparisons in this review are limited and serve more as a comparative context than as a basis for generalization.

The thematic analysis of the 52 articles yielded five main thematic clusters, as summarized in Table 6, with Learning Challenges and Innovative Learning Strategies being the two themes supported by the largest number of studies.

Table 4. Five Main Themes of the Synthesis

Theme	Main Scope
Learning Challenges	Misconceptions, limited laboratories, predominance of teacher-centered instruction
Innovative Learning Strategies	Inquiry-, Problem-, and Project-Based Learning; STEM approaches
Laboratory-Based Learning	Virtual laboratories, PhET simulations, experiments using locally available materials
Digital Technology Integration	LMS, Google Classroom, Moodle, augmented reality, mobile learning
Islamic Values Integration	Linking chemical phenomena with Qur'anic verses, the value of amanah, scientific ethics

The first theme, learning challenges, encompasses students' low conceptual ability; the high prevalence of misconceptions in abstract topics such as atomic structure, chemical bonding, equilibrium, and stoichiometry; limited laboratory facilities; and the predominance of teacher-centered instruction. Several studies also reported students' difficulties in connecting macroscopic, submicroscopic, and symbolic representations in chemistry, consistent with Johnstone's (1991) triplet framework of representation, resulting in only partial development of conceptual understanding.

The second theme, innovative learning strategies, shows that the most frequently implemented models include Inquiry-Based Learning, Project-Based Learning, Problem-Based Learning, STEM approaches, Contextual Teaching and Learning, and Discovery Learning. Most studies reported improvements in critical thinking, scientific literacy, creativity, and learning motivation following the implementation of these models.

The third theme, laboratory-based learning, confirms that practical work remains an essential component, even though many madrasahs face shortages of laboratories, chemicals, and experimental equipment. As alternatives, various studies have developed virtual laboratories, PhET simulations, experimental videos, home laboratories, and green chemistry experiments, which have been shown to improve science process skills while reducing dependence on conventional laboratories.

The fourth theme, digital technology integration, reveals increasing use of Learning Management Systems (LMS), Google Classroom, Moodle, PhET interactive simulations, augmented reality, mobile learning, and video-based learning. The use of these technologies not only broadens access to learning materials but also enriches the visualization of abstract chemical concepts.

The fifth theme, Islamic values integration, comprises approaches that include linking chemical phenomena with Qur'anic verses, instilling the value of amanah (trustworthiness) in practical activities, strengthening scientific ethics through an Islamic perspective, environment-based learning as an implementation of the concept of khalifah fil ardh (human stewardship of the earth), and reflection on the regularity of natural laws as a manifestation of the greatness of God. Nevertheless, most studies still integrate Islamic values at an illustrative level, and only a small number have developed instructional models that genuinely combine the conceptual dimensions of chemistry with the systematic formation of Islamic character.

In summary, the synthesis of the 52 articles produced three main findings: (1) chemistry learning in madrasahs continues to face structural and pedagogical challenges, particularly related to limited laboratories, student misconceptions, and teachers' competence in integrating scientific approaches with Islamic values; (2) pedagogical innovations based on active learning and digital technology show consistent effectiveness in improving conceptual understanding, learning motivation, critical thinking skills, and science process skills; and (3) the integration of Islamic values is a distinguishing characteristic of chemistry learning in madrasahs, yet its implementation still requires the development of more systematic, evidence-based models supported by stronger teacher competence and curriculum policy. An in-depth interpretation of these three findings, including their relationship to theories of science education and Islamic education, is presented in the Discussion section.

Challenges of Chemistry Learning in Madrasah

The challenges of chemistry learning in madrasahs cannot be understood merely as a problem of low student achievement. The synthesis of the 52 articles shows that difficulties in learning chemistry result from complex interactions among the characteristics of chemistry as a discipline, teachers' pedagogical capacity, institutional readiness, and the characteristics of Islamic education itself. In other words, students' low conceptual understanding is a manifestation of a systemic problem involving the curriculum, resources, and learning culture.

Epistemologically, chemistry requires the ability to move dynamically among three levels of representation, namely macroscopic phenomena, submicroscopic representations, and chemical symbols (Johnstone, 1991; Gilbert & Treagust, 2009). When teachers emphasize the memorization of formulas over the construction of conceptual meaning, students struggle to connect these three representations. This explains why the studies included in this review consistently reported misconceptions in atomic structure, chemical bonding, stoichiometry, chemical equilibrium, and acids and bases.

From a constructivist perspective, scientific knowledge cannot be transferred directly from teacher to learner but must be constructed through active interaction with the learning environment. Accordingly, the predominance of expository teaching that is still found in many madrasahs may hinder the development of deep conceptual understanding. In addition to pedagogical factors, limited laboratory facilities remain a relatively consistently reported problem. The laboratory is not merely a space for practical work but a setting in which students connect theory with empirical phenomena through observation, experimentation, and scientific reflection (Hofstein & Lunetta, 2004; Abrahams & Millar, 2008).

Nevertheless, the synthesis also shows that limited physical facilities are not always an absolute barrier to high-quality learning. Several studies indicate that teachers were able to develop alternatives through virtual laboratories, interactive simulations, simple experiments using locally available materials, and green chemistry approaches. This finding suggests that pedagogical innovation can function as an adaptive mechanism in response to infrastructural constraints, although it should be noted that most of this evidence comes from small-scale studies with limited numbers of participants; claims of success should therefore be interpreted with caution and may not be generalizable to all madrasah contexts.

Pedagogical Innovation as a Key Driver of Educational Transformation

One of the most consistent findings of this review is the increasing use of various active learning models. Almost all experimental studies reported improvements in critical thinking, conceptual

understanding, learning motivation, or scientific literacy following the implementation of inquiry-based learning, problem-based learning, project-based learning, discovery learning, or STEM approaches.

However, the success of these models is not determined solely by the name of the instructional model used but by the extent to which teachers are able to create learning environments that allow students to explore concepts independently, develop scientific argumentation, and reflect on their own thinking. The effectiveness of pedagogical innovation is thus more closely related to the quality of implementation than to the choice of model itself, a conclusion that should also be read with caution in light of possible publication bias, given that studies with positive results tend to be published more readily than those reporting less successful implementations.

In the madrasah context, pedagogical innovation has a dimension that differs from that in general schools, because learning is directed not only toward academic achievement but also toward the formation of Islamic character. Approaches that position students as active agents have greater potential to integrate religious values into the process of knowledge construction than one-way instruction does. This finding reinforces the view that transforming chemistry learning in madrasahs requires a paradigm shift in teaching, from the teacher as the main source of information to a facilitator who helps students build connections among scientific concepts, empirical experience, and religious reflection. Even so, the limits of applicability of this finding must be underscored: many madrasahs face constraints related to teacher-student ratios, curriculum load, and limited instructional time, which make the consistent implementation of student-centered pedagogy difficult to achieve in practice.

Digital Transformation and the Future of Chemistry Education

The development of digital technology has been one of the most significant changes in chemistry learning over the past five years. The use of Learning Management Systems, PhET simulations, experimental videos, virtual laboratories, and augmented reality media has been shown to increase student engagement. Nevertheless, technology should not be understood as an end in itself. Some studies reported that the use of digital media does not necessarily improve conceptual understanding when it merely replaces conventional lecture methods. The effectiveness of technology depends heavily on instructional designs that support exploratory, collaborative, and reflective activities.

In the madrasah context, digital transformation presents a new challenge in the form of teachers' need for digital literacy, which cannot be limited to operational skills but must also include the ability to select media appropriate to the characteristics of chemistry content and to the values of Islamic education. The development of teachers' digital competence is therefore an important prerequisite for the successful transformation of learning, while at the same time constituting a real contextual barrier in madrasahs with limited access to digital infrastructure, particularly in regions with low internet connectivity.

Integrating Islamic Values Beyond a Symbolic Approach

An important contribution of this review is the finding that the integration of Islamic values in chemistry learning remains dominated by a symbolic approach. Most studies describe integration through the insertion of Qur'anic verses or hadiths related to natural phenomena, without developing a deeper conceptual relationship between the epistemology of science and Islamic perspectives.

The symbolic approach has pedagogical value in building students' religious awareness. However, when integration stops at the illustrative stage, learning does not fully exploit the potential

of Islamic education as a comprehensive framework of thought. More substantive integration should connect the process of scientific inquiry with values such as amanah (trustworthiness), academic honesty, responsibility toward the environment, and the awareness that the regularity of chemical laws is part of sunnatullah (the divinely ordained order of nature). The integration of Islamic values is thus not intended to replace the scientific method but to broaden the meaning of chemistry learning, so that students not only understand how natural phenomena occur but also develop ethical awareness in the use of that knowledge.

Toward a Holistic Framework for Chemistry Learning in Madrasah

Drawing on the synthesis as a whole, this study proposes a holistic framework that integrates four main components: mastery of scientific concepts, pedagogical innovation, digital transformation, and the internalization of Islamic values. These four components are interrelated: mastery of scientific concepts requires active and contextual learning strategies; pedagogical innovation requires relevant technological support to visualize abstract concepts; and the entire learning process needs to be directed toward character formation through substantive integration of Islamic values. The framework also emphasizes that improving the quality of learning cannot be the responsibility of teachers alone, but requires policy support, the provision of laboratory infrastructure, the development of contextual learning resources, and continuous professional development programs.

Comparison with Previous Literature and Educational Theory

The trajectory of research on chemistry learning in madrasahs is in line with global trends in science education, namely the shift from teacher-centered to learner-centered instruction. Nevertheless, this review also reveals characteristics that distinguish the madrasah context from science education in general, namely the demand to integrate the mastery of scientific concepts with the formation of religious character as part of the goals of Islamic education.

From the perspective of constructivist theory, most of the findings support the view that knowledge is constructed through active learning experiences. Models such as Inquiry-Based Learning, Problem-Based Learning, Project-Based Learning, and contextual learning give learners opportunities to build understanding through observation, discussion, experimentation, and reflection. However, the implementation of constructivist approaches in madrasahs is not yet optimal; several studies still report the predominance of lecture methods, memorization-oriented assessment, and limited laboratory activities, indicating a gap between the modern learning paradigm advocated in the literature and the practices that persist in some madrasahs.

From the perspective of the theory of chemical representation, the findings of this review reinforce the views of Johnstone (1991) and Gilbert and Treagust (2009) that difficulties in learning chemistry arise primarily from students' failure to connect macroscopic, submicroscopic, and symbolic representations. The use of visual media, digital simulations, virtual laboratories, and contextual experiments is therefore crucial, as these help learners build connections among the three representations while also serving as tools to reduce the cognitive load arising from the abstract nature of chemical concepts.

This review also makes a specific contribution to the development of Islamic educational theory. Most studies show that the integration of Islamic values has not yet developed into a comprehensive pedagogical framework and is still largely carried out through the insertion of Qur'anic verses or hadiths relevant to the lesson topic. Based on the synthesis conducted, the integration of Islamic values should be understood as a process of developing scientific ways of thinking grounded in ethical values, social responsibility, and spiritual awareness, so that chemistry learning not only produces the ability to explain natural phenomena scientifically but also cultivates the awareness that

knowledge is an amanah (trust) to be used for the benefit of humankind and the preservation of the environment.

CONCLUSION

This systematic review of 52 articles published between 2021 and 2026 addresses the three research questions posed. With respect to RQ1, the dominant challenges in chemistry learning in madrasahs include low conceptual understanding of abstract topics, limited laboratory facilities, the predominance of teacher-centered instruction, and gaps in teachers' competence to integrate science with Islamic values substantively. With respect to RQ2, pedagogical innovations based on active learning, namely Inquiry-Based Learning, Problem-Based Learning, Project-Based Learning, STEM approaches, virtual laboratories, and contextual learning, consistently have a positive impact on conceptual understanding, critical thinking, motivation, and science process skills, with their effectiveness determined more by the quality of teachers' implementation than by the name of the instructional model. With respect to RQ3, the integration of Islamic values remains dominated by an illustrative approach; instructional models that connect chemical concepts with Islamic values in a more systematic and evidence-based manner are therefore needed.

Based on this synthesis, this study proposes a conceptual framework that integrates four components, namely mastery of chemical concepts, pedagogical innovation, digital transformation, and the internalization of Islamic values, as a mutually reinforcing whole for building meaningful chemistry learning in madrasahs. The take-home message of this review is that improving the quality of chemistry learning in madrasahs will not be achieved through changes in teaching methods alone, but requires simultaneous systemic improvements encompassing the curriculum, teacher capacity, learning facilities, and the scientific culture of madrasahs.

The findings of this review have practical implications for various stakeholders. Chemistry teachers in madrasahs need to develop inquiry-, project-, and problem-based learning combined with contextual experimental activities and substantive rather than merely symbolic integration of Islamic values. Curriculum developers need to design learning materials that balance scientific competence, 21st-century skills, and Islamic character education, with greater scope for laboratory activities and the use of digital technology. Madrasah institutions need to strengthen their support through the provision of adequate laboratories, access to learning technologies, and sustained teacher professional development programs.

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