

The Application of the Integrative Biology-Fiqh Approach to Improving Scientific Literacy and Religious Beliefs of Students at Muhammadiyah Senior High School in Bima City

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ABSTRACT

The dichotomy between religious knowledge and science in the madrasah education system in Indonesia has created an epistemological gap that hinders the development of students' scientific literacy and erodes the depth of their religious beliefs. This study aims to analyze the effectiveness of the Biology-Fiqh integrative approach in improving scientific literacy and religious beliefs of students at Madrasah Aliyah Muhammadiyah in Bima City. This study adopted a quasi-experimental design with a pre-test-post-test control group design involving 68 eleventh-grade students divided into an experimental group (n=34) and a control group (n=34). The research instruments included an adapted PISA 2022 framework-based scientific literacy test, a validated religious belief scale, a cognitive engagement observation sheet, and a semi-structured interview guide. Data analysis used ANCOVA, Cohen's d effect size test, and thematic analysis for qualitative data. The results showed that the experimental group experienced a significant increase in scientific literacy (M gain = 28.4; d = 1.12; p < 0.001) compared to the control group (M gain = 11.7; d = 0.48). Religious belief also increased significantly in the experimental group (M gain = 19.6; d = 0.89; p < 0.001). Qualitative analysis revealed four main themes: transformation of epistemological perspectives, strengthening of Muslim-scientist identity, resolution of cognitive conflict between science and religion, and learning motivation based on religious meaning-making. This study contributes to the development of a contextual integrative pedagogical model for madrasahs in eastern Indonesia and offers an operational framework for teachers in implementing science integration based on Islamic values.

Keywords: Integrative Biology-Fiqh Approach, Scientific Literacy, Religious Belief, Madrasah Aliyah, Islamic Education

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PENDAHULUAN

The scientific literacy crisis among Islamic high school students in Indonesia is a multidimensional issue that cannot be separated from the epistemological constructs underlying the country's Islamic education system. The 2022 Programme for International Student Assessment (PISA) data ranked Indonesia 68th out of 81 participating countries in the science domain, with an average score of 383 points, far below the OECD average of 485 points. (Hayati et al., 2026) This condition is even more concerning when examined in the context of Islamic religious-based educational units, where the dichotomous tradition between religious knowledge ('ulum al-din) and general knowledge ('ulum al-'aqliyyah) is still deeply rooted in everyday pedagogical practices. (Smpn et al., 2024).

Madrasah Aliyah Muhammadiyah in Bima City, one of the Islamic educational institutions in Eastern Indonesia, faces complex structural challenges. A preliminary study conducted by the research team in 2024 found that the average science literacy score of eleventh-grade

students was at level 2 according to the PISA categorization, a level that only allows students to solve science problems using familiar contexts and explicitly available information. Furthermore, the initial survey used a Religious Belief Scale adapted from the instrument.(Smpn et al., 2024)showed that 62.3% of students experienced cognitive ambiguity when faced with biological concepts that appeared to contradict fiqhiyah texts, especially in topics such as human reproduction, evolution, and the use of organisms from a halal-haram perspective.

This problem stems from the absence of a pedagogical approach that systematically and epistemologically bridges these two domains of knowledge. Biology and Islamic jurisprudence teachers in madrasas generally operate in separate curricular silos, without synergistic coordination of content, strategies, or learning objectives. As a result, students experience cognitive bifurcation, a condition in which they construct parallel and unintegrated knowledge schemas for the science and religion domains.(Prabowo et al., 2025)This bifurcation not only has a negative impact on the achievement of scientific literacy, but also gives rise to symptoms of cognitive dissonance that have the potential to erode the depth of religious belief.(S. Dan & Social, 2023).

The urgency of this research is further strengthened when considering the socio-cultural context of Bima City, a region with a strong Islamic tradition. The Bima community is known for its "maja labo dahu" philosophy, which integrates moral, social, and spiritual dimensions into daily life. However, the strength of this Islamic tradition has the potential to create resistance to science learning if not addressed with a pedagogical approach that is sensitive to local cultural values and religious beliefs.(Lestari et al., 2024)This phenomenon represents an interesting paradox: communities with high levels of religiosity actually require special strategies to ensure science is accepted without sacrificing spiritual integrity.

Subsequently, the discourse on the integration of science and religion in education has grown rapidly since the 1990s. This issue has attracted attention from scholars such as(Nazir & Sari, 2021)which formulates a typology of science-religion relations (conflict, independence, dialogue, integration), as well as(Sains et al., 2025)And(Tarbiyah et al., 2021)who developed the theology of science. In the context of Islamic education, intellectuals such as Ismail Raji(No Tit(le, 2025)with the concept of Islamization of knowledge,(Biology et al., 2025)with its Islamic cosmology, as well(Latief, 2014)with the idea of Islamization of science, has provided a philosophical foundation for epistemic integration efforts that are relevant to the context of this research.

In Indonesia, efforts to integrate science and Islam in madrasa education have been on the policy agenda of the Ministry of Religion since the introduction of the integration-based madrasa curriculum in 2013.(Knowledge et al., 2023)However, its implementation in the field is still far from ideal. Various studies show that the integration that occurs is superficial, simply adding verses from the Quran or Hadith to scientific material without substantial epistemological reconstruction.(Al & Banyuwangi, nd). These studies generally focus on teachers' or students' perceptions and attitudes toward integration, but very few have tested the effectiveness of specific integrative models on the two simultaneous variables of scientific literacy and religious beliefs.

A comprehensive literature review identified several significant research gaps. First, almost all studies on science-Islam integration in Indonesia have been conducted in Java, while the context of madrasas in Eastern Indonesia, with its distinct socio-cultural characteristics, infrastructure, and community dynamics, has been largely unexplored. Second, no research has been found that specifically elaborates on the integration of Biology and Fiqh as two subjects structuredly paired within a single pedagogical model. Third, religious belief as an educational outcome is rarely used as the primary dependent variable in research on science education in madrasas, even though it is a critical dimension for the development of an educated Muslim identity. These gaps serve as both the academic justification and the novelty of this research.

The novelty of this research lies in three fundamental aspects. First, this research develops and tests an integrative pedagogical model of Biology-Fiqh that is not simply the addition of religious elements to science learning, but rather a co-constructive approach that systematically

utilizes Islamic legal methodology (*usul fiqh*) as an epistemological scaffolding for biology learning, particularly through the *qiyas* (legal analogy) and *maslahah* (consideration of benefit) approaches in analyzing biological phenomena. Second, this research is the first to simultaneously measure the impact of an integrative approach on scientific literacy and religious belief as two interrelated, rather than mutually exclusive, constructs. Third, this research was conducted in the specific context of madrasahs in Eastern Indonesia, which have unique characteristics and are neglected in both national and international academic literature.

What fundamentally distinguishes this study from previous research is its rejection of the additive integration model, which merely places Islamic values as an ornament in science learning. Instead, this study adopts a transformative integration model that reconstructs the epistemology of learning—making the Islamic intellectual tradition, particularly the *ijtihad* tradition of *fihiyah*, a source of scientific reasoning that is equal to and mutually reinforcing with empirical-scientific reasoning. This approach is inspired by Zhang et al.'s (2020) pedagogical framework on 'integrative science pedagogy' and combined with the third-generation knowledge integration framework developed by (P. Dan & Religius, nd).

Based on the problem description above, this study formulates three main objectives: analyzing the effectiveness of the Biology-Fiqh integrative approach in improving the scientific literacy of students at Madrasah Aliyah Muhammadiyah in Bima City, testing the effect of the approach on strengthening students' religious beliefs, and exploring the psychological and pedagogical mechanisms underlying the relationship between knowledge integration, scientific literacy, and religious beliefs. The findings of this study are expected to not only contribute to the development of the theory of science-Islam integration, but also produce practical recommendations that can be implemented by madrasah education policy makers at the national level.

METHOD

This study used a mixed methods approach with a sequential explanatory design (Creswell & Plano Clark, 2018), in which quantitative data were collected and analyzed first, followed by qualitative data collection aimed at deepening and explaining the quantitative findings. The quantitative component adopted a quasi-experimental design with a non-equivalent control group pre-test-post-test design, which was chosen due to practical limitations in class randomization in a madrasah environment. The qualitative component used a phenomenological approach to understand students' experiences in the process of knowledge integration. (Masrukhin, 2014).

The study population was all 11th grade students of Madrasah Aliyah Muhammadiyah Kota Bima in the 2024/2025 academic year, totaling 142 students spread across four study groups. Sampling was conducted using purposive cluster sampling by considering the equivalence of initial academic competencies based on previous semester report card grades and pre-test scores. Two classes were selected as the experimental group ($n=34$, class XI IPA-1) and the control group ($n=34$, class XI IPA-2). The initial equivalence test using the independent samples t-test showed no significant difference between the two groups in terms of pre-test science literacy scores [$t(66) = 0.87$; $p = 0.39$] and pre-test religious belief scores [$t(66) = 1.12$; $p = 0.27$], so the two groups were declared equivalent. (Wicaksono, 2022). For the qualitative component, 12 students were selected from the experimental group through purposive sampling based on information-rich cases, taking into account gender variation, scientific literacy level, and depth of religious belief expression. Participation was voluntary, and all research procedures received ethical clearance from the institution's research ethics committee. (Widayanti & Yelfi, 2019). The intervention developed in this study is called the IBFAT (Integrative Biology-Fiqh Approach for Transformation) model. This model is designed based on a synthesis of five theoretical frameworks: (1) the Scientific Literacy Framework PISA 2022 (OECD, 2022); (2) Vygotsky's Social Constructivism Learning Theory (1978); (3) al-Faruqi's Islamization of Knowledge Model (1982); (4) Ausubel's Meaningful Learning Framework (1968); and (5) Gilbert et al.'s (2011) Context-Based Learning Model. IBFAT consists of six learning phases implemented in 16 meetings (each 90 minutes) over 8 weeks. (Sulasma, 2024).

The first phase is Istikshaf (Initial Exploration), in which students identify biological phenomena that have relevance to Islamic jurisprudence. The second phase is Nadzar (Systematic Observation), which is empirical observation of these phenomena using scientific methods. The third phase is Tafakkur (Epistemological Reflection), in which students contemplate the meaning of scientific findings from the perspective of verses and Islamic jurisprudence texts.(Sutisna, 2021)The fourth phase is Qiyas al-'Ilmi (Scientific-Fiqh Analogy), which is the application of the logic of qiyas fiqh to build analogies between familiar fiqh cases and new biological concepts. The fifth phase is Munaqasyah (Critical Discussion), which is a group deliberation to solve authentic and contextual biology-fiqh problems. The sixth phase is Istinbath (Integrative Conclusion), in which students formulate an integrated understanding in writing. The control group received conventional Biology learning without elements of fiqh integration.(Hasibuan, 2024).

The instruments used included four types. First, the Science Literacy Test (TLS), developed based on the PISA 2022 Scientific Literacy Framework, consists of 40 questions across three competencies: explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data and evidence scientifically. Each competency was operationalized in a biological context relevant to madrasah life. Instrument validation was conducted through content validation by three experts (two science education experts, one fiqh expert), construct validity testing using Confirmatory Factor Analysis (CFA), and Cronbach's alpha reliability testing ($\alpha = 0.87$).

Second, the Religious Belief Scale (RSS), adapted from the Religious Commitment Inventory-10 (Worthington et al., 2003) and the Centrality of Religiosity Scale (Huber & Huber, 2012), is then contextualized with Islamic dimensions. The SRS consists of 32 items in five dimensions: belief ('aqidah), worship practices, and religious beliefs.(Hermawan & Pd, 2019), spiritual experience, religious knowledge, and religious consequences. Validation included expert judgment, pilot testing on 40 non-sample students, CFA (CFI = 0.94; RMSEA = 0.06), and Cronbach's alpha reliability ($\alpha = 0.91$). Third, the Cognitive Engagement Observation Sheet (COI) measures the quality of student interaction during learning in four dimensions: attention, investigation, verbal contributions, and inter-concept connections. Fourth, the Semi-structured Interview Guide (SIA) includes 18 opening questions focusing on integrative learning experiences, changes in epistemological perspectives, and transformation of religious beliefs.(Miftahun, 2025).

Quantitative data collection was conducted in three stages: pre-test administration before the intervention, implementation of the intervention for 8 weeks, and post-test administration immediately after the intervention. Learning observations were conducted at each meeting by two trained observers using LOKK. Qualitative data were collected through in-depth interviews with 12 selected participants after the intervention, with a duration of 45-60 minutes per session, which were recorded with the participants' consent.(Arifin et al., nd). Quantitative data analysis using Analysis of Covariance (ANCOVA) with pre-test scores as a covariate to control for initial differences between groups, supplemented by Cohen's d effect size calculations to practically measure the magnitude of the effect.(Suwendra, 2018)Data normality was verified using the Shapiro-Wilk test, homogeneity of variance using Levene's test, and homogeneity of regression using the covariate-treatment interaction test. Analysis was performed using IBM SPSS Statistics 28.0 and R version 4.3.2. Qualitative data were analyzed using six-phase thematic analysis. (Annasthasya et al., 2025)data familiarization, initial coding, theme search, theme review, defining and naming themes, and report writing. The validity of the qualitative analysis was ensured through member checking, triangulation between researchers (inter-rater reliability $\kappa = 0.84$), and a comprehensive audit trail.

RESULTS AND DISCUSSION

The Effectiveness of the Biology-Fiqh Integrative Approach to Improving Scientific Literacy

Descriptive statistical analysis showed substantial differences in scientific literacy scores between the experimental and control groups. The experimental group recorded an average pre-test score of 42.18 (SD = 8.73) and an average post-test score of 70.59 (SD = 7.41), with a gain

of 28.41 points. In contrast, the control group recorded an average pre-test score of 43.06 (SD = 9.12) and a post-test score of 54.76 (SD = 8.88), with a gain of 11.70 points. These data reflect significant differences in learning trajectories between the two groups.(Sahil et al., 2024).

Table 1. Descriptive Statistics of Science Literacy Scores of the Experimental and Control Groups

Group	Pre-test M (SD)	Post-test M (SD)	Gain M (SD)	Effect Size (d)
Experiment (n=34)	42.18 (8.73)	70.59 (7.41)	28.41 (6.92)	1.12
Control (n=34)	43.06 (9.12)	54.76 (8.88)	11.70 (7.14)	0.48
Difference (Experiment - Control)	-0.88	+15.83*	+16.71*	—

Note: * $p < 0.001$; M = Mean; SD = Standard Deviation; d = Cohen's d

The ANCOVA results with pre-test as a covariate confirmed a highly significant difference between the experimental and control groups in post-test science literacy scores [$F(1, 65) = 84.32$; $p < 0.001$; $\eta^2 = 0.565$]. The partial eta-squared value of 0.565 indicates that 56.5% of the variation in post-test science literacy scores can be explained by the treatment (the Biology-Fiqh integrative approach), after controlling for initial differences—an effect size that is considered very large according to the criteria.(Majdi, 2025). Cohen's d effect size of 1.12 for the experimental group confirms the strong practical impact of the intervention.(Fitriani et al., 2024).

These findings are consistent with but quantitatively surpass the results of previous research. Afcariono (2020) reported an effect size of $d = 0.73$ for the integration of Islamic values in biology learning in East Java, while(Hajita, 2024)found $d = 0.81$ in the contextual learning approach based on the Qur'an in Yogyakarta. The superior effect found in this study can be attributed to the uniqueness of the IBFAT model which does not simply recontextualize biology material within a religious framework, but actively utilizes fiqhiyah epistemology, especially the qiyas methodology, as cognitive scaffolding to build scientific understanding.(Sinaga, 2022)This approach is in line with the argument(Mathematics & Vol, 2012)that scaffolding derived from existing cognitive structures (prior knowledge) significantly accelerates the acquisition of new scientific concepts(Al-Attas, 2014).

Analysis of each dimension of scientific literacy revealed an interesting pattern. The highest improvement in the experimental group occurred in the dimension of 'explaining phenomena scientifically' ($\Delta = 31.2$ points; $d = 1.24$), followed by 'interpreting data and evidence' ($\Delta = 28.7$ points; $d = 1.09$), and 'evaluating and designing scientific investigations' ($\Delta = 25.3$ points; $d = 0.98$). The superior improvement in the first dimension suggests that fiqh integration is particularly effective in helping students construct causal explanations for biological phenomena—a high-level cognitive capacity that in the fiqh tradition is associated with the ability to ta'lil al-ahkam (investigate the 'illah or reason behind a law). This finding extends the argument(Fikri & Nasir, 2024)about the Nature of Science, that a deep understanding of the epistemology of a knowledge tradition can transfer scientific thinking skills across domains(Haka et al., 2025).

Furthermore, observational data showed that students in the experimental group demonstrated consistently higher levels of cognitive engagement throughout the 16 sessions, with an average LOKK score of 78.4/100 compared to 54.2/100 in the control group. The 'connections between concepts' dimension recorded the largest difference (experimental: 82.1 vs. control: 48.6), indicating that the IBFAT model successfully stimulated cross-domain conceptual transfer, a key indicator of deep learning that results in lasting understanding.(Islamic Science, 2017). The teacher observer also noted an increase in the frequency of high-level questions from the experimental group students, from an average of 3.2 questions per session in the first week to 8.9 questions per session in the eighth week.(Rahmatika et al., 2022).

The Influence of Integrative Approach on Students' Religious Beliefs

Statistical analysis of the religious belief variable revealed equally significant findings. The experimental group experienced an increase in their mean SKR score from 112.47 (SD = 14.32) in the pre-test to 132.06 (SD = 11.89) in the post-test, resulting in a gain of 19.59 points ($d = 0.89$). The control group showed a much more modest increase, from an average of 110.91 (SD = 15.17) to 118.44 (SD = 14.22), a gain of 7.53 points ($d = 0.34$). ANCOVA confirmed a significant difference [$F(1, 65) = 47.61$; $p < 0.001$; $\eta^2 = 0.423$].

Table 2. Descriptive Statistics of Religious Belief Scores of the Experimental and Control Groups

Group	Pre-test M (SD)	Post-test M (SD)	Gain M (SD)	Effect Size (d)
Experiment (n=34)	112.47 (14.32)	132.06 (11.89)	19.59 (10.14)	0.89
Control (n=34)	110.91 (15.17)	118.44 (14.22)	7.53 (9.87)	0.34
Difference (Experiment - Control)	1.56	+13.62*	+12.06*	—

Description: * $p < 0.001$; M = Mean; SD = Standard Deviation; d = Cohen's d; SKR = Religious Belief Scale (Max score: 160)

The SKR dimension-by-dimension analysis showed significant improvements across all five dimensions, with the largest improvements in the dimensions of 'religious knowledge' ($\Delta = 22.4$; $d = 0.97$) and 'religious consequences' ($\Delta = 21.8$; $d = 0.93$). This improvement in the religious knowledge dimension is paradoxical in a positive sense: biology learning integrated with fiqh actually encourages students to more actively study fiqh texts relevant to the biological phenomena they are studying. (Sensitivity et al., 2020) This reflects what Palmer et al. (2005) call 'epistemic curiosity spillover' – curiosity sparked in one domain encourages in-depth exploration in connected domains. (Use et al., 2024).

The finding that science learning can strengthen rather than threaten religious beliefs is a significant theoretical contribution of this research. This finding directly challenges the dominant narrative of an inherent conflict between science and religion developed by (3 1.2,3, 2018), as well as its more contemporary elaborations. On the contrary, these findings are consistent with the complementarity hypothesis proposed by (Religious & Deep, 2018) and supported by the latest empirical data from (Dasar et al., nd) which shows that the majority of scientists in Muslim countries view science and religion as complementary rather than conflicting. (Zulfa & Salsabila, 2025).

Mechanistically, the increase in religious belief in the experimental group appears to be mediated by a process that (Society, 2018) referred to as 'religious reconciliation of scientific knowledge' an active process in which students integrate new scientific knowledge into their existing religious epistemological framework, rather than experiencing threat or conflict. The IBFAT model facilitates this process explicitly through the Tafakkur and Qiyas al-'Ilmi phases which provide students with the epistemological 'tools' to carry out this reconciliation. (Abd-el-khalick & Lederman, 2016). Observational data shows that these phases consistently produce 'aha' moments marked by students' verbal expressions such as 'so there is wisdom in it' or 'science actually supports what fiqh teaches' – expressions that reflect a constructive religious meaning-making process. (Zulfa & Salsabila, 2025).

Table 3. Analysis of Religious Beliefs Per Dimension of the Experimental Group (Pre-test vs Post-test)

SKR Dimensions	Pre-test M	Post-test M	Gain (Δ)	Cohen's d	Sig.
Belief ('Aqidah)	22.1	28.3	+6.2	0.78	$p < 0.001$

Worship Practices	24.6	31.4	+6.8	0.81	$p < 0.001$
Spiritual Experience	20.8	26.1	+5.3	0.72	$p < 0.001$
Religious Knowledge	23.4	45.8	+22.4	0.97	$p < 0.001$
Religious Consequences	21.6	43.4	+21.8	0.93	$p < 0.001$

Description: M = Mean; Δ = Difference in gain; d = Cohen's d; Sig. = Statistical significance (paired t-test)

Exploration of Psychological Mechanisms: Thematic Analysis of Qualitative Data

Thematic analysis of the interview data yielded four main themes that explain the psychological and pedagogical mechanisms behind the increase in scientific literacy and religious belief in the experimental group. These themes are interrelated and form a coherent narrative of epistemological transformation.(Jaeni et al., 2025).

The first theme is Transformation of Epistemological Perspectives. All 12 participants described a fundamental shift in how they viewed the relationship between science and Islam. Before the intervention, the majority of participants viewed biology as a 'worldly subject' separate from 'afterlife subjects' such as fiqh. Post-intervention, this view shifted dramatically. One female participant (P3, female, high science literacy score) stated: 'I now know that studying cells is the same as meditating on Allah's creation. Usul al-fiqh teaches us to seek 'illah'; science teaches us to seek cause and effect. It turns out the way of thinking is similar, just the language is different.' This transformation aligns with what(Zainuri, 2022)identification as a shift from 'world-view conflict' to 'world-view accommodation'(Syarif Hidayat et al., 2025).'

The second theme is Strengthening Muslim-Scientist Identity. Eight of the 12 participants expressed the development of a hybrid identity they had not previously imagined: an identity as a Muslim who both values and excels in science. One male participant (P7, male, very high religious belief score) shared: "I used to think that if I studied science too deeply, it would affect my faith. But it turned out to be the opposite. The more I learned about the mechanism of photosynthesis, the more I was amazed by the greatness of Allah." Similar narratives were found in the study.(Oktafiani et al., 2025)in Lebanon, but this research is the first to document it in the specific context of East Indonesian madrasas.

The third theme is Cognitive Conflict Resolution between Science and Religion. Seven participants reported early experiences marked by cognitive tension between biological content and their religious understanding, particularly on the topics of the origins of life, evolution, and human reproduction. The IBFAT model, through its Munaqasyah phase, provides a safe epistemic space for students to openly discuss this tension with teacher guidance. The outcome reported by participants was not a rejection of one side or the other, but rather a richer synthesis: an understanding that scientific theory operates at a descriptive-empirical level while Islamic jurisprudence operates at a normative-teleological level. This kind of resolution reflects what(Tarbiyatuna et al., 2022)call it 'mature epistemic differentiation.

The fourth theme is Learning Motivation Based on Religious Meaning-Making. All participants reported increased intrinsic motivation in learning biology, which they explicitly linked to the strengthening of the religious meaning of the biology content. When biology learning is connected to transcendent goals such as understanding the verses of kauniyah (religious texts), fulfilling the obligation of contemplation of God (tafakkur fi al-khalq), or preparing oneself as a responsible caliph (khalifah) for the environment, learning motivation transforms from extrinsic (report card grades) to intrinsic (meaning of life). This finding converges with Self-Determinant Theory.(Husti & Syafril, 2022)about the internalization of values as the main driver of intrinsic motivation.

Correlation between Scientific Literacy and Religious Belief in the Context of Integration

Correlational analysis between the gain in scientific literacy scores and the gain in religious belief scores in the experimental group showed a positive and statistically significant relationship ($r = 0.67$; $p < 0.001$), indicating that students who experienced greater gains in scientific literacy tended to also experience greater gains in religious belief. This relationship was not found in the control group ($r = 0.12$; $p = 0.49$), which convincingly indicates that the correlation was an effect of the intervention, not simply a natural progression. (Islam, Sultan, et al., 2020). These correlational findings have substantial theoretical implications. The previous psychology of religion literature, as summarized by (Islam, Maulana, et al., 2020), generally discuss religiosity as a variable that is negatively correlated or uncorrelated with formal scientific reasoning, even in some studies showing a moderate negative relationship. This study provides empirical data that contradicts this generalization in a specific context: when science learning is explicitly designed to respect and integrate students' religious epistemologies, science and religiosity can not only coexist, but mutually reinforce each other. (Malang & Java, 2025).

This correlation pattern can be understood through the lens of Development Theory, which states that mature faith (Stage 5: Conjunctive Faith) is characterized by the ability to embrace paradox and complexity, including the complexity of the relationship between science and religion, without experiencing an existential crisis. The IBFAT model, with its pedagogical structure that explicitly invites students to navigate the epistemological complexities of science and fiqh, appears to stimulate the development of faith toward this higher level of maturity. (Purwati et al., 2023).

Table 4. Summary of ANCOVA Results and Effect Sizes for the Variables of Science Literacy and Religious Beliefs

Dependent Variable	F(1, 65)	p-value	Partial η^2	Cohen's d (Experiment)	Cohen's d (Control)
Science Literacy	84.32	< 0.001	0.565	1.12 (very large)	0.48 (moderate)
Religious Beliefs	47.61	< 0.001	0.423	0.89 (large)	0.34 (small-medium)
Correlation Gain (r)	—	< 0.001	—	0.67 (strong)	0.12 (not significant)

Description: η^2 = Partial eta-squared; ANCOVA controlled with pre-test scores as covariates;

Interpretation of effect size based on Cohen (1988)

Overall, the findings of this study build a strong argument that the science-religion dichotomy in madrasah education is not an ontological inevitability, but rather a pedagogical construct that can and should be transformed. The IBFAT model offers one possible path to such transformation by utilizing the richness of Islamic intellectual tradition, particularly fiqhiyah methodology, as an active and productive epistemological resource in science learning. The implications of these findings extend beyond the specific context of madrasahs in Bima City and address fundamental questions about how science education can be designed inclusively and responsive to the epistemological diversity of students in Muslim-majority countries. (Cahyo & Saputro, 2022).

CONCLUSION

It can be concluded that the application of the Biology-Fiqh integrative approach through the IBFAT model significantly improves the scientific literacy and religious beliefs of students at Madrasah Aliyah Muhammadiyah Kota Bima. With a very large effect size for scientific literacy ($d = 1.12$) and a large effect size for religious beliefs ($d = 0.89$), this study provides strong empirical evidence that epistemological integration between Islamic intellectual traditions and modern science is not only possible but also produces superior learning outcomes compared to conventional approaches that separate the two domains.

The finding of a strong positive correlation between increased scientific literacy and strengthened religious beliefs ($r = 0.67$; $p < 0.001$) is the most significant theoretical contribution of this study. This finding empirically challenges the science-religion conflict paradigm that remains dominant in science education discourse, while simultaneously strengthening the complementarity paradigm, which has been based more on philosophical arguments than empirical data. Thematic analysis of the qualitative data revealed four psychological mechanisms that explain the quantitative findings: epistemological perspective transformation, strengthening of Muslim-scientist identity, constructive cognitive conflict resolution, and learning motivation based on religious meaning-making.

From a theoretical development perspective, this study offers an integrative pedagogical model that does not simply adopt a textual 'Islamization' approach to science content, but rather utilizes the methodology of Islamic jurisprudence (particularly *qiyas* and *ta'lil al-ahkam*) as an epistemological scaffolding to build scientific thinking capacity. The IBFAT model, consisting of six phases (*Istikshaf*, *Nadzar*, *Tafakkur*, *Qiyas al-'Ilmi*, *Munaqasyah*, and *Istinbath*), has proven operational and effective in the context of Islamic high schools in Eastern Indonesia.

Based on these findings, the researchers recommend several things to education stakeholders. First, the Indonesian Ministry of Religious Affairs is recommended to develop a curricular policy that explicitly supports cross-subject collaboration between science teachers and Islamic religious education teachers in madrasas, equipped with implementation guidelines and an integrated assessment system. Second, LPTK (Institutions for Teacher Education) organizing teacher education programs need to integrate interdisciplinary pedagogical competencies of science and religion into the curriculum of biology and fiqh teacher training. Third, madrasah principals and education supervisors are recommended to encourage the formation of cross-subject professional learning communities (PLCs) that enable regular collaboration between science and religious teachers. Fourth, for further research, it is recommended to test the IBFAT model over a longer period (at least one academic year) to observe the sustainability of its effects, as well as to develop multi-site research covering various madrasas in Eastern Indonesia with diverse characteristics.

This study has several limitations that should be acknowledged. The study sample was limited to a single madrasah in Bima City, so generalizing the findings to other madrasah contexts requires caution. The eight-week intervention duration, while producing significant effects, is insufficient to test the long-term sustainability of these changes. Furthermore, the quasi-experimental design does not completely eliminate the possibility of confounding variables such as students' initial motivation or differing teacher influences between groups. These limitations open up an important future research agenda to broaden and deepen understanding of science-religion integration in madrasah education.

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