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# Understanding and Acceptance of Evolutionary Concepts Are Not Uniform: A Correlational Study of Three Islamic Boarding Schools

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**Abstract**
Understanding and acceptance of evolution are often assumed to be associated; however, empirical evidence from students attending Islamic boarding schools (*pesantren*) in Indonesia remains limited and rarely accounts for differences in school contexts. This study aimed to describe students' understanding and acceptance of evolutionary concepts, examine the relationship between these two variables within each school, and determine whether this relationship differed across schools. A cross-sectional correlational design was employed, involving 127 students from three Islamic boarding schools (School A, $n$ = 50; School B, $n$ = 34; and School C, $n$ = 43). Evolution acceptance was measured using the Measure of Acceptance of the Theory of Evolution (MATE) 2.0, while understanding was assessed using the multiple-choice test developed by Rutledge and Warden. Data were analyzed using Pearson's and Spearman's correlation coefficients, followed by school-specific regression analyses. Subsequently, multiple regression analysis was conducted with understanding, school, and the Understanding × School interaction as predictors, using robust standard errors. A significant positive association between understanding and acceptance was found only in School B ($r$ = .81, $p$ < .001), whereas no association was detected in School A ($r$ = .03) or School C ($r$ = .06). The regression model incorporating the Understanding × School interaction was statistically significant, $F(2, 121)$ = 19.96, $p$ < .001. These findings indicate that the relationship between understanding and acceptance of evolution is contingent on school context, suggesting that an overall pooled correlation coefficient may not adequately represent the patterns observed across individual schools.

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## Introduction

Evolution occupies a central position in modern biology as a unifying principle that explains biodiversity, the origins of species, and the phylogenetic relationships among all organisms on Earth (Bard, 2021). As a theory, evolution provides an epistemological foundation for a coherent understanding of life phenomena. Evolution is well established in biology and supported by extensive evidence (Urry et al., 2016). However, this standing does not correspond directly to the levels of acceptance and understanding of evolution among learners (Hermann, 2012).

As the world's largest Muslim-majority country, Indonesia provides a relevant context for examining the dynamics between religious belief and acceptance of evolutionary theory. Previous studies in Indonesia have consistently reported that religiosity is a stronger predictor of evolution acceptance than conceptual understanding itself. These findings suggest that the


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relationship between knowledge and acceptance of evolution is mediated by complex affective, epistemological, and cultural factors (Saefi et al., 2026).

Pesantren, traditional Islamic educational institutions in Indonesia, have distinctive characteristics. In addition to transmitting religious knowledge, they shape students' broader worldviews (Niswah et al., 2025). Madura is a region with a strong and relatively homogeneous religious tradition, where pesantren serve as a focal point of the community's Islamic identity (Syarif & Hannan, 2020). Because the national curriculum includes biology as a school subject, students at pesantren may face the challenge of reconciling scientific explanations of evolution with accounts of creation that are deeply embedded in their beliefs (Arifudin, 2016). Sensitive topics such as evolution therefore create a biology learning context that has received little empirical attention.

Yusuf and Nurshaila (2025) argue that understanding evolutionary concepts can be compatible with religious perspectives. A sound understanding of the relationship between Islam and science is important for designing effective teaching strategies that help students understand scientific theories without feeling that their religious identity is threatened. Research on the relationship between understanding and acceptance of evolution among pesantren students in Madura can contribute to efforts to harmonize science and religion in Islamic educational institutions (Muhlisin et al., 2026; Rosidin et al., 2025).

The specific contextual gap addressed by this study is the limited empirical evidence on the relationship between understanding and acceptance of evolution among pesantren students, particularly in Madura. Most studies of evolution acceptance in Indonesia have focused on preservice biology teachers (Bulandari et al., 2019; Rachmatullah et al., 2018; Saefi et al., 2024), while pesantren populations, characterized by intensive religious engagement, have received comparatively little attention. The sociocultural and religious characteristics of this population differ substantially from those of students at general universities, who have been studying more often. Local context plays a significant role in shaping attitudes toward science (Salazar-Enriquez et al., 2023). Pesantren-based educational settings provide a relevant institutional context for examining how students understand and accept evolutionary concepts. In addition to formal biology instruction, students in these institutions learn within an environment shaped by religious educational traditions and institutional values (Pribadi, 2013; Solichin, 2018). Educational characteristics and practices may nevertheless differ across pesantren, so each school's context should be considered when interpreting the relationship between understanding and acceptance of evolution. This relationship among students at pesantren may follow a different pattern from that found among biology undergraduates, whose learning environments may place greater emphasis on scientific thinking (Priyotamtama, 2020).

The primary aim of this study was to analyze the relationship between students' understanding of evolutionary concepts and their acceptance of evolutionary theory at pesantren-based schools in Madura. The analysis empirically examined whether conceptual understanding was correlated with acceptance in a religious population. The study is expected to provide empirical evidence on this relationship in a population with a distinctive religious and cultural background, while offering a local perspective for developing context-sensitive approaches to teaching evolution. The findings also provide an empirical basis for designing more effective and contextually relevant pedagogical interventions in pesantren.

The contextual novelty of this study lies in its systematic examination of the relationship between understanding and acceptance of evolution among students at


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pesantren-based schools in Madura. It contributes to a more complete mapping of evolution acceptance in Indonesia, a literature currently dominated by data from university students. The findings may inform the development of more effective pedagogical approaches to teaching evolution in pesantren. A better understanding of the relationship between understanding and acceptance in this specific context may support the integration of perspectives on the nature of science and religious belief in evolution instruction. This study aligns with efforts to develop biology education that enables the coexistence of science and Islam (Baharudin & Matdoan, 2025).

## Research Method

This quantitative study employed a cross-sectional correlational design. This design was selected because the study examined the strength of the relationship between understanding and acceptance of evolutionary concepts without intervening in or manipulating any variables (Creswell & Creswell, 2017). Because students were nested within three schools, school was treated as a potential moderator. The relationship was examined both separately within each school and in a pooled model that included an interaction term.

The study population comprised students attending senior high schools (SMA/MA) in pesantren settings. The sample consisted of 127 students from three schools, designated School A (n = 50), School B (n = 34), and School C (n = 43) to protect ethics and anonymity. Schools were selected using purposive sampling. Inclusion criteria were being an active Grade 12 student at a pesantren-based school, having received classroom instruction on evolution, and being willing to participate. The three school clusters were not randomly selected; therefore, the findings are not intended to be generalized to the population of students at pesantren-based schools.

Acceptance of evolutionary concepts was measured using the Measure of Acceptance of the Theory of Evolution (MATE) 2.0, developed by Barnes et al. (2022). The instrument contains nine items rated on a five-point Likert scale. Understanding of evolutionary concepts was measured using a 21-item multiple-choice test developed by Rutledge and Warden (2000). The instruments underwent item-validity and reliability testing (Cronbach's α and McDonald's ω) for each school.

Participation was voluntary and based on students' consent. Data were collected during class under the supervision of the researchers and teachers. Instructions clarified that the results would not affect students' academic grades. The ethical purpose of the study was to assess students' understanding of evolutionary concepts. With respect to acceptance of evolutionary theory, students were free to express a position consistent with their beliefs (Smith & Siegel, 2004). The findings were not intended to label any student or school. The study was designed to protect students' personal data and the identities of the schools.

Data were analyzed using jamovi 2.6.44 (The jamovi project, 2024) and the GAMLj 3.6.5 module for jamovi (Gallucci, 2019). The significance level was set at $\alpha = 0.05$ (two-tailed). First, descriptive statistics were calculated for each school. Differences in mean scores across schools were tested using the Kruskal–Wallis test because the assumption of variance homogeneity (Levene's test) was not met. Data normality was examined using the Shapiro–Wilk test for each school. Within-school relationships between Understanding and Acceptance were analyzed using Pearson's correlation, with Spearman's rho ($\rho$) reported as a robustness check for deviations from normality; 95% confidence intervals were also calculated. Assumptions for school-specific simple linear regressions were examined using residual


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normality (Shapiro–Wilk), homoscedasticity (Breusch–Pagan), and influential observations (Cook's D, threshold = 1). Effect sizes were interpreted using Cohen's (1988) criteria. The pooled regression model used multiple linear regression with Understanding, School, and the Understanding × School interaction as predictors to account for the nested data structure. The Breusch–Pagan test indicated non-constant residual variance; therefore, coefficient and interaction tests used standard errors robust to heteroscedasticity (Long & Ervin, 2000).

## Research Findings and Discussion

Data were collected from 127 students in Schools A, B, and C, with nA = 50, nB = 34, and nC = 43. Mean scores for Understanding of Evolutionary Concepts were 50.4 (SD = 9.97) in School A, 50.1 (SD = 9.93) in School B, and 45.5 (SD = 11.36) in School C. The Kruskal–Wallis test showed no significant difference in Understanding scores across the three schools ($\chi^2(2) = 5.56$, $p = 0.062$). Mean Acceptance of Evolutionary Concepts scores were 58.7 (SD = 6.47) in School A, 68.5 (SD = 14.60) in School B, and 68.5 (SD = 14.60) in School C. The Kruskal–Wallis test indicated a significant difference among schools ($\chi^2(2) = 10.44$, $p = 0.005$). Normality was tested using the Shapiro–Wilk test separately for each school. Understanding scores deviated from normality in School A ($W = 0.872$, $p < 0.001$) and School C ($W = 0.918$, $p = 0.005$). Acceptance scores did not deviate from normality in any of the three schools. Accordingly, Spearman's coefficient (ρ) is reported alongside Pearson's coefficient (r) in the correlation analyses. Mean Understanding and Acceptance scores and the data distributions are presented in Table 1.

**Table 1.** Descriptive Statistics by School

| | | | | | Shapiro–Wilk | |
|---|---|---|---|---|---|---|
| | **School** | **n** | **Mean** | **SD** | **W** | **p** |
| Understanding | A | 50 | 50.4 | 9.97 | 0.872 | < 0.001 |
| | B | 34 | 50.1 | 9.93 | 0.940 | 0.063 |
| | C | 43 | 45.5 | 11.36 | 0.918 | 0.005 |
| Acceptance | A | 50 | 58.7 | 6.47 | 0.985 | 0.758 |
| | B | 34 | 68.5 | 14.60 | 0.947 | 0.103 |
| | C | 43 | 56.2 | 19.90 | 0.955 | 0.088 |

A relationship between Understanding and Acceptance was found in only one of the three schools (Table 2). School B showed a strong, statistically significant positive correlation based on Cohen's (1988) criteria ($r(32) = 0.81$, 95% CI [0.65, 0.90], $p < 0.001$). In School B, Understanding explained 66% of the variance in Acceptance. No significant correlation between Understanding and Acceptance was found in School A ($r(48) = 0.03$, 95% CI [−0.25, 0.31], $p = 0.836$) or School C ($r(41) = 0.06$, 95% CI [−0.24, 0.36], $p = 0.699$).

**Table 2.** Correlations and Regression Coefficients for Understanding Predicting Acceptance by School

| **School** | **n** | **r [95% CI]** | **ρ** | **$R^2$** | **b (SE) [95% CI]** | **p** |
|---|---|---|---|---|---|---|
| A | 50 | 0.03 [-0.25; 0.31] | -0.02 | 0 | 0.02 (0.09) [-0.17; 0.21] | 0.84 |
| B | 34 | 0.81 [0.65; 0.90] | 0.84 | 0.66 | 1.20 (0.15) [0.89; 1.50] | < 0.001 |
| C | 43 | 0.06 [-0.24; 0.36] | 0.01 | 0 | 0.11 (0.27) [-0.45; 0.66] | 0.7 |


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For the school-specific regression models, residuals were normally distributed in all three schools (Shapiro–Wilk pA = 0.869, pB = 0.494, and pC = 0.103), and no influential observations were identified (maximum Cook's D = 0.26). Residual homoscedasticity was met in Schools B and C (Breusch–Pagan pB = 0.752 and pC = 0.781) but violated in School A (pA = 0.022). However, the effect of this violation was minimal because the regression slope in School A was close to zero.

The pooled correlation analysis across schools indicated a positive, significant relationship (r = 0.27, p = 0.003). The regression model showed that 27.2% of the variance in Acceptance could be explained by Understanding ($R^2$ = 0.272) (Table 3). The residual normality assumption was met (Shapiro–Wilk p = 0.093), but residual variances were not homogeneous across schools (Breusch–Pagan p < 0.001); therefore, robust standard errors were used for inference. The Understanding × School interaction was significant, indicating that the regression slopes differed across the three schools (F(2, 121) = 19.96, p < 0.001) (Table 4). The regression slope for School B was significantly different from that for School A by 1.18 points (b = 1.18, SE = 0.18, p < 0.001). The slope for School C did not differ significantly from that for School A (b = 0.09, SE = 0.30, p = 0.771) (Table 5). The heterogeneity arose because School B differed from Schools A and C. Because the regression slopes were not parallel across schools, the pooled correlation (r = 0.27, p = 0.003) should not be interpreted as representing a common relationship. The coefficient r = 0.27 was driven primarily by School B and did not represent the relationships in Schools A and C.

**Table 3.** Pooled Regression Model Summary

| $R^2$ | Adj. $R^2$ | df | df (res) | F | p |
|---|---|---|---|---|---|
| 0.272 | 0.242 | 5 | 121 | 9.02 | <.001 |

**Table 4.** Significance Tests for the Regression Model

| | SS | df | F | p | $\eta^2p$ |
|---|---|---|---|---|---|
| Model | 7832.864 | 5 | 9.023 | <.001 | 0.272 |
| Understanding | 2502.195 | 1 | 14.266 | <.001 | 0.106 |
| School | 2105.422 | 2 | 10.626 | <.001 | 0.091 |
| Understanding ⁎ School | 3173.666 | 2 | 19.961 | <.001 | 0.131 |
| Residuals | 21006.868 | 121 | | | |
| Total | 28839.732 | 126 | | | |

*Note.* Inferential tests and p-values are based on robust estimation.

**Table 5.** Regression Model Coefficients

| | | | | 95% Confidence Intervals | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Names | Effect | Estimate | SE | Lower | Upper | β | df | t | p |
| (Intercept) | (Intercept) | 60.684 | 1.229 | 58.252 | 63.117 | 0.013 | 121 | 49.389 | <.001 |
| Understanding | Understanding | 0.440 | 0.111 | 0.221 | 0.660 | 0.309 | 121 | 3.967 | <.001 |
| School 1 | B − A | 8.138 | 1.783 | 4.608 | 11.668 | 0.538 | 121 | 4.564 | <.001 |
| School 2 | C − A | -2.142 | 3.378 | -8.829 | 4.545 | -0.142 | 121 | -0.634 | 0.527 |
| Understanding ⁎ School 1 | Understanding ⁎ (B − A) | 1.175 | 0.175 | 0.829 | 1.522 | 0.825 | 121 | 6.713 | <.001 |


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**Table 5.** Regression Model Coefficients

| Names | Effect | Estimate | SE | 95% Confidence Intervals | | β | df | t | p |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Lower | Upper | | | | |
| Understanding ⁎ School 2 | Understanding ⁎ (C − A) | 0.087 | 0.297 | -0.501 | 0.674 | 0.061 | 121 | 0.292 | 0.771 |

*Note.* Inferential tests and p-values are based on robust estimation.

This study examined the relationship between understanding and acceptance of evolutionary concepts among pesantren students while accounting for the nested structure of students within schools. The main finding was that the relationship was not uniform: it was positive and significant in one school and was not detected in the other two. The pooled correlation ($r = 0.27$, $p = 0.003$) arose almost entirely from School B. The aggregate coefficient did not describe the relationship between the two variables in Schools A and C. The correlation coefficients for School A ($r = 0.03$, 95% CI [−0.25, 0.31]) and School C ($r = 0.06$, 95% CI [−0.24, 0.36]) should be interpreted cautiously in light of their confidence intervals. The appropriate interpretation is that there was insufficient evidence of a relationship between Understanding and Acceptance in either school.

The pattern of variability adds another layer to the interpretation: Schools A and C differed in the variability of Acceptance. Acceptance scores varied relatively little in School A ($SD = 6.47$) but substantially in School C ($SD = 19.90$). This suggests that factors beyond Understanding may contribute to variation in Acceptance in School C, whereas Acceptance was relatively uniform in School A. The mean Understanding scores did not differ significantly across schools, while Acceptance scores did, suggesting that differences in Acceptance across schools cannot be explained by differences in Understanding.

These findings support the view that understanding and acceptance of evolution are related constructs, but their empirical relationship is not consistent across school contexts. A strong positive relationship was found in School B, whereas no relationship was detected in Schools A and C. This pattern indicates that students' understanding of evolution is not uniformly associated with their acceptance of evolution across all school contexts. Because the relationship varies by school context, understanding of evolution alone is insufficient to consistently characterize students' acceptance of evolution.

Differences in the relationship across schools also raise the possibility that factors other than understanding are associated with acceptance of evolution. Religiosity, perceptions of conflict between scientific explanations and religious beliefs, and learning experiences may be possible explanations (Afkarina et al., 2024). However, these factors were not measured in this study, so their contributions to the observed pattern cannot be established. Previous research on teaching approaches that address the relationship between science and belief provides context for understanding the complexity of evolution acceptance, but the effectiveness of such approaches requires further empirical testing.

These findings indicate that school context should be considered when designing evolution instruction, rather than assuming that a single instructional approach will produce uniform patterns of acceptance. This study cannot identify a particular approach as the most effective for increasing acceptance of evolution. Future research should directly examine


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non-cognitive factors and characteristics of instructional practice, and test relevant teaching approaches using intervention designs.

The literature suggests that the relationship between understanding and acceptance of evolutionary theory is neither simple nor consistently unidirectional, and is often influenced by other moderating variables. Pobiner et al. (2025) reported that teaching human evolution in a way that integrates cultural and religious values can improve students' understanding and acceptance of evolutionary theory. Contextualized evolution instruction has been shown to bridge cognitive and affective gaps. Wiles and Alters (2011) further reported that an educational intervention explicitly addressing non-scientific factors significantly increased student acceptance, with effects persisting for up to a year after instruction. This finding underscores the importance of a multidimensional approach to evolution education. Cavallo et al. (2011) found that improved understanding of evolutionary concepts did not automatically lead to changes in acceptance or students' views of the nature of science. They found no strong direct correlation between these outcomes, suggesting that understanding and acceptance should be treated as distinct constructs and addressed separately. Korfmacher et al. (2026) confirmed that acceptance of evolutionary theory at the senior high school level is not determined solely by conceptual understanding; it is also significantly influenced by sociocultural, religious, epistemological, and psychological factors, calling for a holistic approach responsive to learners' contexts.

A limitation of this study is that it involved only three schools; therefore, the findings apply only to these schools and do not provide a statistical basis for generalization to the wider pesantren population. Differences among schools cannot be disentangled from differences in teachers, curricula, student composition, and pesantren environments; consequently, these data do not explain why School B differed. The cross-sectional correlational design does not support causal inference or establish whether Understanding influences Acceptance. Future research should include more schools so that multilevel models with random slopes can be estimated and potential moderators of between-school differences, such as religiosity and perceived conflict between science and religion, can be measured (Brem et al., 2003). Teacher attitudes, understanding of the nature of science, and teleological reasoning should also be considered (Barnes et al., 2017).

Smith and Siegel (2004) argue that teaching evolutionary theory in the classroom does not necessarily lead students to accept it. Teachers need not seek to change students' personal beliefs about evolution; their primary role is to help students understand the rational basis of science itself. Students' conceptual understanding of evolution, together with non-cognitive factors, contributes to acceptance of evolutionary theory in the classroom (Sinatra et al., 2003; Weisberg et al., 2018). Consistent with this view, the zero correlations found in two schools may help explain why the cognitive pathway was evident only under certain conditions. Research in religious communities has shown that religious beliefs play a substantial role in shaping acceptance of evolutionary theory (Hokayem & BouJaoude, 2008; Peker et al., 2010).

## Conclusion

This study shows that the relationship between understanding and acceptance of evolutionary concepts among students at pesantren-based schools is not uniform across schools. The findings support the view that understanding and acceptance of evolution are related constructs, but their relationship may vary with school context. This conclusion is


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limited to the three schools studied and the correlational design; it should not be interpreted as evidence of causation or generalization to all pesantren.

## Recommendations

Future studies should directly measure a broader set of potential moderators that may help explain differences among schools, including religiosity, perceived conflict between science and religion, teacher attitudes, and understanding of the nature of science.

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