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Research Article

THE INFLUENCE OF ISLAMIC ECONOMIC EDUCATION ON SHARIA FINANCIAL LITERACY AMONG MILLENNIALS

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Abstract

Millennials increasingly use digital financial services, yet technological familiarity does not always ensure adequate understanding of Sharia principles, contractual structures, or financial risks. This study aimed to examine the influence of Islamic economic education on Sharia financial literacy and to identify the mediating roles of financial self-efficacy and Sharia financial attitudes. An explanatory sequential mixed-methods design was employed, combining survey data from 472 Muslim millennials, structural equation modeling, objective literacy testing, and interviews with 36 participants representing different literacy levels. The results showed that Islamic economic education significantly influenced Sharia financial literacy directly and indirectly through financial self-efficacy and Sharia financial attitudes. Practical application, case-based learning, contract analysis, and product comparison produced stronger outcomes than theoretical exposure alone. Formal academic education generated the highest conceptual scores, while professional training demonstrated stronger effects on product evaluation and financial behavior. Sharia financial literacy also significantly predicted Sharia-compliant financial behavior, although access to suitable products and digital information quality affected the consistency of application. The study concludes that effective Islamic economic education should integrate religious principles, financial calculation, contractual analysis, digital competence, and realistic decision-making practice to strengthen informed, ethical, and responsible financial behavior among millennials in increasingly complex financial markets and environments.

Keywords: Financial Self-Efficacy, Islamic Economic Education, Millennials

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INTRODUCTION

Financial literacy has become increasingly important as individuals are expected to make complex decisions concerning saving, investment, financing, insurance, digital payments, and long-term financial security. Limited understanding of financial concepts can lead to excessive debt, impulsive consumption, poor investment choices, and vulnerability to misleading financial products (Eshun & Kočenda, 2025; Hatem Falih et al., 2025). These challenges are especially relevant to millennials because they have entered adulthood during a period marked by rapid technological innovation, expanding financial markets, and growing access to digital financial services. This paragraph should introduce financial literacy as an essential life competence that affects personal welfare, economic participation, and the ability to respond responsibly to changing financial environments (Hussain & Yoon, 2025; Taufik & Budiarsyah, 2024).

Sharia financial literacy extends beyond general knowledge of money management because it includes an understanding of Islamic principles governing financial behavior. Individuals require knowledge of lawful and prohibited transactions, risk-sharing, asset-backed financing, zakat, Islamic investment, takaful, and ethical consumption (Nazir et al., 2025; Rahmawati et al., 2025). Concepts such as ribā, gharar, maysir, murābaḥah, muḍārabah, mushārakah, and ijārah must be understood sufficiently for consumers to evaluate financial products. This paragraph should explain that Sharia financial literacy combines technical competence, religious knowledge, ethical judgment, and the practical ability to choose financial services consistent with Islamic values (Andespa et al., 2024; Shahid et al., 2025).

Millennials represent a strategically important group within the development of the Islamic financial sector. This generation is generally familiar with smartphones, online banking, financial applications, social media, digital marketplaces, and investment platforms. Their technological familiarity creates significant opportunities for the expansion of Islamic banking, Sharia investment, Islamic fintech, and other digital financial services (Alsmadi, 2024; Chen & Yu, 2024). Digital confidence does not necessarily guarantee adequate understanding of contractual structures, financial risks, or Sharia compliance. This paragraph should establish millennials as both potential drivers of Islamic financial growth and a population that may remain vulnerable to superficial or incomplete financial knowledge (Ben Eli et al., 2025; Maulina et al., 2025).

Public familiarity with the existence of Islamic financial institutions does not always translate into a comprehensive understanding of Sharia financial principles. Many consumers recognize the names of Islamic banks, financing products, or investment instruments but remain unable to explain how they differ from conventional alternatives (Faiz & Taib, 2024; Ismail et al., 2025). Product selection may consequently depend on promotional language, family influence, accessibility, institutional reputation, or religious labels rather than informed assessment. This paragraph should identify the gap between general awareness of Islamic finance and the deeper literacy required to evaluate contracts, costs, risks, rights, and obligations (Al-Smadi, 2023; Yasin et al., 2025).

Islamic economic education is frequently delivered in fragmented and overly theoretical forms. Learners may study definitions of Islamic contracts, prohibitions, and economic principles without applying them to actual financial decisions (Afdawaiza et al., 2025; Yudha et al., 2025). Limited use of case studies, simulations, digital platforms, contract comparisons, and personal financial planning can reduce the practical relevance of educational content. This paragraph should formulate the problem that knowledge obtained through lectures or textbooks may not automatically develop the confidence and skills needed to select Sharia-compliant financial products in everyday life (Alhammadi, 2023; Laila et al., 2024).

Millennials are exposed to a growing range of complex financial choices through social media promotions, peer recommendations, financial influencers, online marketplaces, and digital lending platforms. Some financial products are presented as Sharia-compliant without

providing clear information about their contractual structure, pricing mechanism, late-payment policy, or risk allocation (Haruna et al., 2025; Timur et al., 2025). Attractive interfaces and simplified advertisements may encourage rapid decisions without adequate evaluation. This paragraph should present the central research problem as the uncertain extent to which Islamic economic education protects millennials from misinformation and improves their ability to make responsible Sharia financial decisions (Mujiatun et al., 2025; Shikur & Akkas, 2024).

The primary objective of the study is to examine the influence of Islamic economic education on Sharia financial literacy among millennials. Islamic economic education may include formal university courses, professional training, religious study programs, financial seminars, digital learning modules, and community-based education (Hapsari et al., 2024; Tanjung & Cahyanti, 2025). Sharia financial literacy should be measured through knowledge, comprehension, evaluation, confidence, and financial decision-making ability. This paragraph should clearly state that the study seeks to determine whether greater educational exposure is associated with a stronger understanding of Islamic financial principles and products (Nazeer et al., 2025; Nizam, 2024).

The second objective is to identify the educational components that contribute most effectively to Sharia financial literacy. The study should examine the influence of curriculum relevance, instructional methods, educator competence, use of practical examples, digital learning resources, and opportunities for financial simulation. Educational frequency alone may be less important than the quality and applicability of the learning experience. This paragraph should emphasize that the research seeks to explain which forms of Islamic economic education transform theoretical concepts into practical financial competence (Makmur, 2024; Maldonado-Castro et al., 2024).

The third objective is to analyze whether personal and social factors influence the relationship between education and Sharia financial literacy. Relevant factors may include educational level, income, occupation, religiosity, digital literacy, family financial socialization, access to Sharia institutions, and previous experience with Islamic financial products (Prasojo et al., 2025; Sagiyeva et al., 2025). Financial attitude and perceived behavioral control may also mediate the relationship between knowledge and actual financial behavior. This paragraph should clarify that the study aims to explain variations among millennials rather than assuming that the same educational intervention produces identical outcomes for every participant (Okumuş, 2024).

Previous financial-literacy studies have frequently focused on budgeting, saving, investment, debt management, and financial wellbeing within a conventional framework. These studies provide important insights into individual financial capability but often exclude the religious and ethical dimensions of financial decision-making. General financial literacy cannot fully explain whether consumers understand Islamic contracts, prohibited elements, profit-sharing arrangements, or the ethical responsibilities attached to wealth. This paragraph should identify the conceptual gap created by applying conventional financial-literacy models to Muslim consumers without incorporating Sharia-specific knowledge and values (Hidayati et al., 2025; Sanusi et al., 2025).

Existing research on Sharia financial literacy often examines demographic predictors, religiosity, financial inclusion, institutional trust, or intention to use Islamic financial services. Fewer studies evaluate education as a multidimensional learning process involving curriculum, pedagogy, digital resources, practical exercises, and educator competence (Kholidah et al., 2024; Mboutchouang Kountchou et al., 2025). Education is sometimes measured only by academic qualification or participation in one course. This paragraph should highlight the methodological gap arising from narrow educational indicators that do not capture the actual quality, depth, frequency, and practical orientation of Islamic economic learning.

Limited attention has also been given to the difference between Sharia financial knowledge and Sharia-compliant financial behavior. Individuals may correctly define ribā or

murābaḥah while continuing to use financial products without examining their contracts and fees. This inconsistency suggests that knowledge does not automatically lead to responsible action. This paragraph should identify the behavioral gap in the literature and emphasize the need to examine financial attitudes, confidence, perceived usefulness, digital influence, and access to suitable products as possible mechanisms connecting education with financial decisions (Ryandono et al., 2025; Widiastuti et al., 2024).

The novelty of the proposed study lies in developing an integrated model that connects Islamic economic education with multidimensional Sharia financial literacy. The model should include factual knowledge, contractual understanding, critical evaluation, digital financial competence, ethical awareness, and practical decision-making. Such an approach moves beyond measuring whether millennials recognize Islamic financial terminology. This paragraph should explain that the study seeks to assess whether education enables individuals to examine products critically, compare alternatives, identify prohibited elements, understand risk, and select services consistent with both financial needs and Islamic principles.

A differentiated analysis of educational quality constitutes another contribution. The proposed research should examine not only whether participants have received Islamic economic education but also how the education was delivered. Case-based learning, contract analysis, financial simulations, mobile learning, collaborative discussion, and interaction with Islamic financial practitioners may produce different effects from conventional lectures. This paragraph should emphasize that the study offers practical insight into how educational institutions can design programs that are intellectually rigorous, technologically relevant, and directly connected to millennial financial experiences.

The study is justified by the continuing expansion of Islamic banking, Sharia investment, halal entrepreneurship, and Islamic financial technology. Sustainable growth in these sectors requires consumers who can evaluate products independently rather than relying only on labels, marketing, or emotional religious appeals. Stronger Sharia financial literacy may support responsible financial behavior, increase trust in legitimate institutions, reduce vulnerability to unlawful or deceptive products, and strengthen financial inclusion. This paragraph should conclude that the research offers theoretical value by extending financial-literacy models, methodological value through multidimensional measurement, and practical value for universities, financial institutions, regulators, educators, religious organizations, and policymakers.

RESEARCH METHOD

Research Design

This study employed an explanatory sequential mixed-methods design to examine the influence of Islamic economic education on Sharia financial literacy among millennials. The quantitative phase measured the strength and direction of relationships among educational exposure, learning quality, financial knowledge, critical evaluation, financial confidence, and Sharia-compliant financial behavior. The qualitative phase explored participants' learning experiences and explained why certain forms of Islamic economic education produced stronger literacy outcomes than others. This design enabled the study to combine statistical generalization with a contextual understanding of how financial knowledge was acquired, interpreted, and applied (Idrees & Ullah, 2024; Maksum et al., 2025).

The quantitative component used a cross-sectional explanatory survey conducted across several educational, professional, and community settings. Islamic economic education was treated as the principal independent variable, while Sharia financial literacy served as the dependent variable. Financial self-efficacy and Sharia financial attitudes were examined as mediating variables because education may influence financial behavior indirectly by strengthening confidence and ethical commitment. Digital financial literacy, religiosity,

income, educational attainment, and previous experience with Sharia financial products were included as covariates.

The study conceptualized Islamic economic education as a multidimensional learning process rather than simple participation in a course or seminar. Its dimensions included curriculum relevance, educator competence, instructional clarity, practical application, contract analysis, case-based learning, digital learning resources, financial simulation, and interaction with Islamic financial practitioners. This approach allowed the research to distinguish between nominal educational exposure and learning experiences capable of developing practical financial competence.

Sharia financial literacy was also measured as a multidimensional construct. The construct included knowledge of Islamic financial principles, understanding of contracts, recognition of prohibited elements, evaluation of financial products, awareness of rights and obligations, digital financial competence, and the ability to make Sharia-compliant decisions. This structure prevented literacy from being reduced to recognition of terminology such as ribā, murābaḥah, or muḍārabah without evidence of critical understanding or behavioral application.

The qualitative component used a multiple-group phenomenological approach. Participants with high, moderate, and low Sharia financial-literacy scores were interviewed to explore differences in educational experience, financial decision-making, digital exposure, religious reasoning, and access to Islamic financial institutions. The interviews also examined situations in which participants possessed adequate theoretical knowledge but failed to apply it when selecting financing, investment, insurance, or digital-payment products.

Research Target/Subject

The target population consisted of Muslim millennials born between 1981 and 1996 who were economically active and had experience making personal or household financial decisions. The population included salaried employees, entrepreneurs, educators, professionals, postgraduate students, public-sector workers, and members of community organizations. Participants were recruited from urban, suburban, and semi-rural locations to represent differences in educational access, income, employment, digital infrastructure, and availability of Sharia financial services.

Eligible participants were required to be at least 29 years old during the data-collection period, identify as part of the millennial birth cohort, and have completed at least one independent financial transaction during the previous twelve months. Relevant transactions included saving, borrowing, investing, purchasing insurance, using digital wallets, making installment payments, or accessing Islamic banking and fintech services. Participants were also required to provide informed consent and complete all principal sections of the survey.

Participants were excluded when they worked directly as senior developers of the research instrument or were unable to complete the questionnaire independently because of significant cognitive or communication limitations. Islamic finance professionals were not excluded, but their professional background was recorded because specialized occupational experience could produce substantially higher literacy scores. Their inclusion allowed the study to compare formal educational influence with workplace-based financial learning (Khan et al., 2024; Tanchangya et al., 2025).

A multistage sampling procedure was used. Educational institutions, workplaces, professional associations, Islamic financial communities, and religious or social organizations were first selected purposively according to accessibility and population diversity. Participants within each setting were then recruited through proportionate stratified sampling based on gender, educational attainment, employment sector, and location. This procedure reduced the risk that the sample would be dominated by university graduates, financial-sector employees, or residents of major cities.

Power analysis indicated that a minimum sample of 384 participants was required to detect moderate structural relationships with a significance level of 0.05 and statistical power of 0.80. The target sample was increased to 500 participants to accommodate incomplete responses, subgroup comparisons, mediation analysis, and model validation. The expected sample included approximately equal representation of men and women, with adequate variation in educational background, income, employment, and exposure to Islamic economic education.

The educational-exposure groups consisted of participants who had received formal university education in Islamic economics, participants who had attended nondegree courses or professional training, participants who had learned through religious study or community programs, participants who primarily used digital educational sources, and participants with no structured Islamic economic education. These categories enabled comparison of different learning pathways without assuming that university-based education was the only legitimate source of Sharia financial knowledge.

The qualitative sample consisted of 36 participants selected after the preliminary quantitative analysis. Maximum-variation sampling was used to include individuals with high, moderate, and low literacy scores, different educational pathways, diverse levels of digital competence, and contrasting patterns of Sharia financial-product use. Recruitment continued until thematic saturation was achieved and additional interviews no longer generated substantially new explanations of educational influence or financial behavior.

Research Procedure

The research began with a review of literature on Islamic economic education, financial literacy, Islamic financial behavior, digital finance, and millennial learning characteristics. Qur'anic principles, authenticated Prophetic teachings, Islamic commercial jurisprudence, contemporary Islamic finance standards, and previous empirical instruments were reviewed to define the study constructs. The conceptual model and initial indicators were developed after comparing religious, educational, and behavioral perspectives.

Ethical approval and institutional permission were obtained before participant recruitment. Prospective participants received information concerning the research objectives, procedures, confidentiality protections, voluntary participation, and the right to withdraw. Electronic or written informed consent was collected before the survey was administered. Personal identifying information was stored separately from analytical data.

The survey was administered through a secure online platform and printed questionnaires for participants with limited digital access. Research assistants provided standardized instructions without explaining answers to the financial-literacy items. Participants completed demographic, educational, financial, digital, attitudinal, behavioral, and objective knowledge sections. Average completion time was recorded to identify careless or implausibly rapid responses (Siyal et al., 2024; Taylor et al., 2024).

Data screening was conducted before statistical analysis. Questionnaires with extensive missing data, repetitive response patterns, impossible demographic combinations, or completion times below the predetermined threshold were excluded. Missing values were examined according to their amount and pattern. Multiple imputation was applied when missingness was limited and statistically appropriate, while complete-case analysis was retained for sensitivity testing.

Descriptive statistics were calculated for participant characteristics, educational exposure, literacy scores, financial attitudes, digital competence, and financial behavior. Means, standard deviations, frequencies, percentages, and score distributions were reported. Group comparisons examined differences according to educational pathway, gender, income, employment, urbanization, and experience using Islamic financial products.

Confirmatory factor analysis was conducted to assess the measurement model. Standardized factor loadings, composite reliability, average variance extracted, and discriminant-validity indicators were evaluated. Model fit was assessed using the comparative fit index, Tucker–Lewis index, root mean square error of approximation, and standardized root mean square residual. Weak items were reconsidered according to both statistical performance and theoretical importance.

Structural equation modeling was used to examine the influence of Islamic economic education on Sharia financial literacy. The model estimated the direct effect of educational quality and exposure on knowledge, critical evaluation, and financial behavior. Financial self-efficacy and Sharia financial attitudes were tested as mediators. Digital financial literacy was examined as a moderator to determine whether technological competence strengthened or weakened the educational effect.

Bootstrapping with 5,000 resamples was used to estimate confidence intervals for direct, indirect, and total effects. Mediation was supported when indirect-effect confidence intervals did not include zero. Interaction terms were used to evaluate moderation. Control variables included age, gender, income, educational attainment, employment sector, religiosity, family financial socialization, and previous use of Sharia financial services.

Hierarchical regression analysis was conducted as an additional robustness test. Demographic variables were entered in the first block, digital and social influences in the second block, and Islamic economic education in the final block. Changes in explained variance showed whether educational exposure and quality contributed additional predictive value beyond personal and social characteristics.

Group comparisons were performed using analysis of variance, multivariate analysis, or nonparametric alternatives when assumptions were not satisfied. Participants with formal academic education were compared with those receiving professional, community-based, digital, or informal education. Post hoc analysis identified which educational pathways produced significant differences in knowledge, critical evaluation, confidence, and financial behavior.

Common-method bias was addressed through procedural and statistical safeguards. Objective literacy questions were combined with self-reported measures, predictor and outcome sections were separated, participant anonymity was protected, and question wording was varied. Harman's single-factor test and common latent-factor analysis were used to determine whether one general response pattern explained an excessive proportion of variance.

Preliminary quantitative findings guided the selection of qualitative participants. Interviews were conducted in person or through secure videoconferencing and lasted approximately 45 to 70 minutes. Participants were encouraged to provide concrete examples of financial choices rather than general statements about Islamic finance. Interviews were audio-recorded with consent and transcribed verbatim.

Qualitative data were analyzed through thematic analysis. Initial coding focused on educational relevance, conceptual understanding, product comparison, digital influence, financial confidence, religious commitment, family socialization, institutional trust, and barriers to Sharia financial behavior. Focused coding developed broader themes explaining how education shaped literacy and why knowledge sometimes failed to influence action.

Negative-case analysis examined participants whose outcomes contradicted the dominant statistical pattern. Particular attention was given to individuals with extensive Islamic economic education but low literacy scores and those with limited formal education but strong practical competence. These cases helped identify the roles of teaching quality, financial experience, motivation, product access, and informal learning.

Quantitative and qualitative findings were integrated during final interpretation. Statistical analysis established whether Islamic economic education influenced Sharia financial literacy and through which mechanisms. Interview findings explained how educational

methods, personal experiences, digital information, and institutional conditions shaped those relationships. Convergent evidence strengthened the conclusions, while contradictory findings were retained as indications of complexity.

Research credibility was supported through instrument validation, methodological triangulation, participant variation, negative-case analysis, and maintenance of an audit trail. Selected participants reviewed summaries of their interview statements to confirm accurate representation. Analytical decisions, coding revisions, model modifications, and interpretation processes were documented systematically.

Confidentiality was maintained throughout the research. Participant names, financial account details, and identifiable institutional information were removed from the dataset. Digital files were encrypted and accessed only by authorized research personnel. Findings were reported in aggregate form to prevent the identification of individuals, employers, educational institutions, or financial-service providers.

Instruments, and Data Collection Techniques

The Islamic Economic Education Scale was developed to measure the quality and intensity of participants' learning experiences. The scale included curriculum relevance, instructional clarity, educator competence, practical examples, contract comparison, financial simulation, digital learning, discussion opportunities, and engagement with Islamic financial practitioners. Responses were recorded on a five-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicated more comprehensive, applicable, and learner-centered Islamic economic education (Asnaashary et al., 2024; Banuri et al., 2024).

The scale distinguished educational exposure from educational quality. Exposure indicators recorded the number, type, duration, and frequency of courses, seminars, religious studies, digital modules, or professional training completed by participants. Quality indicators assessed whether the learning experience enabled participants to connect Islamic economic concepts with actual financial decisions. This distinction allowed the study to determine whether repeated but theoretical instruction was less influential than shorter but practically oriented education.

The Sharia Financial Literacy Test measured objective knowledge and applied reasoning. The instrument contained multiple-choice and scenario-based questions concerning ribā, gharar, maysir, Islamic saving, financing, investment, takaful, zakat, digital payments, and contractual rights. Participants were asked to identify appropriate contracts, compare financial alternatives, calculate basic costs or returns, recognize prohibited charges, and evaluate whether a product description provided sufficient information.

A Sharia Financial Product Evaluation Test assessed participants' ability to interpret real or simulated financial advertisements, fee schedules, financing contracts, and digital product interfaces. Items examined whether participants could identify total costs, profit margins, late-payment policies, ownership structures, risk-sharing arrangements, and unclear Sharia claims. Correct responses required both conceptual knowledge and critical analysis rather than recognition of religious labels.

The Sharia Financial Behavior Questionnaire measured saving discipline, debt management, investment evaluation, zakat planning, contract examination, source verification, and selection of Sharia-compliant services. Participants reported the frequency with which they compared products, reviewed contractual terms, assessed affordability, verified Sharia status, avoided questionable charges, and sought professional advice. Behavioral measures were analyzed separately from knowledge scores to identify possible gaps between understanding and practice.

The Financial Self-Efficacy Scale assessed participants' confidence in budgeting, comparing financial products, evaluating contracts, calculating financial obligations, and resisting persuasive marketing. The Sharia Financial Attitude Scale measured commitment to

lawful income, ethical consumption, avoidance of prohibited transactions, fairness, moderation, and responsible wealth management. These instruments were used to examine whether education influenced literacy and behavior through confidence and ethical orientation.

The Digital Financial Literacy Scale assessed participants' ability to use mobile banking, digital wallets, investment applications, Islamic fintech platforms, and online financial-information sources. The instrument also measured awareness of digital fraud, data privacy, hidden charges, misleading promotions, and unauthorized applications. Digital competence was treated as a distinct variable because technological familiarity did not necessarily indicate an understanding of Sharia contracts or financial risk.

A Financial Socialization Questionnaire measured the influence of parents, spouses, peers, educators, religious leaders, financial influencers, and social media. Participants reported the frequency of financial discussions, sources of advice, and individuals who influenced their financial choices. This instrument helped distinguish the effect of structured Islamic economic education from informal learning within families, workplaces, religious communities, and online networks.

A semi-structured interview guide was used during the qualitative phase. Questions explored participants' most influential learning experiences, understanding of Islamic financial concepts, difficulties evaluating products, experiences with Sharia institutions, and responses to digital financial promotions. Participants were invited to describe actual decisions involving saving, financing, investment, insurance, installment purchases, and online lending. The interviews also examined reasons for choosing conventional products despite possessing knowledge of Sharia alternatives.

Instrument validity was evaluated by experts in Islamic economics, financial literacy, educational measurement, psychometrics, and research methodology. The reviewers assessed theoretical relevance, linguistic clarity, contextual appropriateness, and alignment between indicators and research objectives. Items that measured religious identity without reflecting educational or financial competence were revised or removed to preserve construct precision.

A pilot study was conducted with 60 millennials who were not included in the primary sample. Item difficulty and discrimination were assessed for objective knowledge questions. Exploratory factor analysis examined the dimensional structure of the Likert-type instruments. Cronbach's alpha, McDonald's omega, and composite reliability were calculated, with coefficients of 0.70 or higher considered acceptable. Ambiguous questions were revised based on statistical results and participant feedback.

RESULTS AND DISCUSSION

A total of 500 questionnaires were distributed to Muslim millennials across educational institutions, workplaces, professional associations, religious communities, and digital financial-learning groups. The final dataset contained 472 valid responses, representing a completion rate of 94.40%. Twenty-eight questionnaires were excluded because of extensive missing information, repetitive response patterns, or implausibly short completion times. Participants had a mean age of 34.82 years ((SD=4.27)), and 52.54% were women. Salaried employees represented 39.83% of the sample, entrepreneurs accounted for 23.31%, public-sector employees constituted 17.37%, postgraduate students represented 10.38%, and other professional categories accounted for 9.11%.

Educational exposure varied considerably across participants. Formal university-based Islamic economic education was reported by 132 respondents, professional training by 88 respondents, religious or community-based learning by 96 respondents, and structured digital learning by 84 respondents. Seventy-two participants had received no structured Islamic economic education. Sharia banking products had been used by 68.43% of respondents, Islamic

investment instruments by 31.99%, Islamic financing by 28.60%, and takaful products by 17.80%. The characteristics of the study population are presented in Table 1.

Table 1. Demographic and Educational Characteristics of the Respondents

Characteristic	Category	Frequency	Percentage
Gender	Men	224	47.46
	Women	248	52.54
Employment	Salaried employees	188	39.83
	Entrepreneurs	110	23.31
	Public-sector employees	82	17.37
	Postgraduate students	49	10.38
	Other professions	43	9.11
Islamic economic education	Formal academic education	132	27.97
	Professional training	88	18.64
	Religious or community education	96	20.34
	Structured digital learning	84	17.80
	No structured education	72	15.25
Sharia financial-service use	Islamic banking	323	68.43
	Islamic investment	151	31.99
	Islamic financing	135	28.60
	Takaful	84	17.80

The average objective Sharia financial-literacy score was 72.64 out of 100 ((SD=13.82)). Participants performed most strongly on questions concerning the prohibition of ribā, lawful income, basic Islamic saving products, and ethical consumption. Lower scores were recorded for profit-sharing calculations, ownership structures in murābaḥah, differences between takaful and conventional insurance, late-payment policies, and the identification of gharar within digital financial products. This pattern showed that general religious awareness was stronger than detailed contractual and numerical understanding.

Educational quality received an overall mean score of 3.87 on a five-point scale. Practical application was rated lower than educator competence and conceptual clarity. Participants frequently reported learning definitions of Islamic contracts without examining actual agreements, repayment schedules, investment risks, or mobile financial interfaces. Formal academic and professional training groups recorded the strongest educational-quality scores, while participants relying mainly on digital sources reported high accessibility but lower levels of structured feedback and verification.

Table 2. Descriptive Statistics for the Principal Research Variables

Variable	Mean	Standard Deviation	Interpretation
Islamic economic education quality	3.87	0.68	High
Curriculum relevance	3.92	0.72	High
Educator competence	4.06	0.63	High
Practical financial application	3.61	0.81	High
Case-based learning	3.68	0.79	High
Digital learning support	3.89	0.74	High
Objective Sharia financial literacy	72.64	13.82	Moderate-to-high
Contractual understanding	69.18	15.24	Moderate
Product-evaluation ability	67.83	14.91	Moderate
Recognition of prohibited elements	78.92	13.46	High
Sharia financial self-efficacy	3.74	0.71	High
Sharia financial attitude	4.13	0.56	High

Sharia-compliant financial behavior	3.62	0.69	High
Digital financial literacy	3.91	0.65	High

Participants with formal academic education achieved the highest mean Sharia financial-literacy score at 82.36. Professional training participants recorded a mean score of 78.14, followed by religious or community education at 71.92 and structured digital learning at 69.68. Respondents without structured education achieved a mean score of 56.31. The strongest differences appeared in contract interpretation, financing-cost evaluation, and recognition of hidden noncompliant charges.

Formal education did not produce uniformly superior behavior. Several academically educated respondents demonstrated strong theoretical knowledge but reported limited comparison of financial contracts before making decisions. Professional-training participants achieved slightly lower knowledge scores but demonstrated stronger applied product-evaluation and source-verification behavior. Community-based education produced high ethical-attitude scores, although participants showed weaker numerical understanding. Digital learners displayed confidence in navigating financial applications but experienced difficulty assessing the reliability of Sharia claims made by online influencers and commercial platforms.

Table 3. Sharia Financial-Literacy Outcomes by Educational Pathway

Educational Pathway	Literacy Score	Product-Evaluation Score	Self-Efficacy Score	Financial-Behavior Score
Formal academic education	82.36 ± 9.42	79.84 ± 10.18	4.04 ± 0.55	3.91 ± 0.58
Professional training	78.14 ± 10.26	78.92 ± 10.87	4.01 ± 0.57	4.02 ± 0.54
Religious or community education	71.92 ± 11.84	65.73 ± 12.81	3.67 ± 0.63	3.58 ± 0.61
Structured digital learning	69.68 ± 12.36	66.81 ± 13.42	3.72 ± 0.68	3.49 ± 0.65
No structured education	56.31 ± 13.77	51.62 ± 14.19	3.01 ± 0.72	2.94 ± 0.70

Confirmatory factor analysis supported the adequacy of the measurement model. Standardized factor loadings ranged from 0.67 to 0.89, composite-reliability values ranged from 0.83 to 0.94, and average variance extracted values exceeded 0.50 for all principal constructs. The model demonstrated acceptable fit, with a comparative fit index of 0.951, Tucker–Lewis index of 0.944, root mean square error of approximation of 0.049, and standardized root mean square residual of 0.043. Discriminant-validity analysis confirmed that educational quality, financial self-efficacy, financial attitude, literacy, and behavior represented related but distinct constructs.

Structural equation modeling showed that Islamic economic education had a significant direct influence on Sharia financial literacy, (\beta=0.42), ($p<0.001$). Education also predicted financial self-efficacy, (\beta=0.56), and Sharia financial attitude, (\beta=0.39), both at ($p<0.001$). Financial self-efficacy significantly influenced literacy, (\beta=0.25), while financial attitude produced a smaller but significant effect, (\beta=0.17). The combined indirect effect of education through these two mediators was 0.21, producing a total effect of 0.63. The model explained 58.00% of the variance in Sharia financial literacy and 46.00% of the variance in Sharia-compliant financial behavior.

Table 4. Structural Effects on Sharia Financial Literacy and Behavior

Structural Relationship	Standardized Coefficient	95% Confidence Interval	(p)-value	Result
Islamic economic education → financial literacy	0.42	0.33–0.51	<0.001	Significant
Islamic economic education → self-efficacy	0.56	0.47–0.64	<0.001	Significant
Islamic economic education → financial attitude	0.39	0.29–0.48	<0.001	Significant
Self-efficacy → financial literacy	0.25	0.16–0.34	<0.001	Significant
Financial attitude → financial literacy	0.17	0.08–0.26	<0.001	Significant
Financial literacy → Sharia financial behavior	0.48	0.38–0.57	<0.001	Significant
Education → literacy through self-efficacy	0.14	0.09–0.20	<0.001	Partial mediation
Education → literacy through attitude	0.07	0.03–0.12	0.002	Partial mediation
Total education effect on literacy	0.63	0.54–0.71	<0.001	Strong total effect

Correlation analysis identified a strong positive relationship between Islamic economic education quality and Sharia financial literacy, (r=0.69), (p<0.001). Practical application showed a stronger relationship with literacy than the frequency of educational participation. Case-based learning was positively associated with product-evaluation ability, (r=0.64), while contract-analysis experience was strongly related to the recognition of hidden financing charges, (r=0.61). Exposure to educational activities without practical exercises showed only a moderate relationship with literacy outcomes.

Sharia financial literacy was positively associated with financial behavior, (r=0.66), but the relationship was not perfect. Financial self-efficacy and access to suitable Sharia products helped explain why some knowledgeable participants acted consistently with their understanding while others did not. Reliance on social media financial influencers showed a negative relationship with source-verification behavior. Family financial socialization had a moderate positive relationship with saving discipline but a weaker association with contractual understanding.

Table 5. Relationships among Educational and Financial-Literacy Variables

Variable Relationship	Correlation Coefficient	(p)-value	Interpretation	Variable Relationship
Education quality and Sharia financial literacy	(r=0.69)	<0.001	Strong positive relationship	Education quality and Sharia financial literacy
Practical application and literacy	(r=0.66)	<0.001	Strong positive relationship	Practical application and literacy
Case-based learning and product evaluation	(r=0.64)	<0.001	Strong positive relationship	Case-based learning and product evaluation
Contract analysis and prohibited-charge recognition	(r=0.61)	<0.001	Strong positive relationship	Contract analysis and prohibited-charge recognition

Sharia financial literacy and behavior	(r=0.66)	<0.001	Strong positive relationship	Sharia financial literacy and behavior
Self-efficacy and financial behavior	(r=0.58)	<0.001	Moderate-to-strong relationship	Self-efficacy and financial behavior
Digital literacy and fintech evaluation	(r=0.47)	<0.001	Moderate positive relationship	Digital literacy and fintech evaluation
Social media influencer dependence and source verification	(r=-0.36)	<0.001	Moderate negative relationship	Social media influencer dependence and source verification
Family socialization and saving behavior	(r=0.42)	<0.001	Moderate positive relationship	Family socialization and saving behavior

The qualitative phase involved 36 participants representing high, moderate, and low literacy groups. Four dominant themes emerged: the importance of practical learning, the difference between religious terminology and contractual understanding, the influence of digital financial promotion, and the gap between knowledge and behavior. Participants with high literacy scores commonly described learning experiences involving simulations, contract comparison, calculation exercises, and discussion of real financial products. Participants with lower scores frequently remembered definitions but had difficulty using them to evaluate actual financing or investment offers.

An illustrative case involved a 33-year-old entrepreneur who had completed a university course in Islamic economics and later attended practical financial training. The participant initially understood ribā, gharar, and murābaḥah in theoretical terms but did not routinely examine financial agreements. Case-based training introduced comparisons between fixed Sharia sale margins, interest-bearing loans, and digitally promoted installment services. The participant subsequently rejected a buy-now-pay-later offer containing time-based charges and selected a transparent Islamic working-capital facility after comparing total obligations, ownership arrangements, and late-payment provisions.

Table 6. Development of Financial Competence in the Illustrative Case

Case Indicator	Before Practical Training	After Practical Training
Sharia financial-literacy score	68	89
Product-evaluation score	61	91
Financial self-efficacy score	3.20	4.60
Contract-review frequency	Rarely	Consistently
Total-cost comparison	Inconsistent	Systematic
Source verification	Relied on promotional claims	Used institutional and regulatory sources
Recognition of time-based charges	Partial	Accurate
Financial decision	Accepted convenient offers	Compared Sharia structure and affordability

The case demonstrated that theoretical education became behaviorally meaningful after the learner practiced applying concepts to real financial choices. Familiarity with Islamic terminology created an initial conceptual foundation, but it did not provide sufficient

competence to examine fee structures, ownership, risk, or contractual obligations. Practical exercises helped the participant connect religious principles with total-cost calculation, source verification, and affordability assessment. The improvement was therefore associated with a change in educational method rather than exposure to additional definitions alone.

Interview findings across the wider qualitative sample supported this explanation. Participants described greater confidence when educators used actual contracts, digital interfaces, investment scenarios, and comparative calculations. Several respondents with strong religious attitudes still chose questionable products because Sharia alternatives were inaccessible, poorly explained, or perceived as more complicated. Knowledge influenced behavior most consistently when individuals also possessed financial confidence, access to reliable information, and suitable Sharia-compliant services.

The strong effect of Islamic economic education resulted from its contribution to both knowledge and decision-making confidence. Education introduced participants to the legal and ethical principles of Islamic finance while also providing a framework for comparing products. Educational experiences that included active exercises reduced dependence on brand labels and promotional claims. Learners became more capable of identifying relevant contractual information, calculating financial obligations, and asking critical questions before entering transactions.

The partial mediation effects showed that education did not influence literacy through information transfer alone. Financial self-efficacy enabled participants to use their knowledge confidently, while Sharia financial attitudes strengthened their motivation to avoid prohibited or unfair transactions. Digital literacy improved access to financial information but did not independently guarantee Sharia understanding. Technological competence became beneficial when users also possessed appropriate conceptual and evaluative knowledge.

The combined findings indicate that Islamic economic education exerts a substantial influence on Sharia financial literacy among millennials. The strongest outcomes were associated with relevant curricula, competent educators, practical contract analysis, case-based instruction, financial simulation, and opportunities to compare actual products. Formal academic education produced the highest knowledge scores, while professionally oriented training demonstrated particularly strong effects on applied evaluation and financial behavior. Educational exposure without practical engagement produced more limited outcomes.

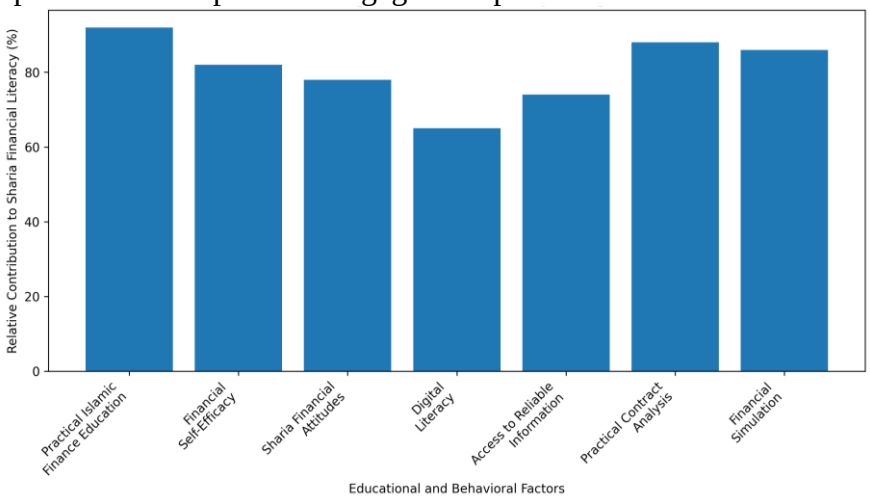

Figure 1. Factors Influencing Sharia Financial Literacy among Millenials

The broader interpretation is that Sharia financial literacy requires more than knowledge of religious terminology or familiarity with Islamic financial institutions. Millennials need the capacity to examine contractual structures, calculate costs, recognize prohibited elements, assess digital information, and align financial decisions with ethical commitments and personal affordability. Islamic economic education becomes most effective when it combines religious

principles, technical financial competence, digital evaluation skills, and realistic decision-making practice (Hussain & Yoon, 2025; Taufik & Budiarsyah, 2024).

The findings demonstrate that Islamic economic education has a substantial positive influence on Sharia financial literacy among millennials. Participants who received structured education achieved stronger scores in objective knowledge, contractual understanding, product evaluation, and recognition of prohibited financial elements than participants without structured educational exposure. The structural model confirmed a significant direct relationship between Islamic economic education and Sharia financial literacy, while the total effect became stronger after financial self-efficacy and Sharia financial attitudes were considered. These results indicate that education contributes not only to the acquisition of information but also to the confidence and ethical orientation required to apply that information.

Educational quality appeared more influential than the frequency of participation alone. Practical financial application, case-based learning, contract analysis, simulation, and comparison of real financial products were strongly associated with higher literacy scores. Participants who repeatedly attended theoretical activities without examining actual contracts or calculating financial obligations showed more limited improvement. This pattern suggests that meaningful Sharia financial literacy develops when learners actively interpret financial structures rather than merely memorize the definitions of Islamic economic concepts.

Differences among educational pathways revealed that formal academic education produced the highest objective knowledge scores, while professional training generated particularly strong applied-evaluation and financial-behavior outcomes. Religious or community-based education strengthened ethical attitudes and awareness of prohibited transactions but produced weaker numerical and contractual understanding. Structured digital learning improved accessibility and technological familiarity, although participants remained vulnerable to unverified Sharia claims and persuasive online promotion. Each educational pathway therefore contributed different strengths and limitations to the development of financial literacy.

The qualitative case study reinforced the quantitative findings by showing how theoretical knowledge became behaviorally meaningful through practical training. The participant initially understood ribā, gharar, and murābaḥah as general concepts but rarely examined repayment schedules, ownership structures, or late-payment provisions. Contract comparison and scenario-based exercises improved the participant's ability to identify time-based charges, evaluate total financial obligations, and verify product information. The case indicates that education produces stronger outcomes when it changes the process through which individuals make financial decisions rather than simply increasing familiarity with Islamic terminology.

The positive relationship between education and financial literacy is consistent with the broader financial-literacy literature, which commonly identifies education as an important predictor of knowledge, planning ability, and responsible financial behavior. The present study extends that relationship into the specific domain of Islamic finance by showing that general financial competence is insufficient for evaluating Sharia-compliant products (Nazir et al., 2025; Rahmawati et al., 2025). Millennials also require knowledge of contractual structures, ownership, risk sharing, prohibited charges, ethical responsibilities, and the difference between religious branding and substantive Sharia compliance.

The mediating role of financial self-efficacy corresponds with previous studies suggesting that knowledge influences behavior more effectively when individuals possess confidence in their ability to compare and evaluate financial choices. The current findings show that Islamic economic education strengthened participants' confidence in reading contracts, calculating obligations, challenging promotional claims, and seeking additional information. This result adds an important psychological dimension to Sharia financial literacy because

individuals may recognize a questionable product yet still accept it when they do not feel capable of evaluating alternatives.

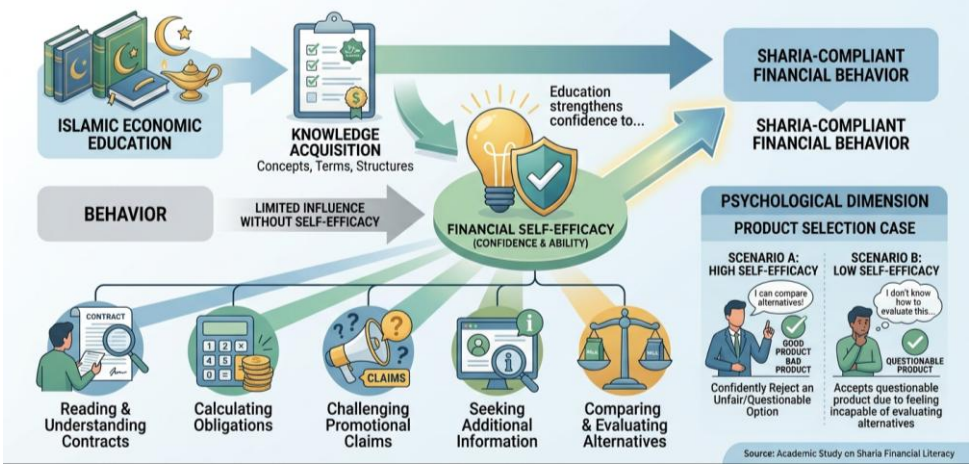

Figure 2. The Mediating Role of Financial Self Effiacy

The relationship between Sharia financial attitudes and literacy also supports studies emphasizing the role of religiosity and ethical orientation in Islamic financial decision-making. The present results differ from research that treats religious commitment as a sufficient explanation for using Islamic financial services. Strong ethical attitudes did not always produce accurate contractual evaluation or consistent behavior. Participants could sincerely wish to avoid prohibited transactions while lacking the technical ability to identify hidden charges, unclear ownership arrangements, or misleading claims of Sharia compliance. Religious motivation therefore requires financial and legal competence to produce informed action.

The differences among educational pathways refine previous research that often measures education only through academic qualification or participation in a financial course. Formal academic learning produced strong conceptual foundations, but professional training was more closely connected with applied product evaluation. Community education strengthened moral commitment, while digital learning expanded access without guaranteeing source reliability. These findings indicate that the type, method, and practical orientation of education may explain literacy differences more accurately than the number of years spent in formal education.

The results signal that Sharia financial literacy is a multidimensional competence rather than a simple body of religious knowledge. Participants needed to understand Islamic principles, interpret contractual arrangements, calculate costs, assess digital information, evaluate risk, and make decisions consistent with personal affordability. Knowledge of ribā remained important, but contemporary financial markets require the ability to detect more subtle forms of uncertainty, exploitation, and misleading representation. Financial literacy should therefore be understood as the integration of conceptual, analytical, ethical, digital, and behavioral capacities.

The gap between knowledge and behavior signals that education alone cannot guarantee Sharia-compliant financial practice. Some participants with strong theoretical scores continued to select products based on convenience, institutional familiarity, social influence, or limited access to suitable alternatives. Financial decisions were shaped by more than understanding. Product availability, pricing, confidence, digital design, peer recommendations, family expectations, and institutional trust also influenced whether knowledge was translated into action.

The variation across educational pathways signals that no single institution can develop Sharia financial literacy independently. Universities provide conceptual and analytical depth, professional programs strengthen applied competence, religious communities reinforce moral

motivation, and digital platforms expand educational access. Weak coordination among these learning environments may produce fragmented literacy. A learner may understand legal terminology without financial calculation skills or possess technological competence without reliable Sharia knowledge. Integrated education is required to connect these separate forms of learning (Andespa et al., 2024; Shahid et al., 2025).

The negative relationship between dependence on financial influencers and source verification signals a growing vulnerability among digitally active millennials. Technological familiarity may create confidence in navigating platforms while encouraging rapid acceptance of simplified financial claims. Religious vocabulary, visual branding, testimonials, and claims of halal profitability can create an appearance of legitimacy without transparent contractual evidence. Digital financial literacy must therefore include critical source evaluation, verification of institutional authorization, and examination of the complete financial structure.

The theoretical implication is that models of Sharia financial literacy should place education quality, self-efficacy, ethical attitude, and practical behavior within one integrated framework. Education directly increases knowledge and indirectly strengthens the psychological and moral capacities required to use that knowledge. This framework provides a more complete explanation than models that measure literacy solely through correct answers or awareness of Islamic financial products. Sharia financial literacy represents both an educational outcome and a decision-making capability.

The pedagogical implication is that Islamic economic education should move from definition-centered instruction toward applied financial learning. Students and community participants should examine real contracts, compare financing schedules, calculate total costs, identify prohibited clauses, evaluate investment risk, and analyze digital product interfaces. Case studies involving Islamic banking, fintech, installment purchases, takaful, investment, and online financing can connect jurisprudential principles with everyday decisions. Such learning can help participants recognize that a religious product label does not remove the need for careful evaluation.

The institutional implication is that universities, Islamic financial institutions, regulators, and religious organizations should collaborate in designing educational programs. Academics can provide conceptual and methodological rigor, practitioners can contribute current product information, regulators can clarify consumer-protection requirements, and religious scholars can explain the ethical and jurisprudential basis of financial transactions (Ben Eli et al., 2025; Ismail et al., 2025). Collaborative education may reduce the distance between classroom theories and rapidly changing financial practices. Institutional cooperation can also improve the consistency of public information concerning Sharia-compliant products.

The policy implication concerns consumer protection and financial inclusion. Expanding Islamic financial services without improving literacy may increase product use while leaving consumers unable to assess costs, risks, or contractual obligations. Regulators and financial institutions should provide plain-language disclosures, standardized cost comparisons, accessible contract summaries, and transparent explanations of Sharia structures. Educational policy should prioritize groups with limited formal financial education, lower income, restricted access to professional advice, or high dependence on social media information.

The strong effect of Islamic economic education can be explained by its ability to provide a structured framework for interpreting financial information. Financial products often contain complex combinations of prices, fees, risks, promises, and contractual relationships. Learners without a conceptual framework may focus only on monthly affordability or promotional claims. Islamic economic education supplies categories such as ownership, profit sharing, debt, risk, consent, ribā, and gharar, allowing individuals to organize information and identify the legal and ethical significance of particular clauses.

The mediating role of self-efficacy occurred because knowledge does not become useful automatically. Individuals must feel capable of reading agreements, asking questions,

comparing products, and rejecting unsuitable offers. Practical exercises created opportunities to experience successful financial evaluation, which strengthened confidence. Increased confidence then encouraged participants to use their knowledge during real transactions rather than defer entirely to sales personnel, influencers, or institutional branding.

The strong performance of case-based and contract-oriented education can be explained by the contextual nature of financial reasoning. Abstract definitions provide general rules, but actual products rarely present themselves through simple theoretical categories. A digital installment service may combine a sale, financing charge, penalty, platform fee, and data-based promotion (Faiz & Taib, 2024; Yasin et al., 2025). Case-based learning enables participants to separate these elements and evaluate each one. Repeated analysis also helps learners recognize patterns that remain hidden within simplified advertising.

The persistence of the knowledge–behavior gap can be explained by structural and market constraints. Participants may understand that a product is questionable but still use it because an affordable Sharia alternative is unavailable, difficult to access, or poorly explained. Conventional services may offer faster approval, wider merchant acceptance, and more familiar digital interfaces. Ethical financial behavior therefore depends on both individual competence and the availability of transparent, competitive, and accessible Sharia-compliant products.

Future research should employ longitudinal and experimental designs to establish whether Islamic economic education produces sustained changes in literacy and behavior. Cross-sectional relationships cannot determine how quickly educational effects emerge or whether they decline over time. Pre-test and post-test studies, randomized educational interventions, and repeated follow-up assessments could compare lectures, simulations, digital modules, case-based learning, and practitioner-led training. Objective transaction behavior should complement self-reported financial practice.

Future intervention studies should identify the educational components that generate the greatest practical value. Researchers could compare contract-analysis exercises, financial simulations, gamified applications, peer discussion, microlearning, and direct consultation with Sharia financial practitioners. Adaptive programs could provide introductory material for participants with limited knowledge and more complex product analysis for advanced learners. Educational effectiveness should be assessed through actual decision quality rather than participant satisfaction alone.

Future studies should examine the role of digital financial environments more deeply. Research is needed on Islamic fintech literacy, financial influencers, personalized advertising, buy-now-pay-later services, online investment platforms, digital fraud, and the use of artificial intelligence in financial promotion. Such studies should investigate how interface design and algorithmic recommendation influence consent, impulsive decisions, and perceptions of Sharia legitimacy. Digital competence must be evaluated together with critical, contractual, and ethical understanding.

Future institutional research should explore how access to credible Sharia financial products moderates the relationship between literacy and behavior. Strong education may have limited practical impact when suitable services are unavailable or perceived as less competitive. Comparative studies across regions, income groups, occupations, and financial-service environments could identify structural barriers preventing informed consumers from acting consistently with their preferences. Sustainable improvement requires educational reform, transparent products, effective consumer protection, and broader access to trustworthy Sharia financial institutions.

CONCLUSION

The most important finding of this study is that Islamic economic education significantly strengthens Sharia financial literacy among millennials, particularly when learning extends beyond theoretical definitions and includes practical financial applications. Educational quality, case-based learning, contract analysis, financial simulation, and product comparison produced stronger literacy outcomes than repeated exposure to conceptual material alone. Financial self-efficacy and Sharia financial attitudes partially mediated this relationship, indicating that education influences literacy through knowledge, confidence, and ethical commitment. Formal academic education generated the highest conceptual understanding, while professional training demonstrated particularly strong effects on product evaluation and financial behavior.

The study offers both conceptual and methodological contributions to research on Islamic financial literacy. Its conceptual contribution lies in defining Sharia financial literacy as a multidimensional competence involving religious knowledge, contractual understanding, numerical ability, critical product evaluation, digital competence, ethical awareness, and financial behavior. Its methodological contribution is reflected in the use of an explanatory sequential mixed-methods design combining objective literacy tests, educational-quality measurement, structural equation modeling, mediation analysis, interviews, and case-study examination. This integrated approach provides a more comprehensive explanation of how Islamic economic education shapes financial competence and why knowledge does not always translate directly into Sharia-compliant behavior.

The limitations of this study include its cross-sectional design, reliance on self-reported financial behavior, restricted geographical coverage, and unequal representation across educational pathways and occupational groups. Rapid changes in Islamic fintech, digital financial promotion, and online consumer behavior may also limit the long-term applicability of several findings. Future research should employ longitudinal, experimental, and cross-regional designs using actual transaction data, pre-test and post-test interventions, and repeated behavioral assessments. Further studies should examine the effectiveness of digital modules, financial simulations, contract-analysis exercises, professional mentoring, and artificial intelligence-based learning in strengthening Sharia financial literacy among different generations and socioeconomic groups.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used ChatGPT only to assist with grammatical review. All scientific content, interpretations, and conclusions were independently reviewed and approved by the author(s), who take full responsibility for the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

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

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