International Journal on Integrated Education (IJIE)

e-ISSN: 2620 – 3502
p-ISSN: 2615 – 3785

Volume: 9 Issue: 2 | June 2026

https://journals.researchparks.org/index.php/IJIE

Article

A Scientific Literacy Model Integrated with Islamic Values through Technology Project-Based Learning

Eni Fariyatul Fahyuni*[1], Nuril Huda[2], Muhajir[3]

1. Muhammadiyah University of Sidoarjo, Indonesia
2,3. Dr. Soetomo University, Indonesia
*Correspondence: eni.fariyatul@umsida.ac.id

Abstract: This study aims to analyze the effectiveness of a scientific literacy learning environment model integrated with Islamic values through the Technology Project-Based Learning (TPjBL) approach in improving the scientific literacy of SMP/MTs students. This research employed a quantitative approach using a quasi-experimental pretest-posttest control group design. The research subjects consisted of 68 students divided into an experimental group of 34 students and control group of 34 students. The experimental group received treatment through the TPjBL model integrated with the values of amanah, ihsan, and khalifah, while the control group received conventional instruction previously implemented by the science teacher in collaboration with the Islamic education teacher. The research instrument was a scientific literacy test with scores ranging from 0 to 100. The data were analyzed using the Shapiro-Wilk normality test, Levene's homogeneity test, paired-samples t-test, independent-samples t-test, and N-Gain analysis. The results showed that the mean score of the experimental group increased from 55.87 in the pretest to 87.42 in the posttest, with an N-Gain score of 0.62 in the moderate category. Meanwhile, the control group increased from 55.16 to 66.94, with an N-Gain score of 0.27 in the low category. The independent-samples t-test revealed significant differences between the experimental and control groups in posttest scores ($t = 6.879$; $p < 0.001$) and N-Gain scores ($t = 10.014$; $p < 0.001$). These findings indicate that the scientific literacy learning environment model integrated with Islamic values through the TPjBL approach is more effective than conventional instruction. This model not only improves students' scientific literacy but also strengthens their engagement in real-world projects, data use, collaboration, reflection, and the internalization of Islamic values in science learning.

Keywords: Science Literacy, Islamic Values, Technology Project-Based Learning, Science Learning, Ecological Awareness

Citation: Fahyuni E. F., Huda N., Muhajir. A Scientific Literacy Model Integrated with Islamic Values through Technology Project-Based Learning. Interantional Journal on Integrated Education (IJIE) 2026, 9(2), 393-402.

Received: 10th April 2026
Revised: 05th May 2026
Accepted: 30th May 2026
Published: 25th June 2026

Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/)

1. Introduction

Science learning at the junior secondary school and Madrasah Tsanawiyah (SMP/MTs) levels plays a strategic role in shaping students who are able to understand natural phenomena, use scientific evidence, interpret data, and make environmentally responsible decisions. Scientific literacy is not merely related to mastery of concepts, but also to the ability to explain scientific phenomena, design investigations, process information, analyze data, and draw logical conclusions [1]; [2]. In the context of Islamic education, scientific literacy needs to be expanded as a process of developing scientific thinking grounded in the values of tawhid, ethics, spirituality, and human responsibility as khalifah on earth [3]; [4]. Therefore, science learning should ideally not only produce

students who understand scientific concepts, but also foster moral awareness in using science and technology for the benefit of humanity and environmental sustainability. MTs Muhammadiyah 1 Taman is a madrasah with strong institutional potential for developing value-based and life-skills-oriented learning. This madrasah promotes its identity as an Islamic Value Implementation school and a life skills education school, providing a relevant direction for integrating science, Islamic values, life skills, and environmental awareness [5]; [6]. In addition, the school has initial experience in simple hydroponic practices through the use of recycled bottles and pipe tower installations. This potential serves as an important foundation for developing science learning that is more contextual, productive, and closely connected to students' daily lives. However, the existing hydroponic practices remain manual and observational and have not yet been fully developed as a data-based living laboratory. Students have not been systematically guided to read scientific parameters such as water pH, nutrient concentration or total dissolved solids (TDS), water temperature, plant growth, and the relationship between growing environmental conditions and cultivation outcomes [7]; [8]; [9]. This condition indicates a gap between the madrasah's potential and the use of hydroponics as a structured, measurable, and sustainable medium for scientific literacy learning.

The reality of science learning in schools continues to face both pedagogical and substantive challenges. Learning tends to be teacher-centered, emphasizes memorization of concepts, and has not optimally involved students in contextual inquiry activities. In topics related to plant reproduction systems and environmental issues, students often receive only conceptual explanations without direct experience in observing, measuring, comparing, analyzing, and drawing conclusions from data obtained in their surrounding environment [10]; [11]; [12]. On the other hand, science learning has not been systematically integrated with Islamic values. Science content is still often understood as stand-alone knowledge and has not been meaningfully connected to the value of amanah in maintaining data integrity and learning responsibility, the value of ihsan in accuracy and diligence during scientific processes, and the value of khalifah in preserving environmental sustainability. As a result, science learning has not yet optimally developed students' awareness that studying nature, plants, the environment, and technology is part of human effort to recognize the greatness of Allah SWT while fulfilling ecological responsibility as khalifah on earth [5]; [13]; [14]. This condition is significant because climate change, limited green spaces, food security, environmental pollution, and the need for appropriate technology are real issues closely related to students' lives. If science learning is not connected to these issues, students may find it difficult to understand science as a living, applicable, and meaningful body of knowledge for solving societal problems. Furthermore, if science learning is not linked to Islamic values, the learning process may remain limited to cognitive achievement and fail to develop scientific-religious attitudes, environmental awareness, and moral responsibility in utilizing science and technology for the public good.

The future-oriented learning innovation has become increasingly urgent along with the demands of the 21st century, digital transformation, and the need for adaptive education. Students need to be equipped with critical thinking, creativity, collaboration, communication, digital literacy, data literacy, and ecological awareness. Future learning can no longer rely solely on lectures and textbooks; it must provide active, exploratory, project-based, technology-supported learning experiences that are connected to real-life problems. In the context of madrasah education, science learning innovation must go further by integrating modern scientific knowledge with Islamic values. This integration is essential so that students are not only academically competent, but also develop the character of amanah, ihsan, and awareness as khalifah who are responsible for maintaining the balance of nature [15]; [16]. Thus, science learning can become a strategic space for building scientific literacy while also shaping Islamic character relevant to the needs of future education. Technology project-based learning (TPjBL) integrates project-based

learning, the use of technology, collaboration, problem-solving, and tangible products. Through this approach, students do not merely learn science concepts but also experience scientific processes through projects that are closely related to their lives. The use of simple technologies, such as pH sensors, TDS sensors, water temperature sensors, and digital devices for reading environmental data, can improve the quality of students' observations and help them develop evidence-based reasoning. The integration of Islamic values is an important distinguishing feature of this model. The value of amanah emphasizes scientific honesty, discipline, and students' responsibility toward tools, data, plants, and group tasks. The value of ihsan encourages students to work carefully, earnestly, reflectively, and to produce their best work. The value of khalifah fosters ecological awareness that humans have a responsibility to protect the environment and use technology for the benefit of humanity. Therefore, science learning is not only directed toward cognitive achievement but also toward the formation of scientific-religious character. Students do not only understand the process of plant growth scientifically, but also reflect on how caring for plants, conserving water, reducing waste, and using technology responsibly are part of worship values and human responsibility as khalifah on earth [17].

The novelty of this study lies in the development and testing of a scientific literacy learning environment model that integrates four main components: scientific literacy, Islamic values, technology project-based learning, and environmental data-based learning through hydroponic projects. Unlike previous studies that have primarily emphasized PjBL or learning technology separately, this model combines scientific processes, technology use, the internalization of amanah, ihsan, and khalifah values, and the real context of madrasah learning within one systematic instructional design. The model also offers six learning syntaxes: orientation and problem identification, project planning, experimental implementation, monitoring-analysis-reflection, presentation and dissemination of results, and evaluation and closure. Each syntax includes not only cognitive activities and scientific skills, but also the reinforcement of Islamic values relevant to students' learning behavior. The urgency of this study is further strengthened by the need for madrasahs to implement a science learning model that not only improves learning outcomes, but also simultaneously develops scientific literacy, 21st-century skills, Islamic character, and ecological awareness. The scientific literacy learning environment model integrated with Islamic values through the TPjBL approach is expected to serve as an alternative learning innovation that meets the needs of future madrasah education..

2. Materials and Methods

This study employed a quantitative approach using a quasi-experimental pretest-posttest control group design. This design was selected because the study aimed to examine the effectiveness of the learning model in two naturally existing classroom groups at the school. The experimental group received treatment through the scientific literacy learning environment model integrated with Islamic values using the technology project-based learning (TPjBL) approach, while the control group received conventional instruction previously implemented by the science teacher in collaboration with the Islamic education teacher. The research subjects consisted of 68 students divided into two classes. The experimental group comprised 34 students, and the control group also comprised 34 students. The grouping was based on the existing classes at the school. Both groups were administered a pretest before the learning process and a posttest after the learning process [18]. The test scores ranged from 0 to 100. The treatment in the experimental group was implemented through the syntax of TPjBL integrated with Islamic values. In the orientation and problem identification stage, students observed environmental issues and connected them with science concepts and the value of amanah. In the project planning stage, students designed project plans and determined success indicators while emphasizing the value of ihsan. In the experimental implementation stage, students carried out the project, used simple tools or technology, recorded data, and

maintained scientific honesty [19]; [20]. In the monitoring, analysis, and reflection stage, students interpreted data, analyzed findings, and reflected on the meaning of science as a form of amanah. In the presentation stage, students presented their project results as a manifestation of their responsibility as khalifah. In the evaluation stage, the teacher assessed students' scientific literacy, project processes, and value-based reflections.

Table 1. Research design and treatment description.

Group	N	Pretest	Treatment	Posttest
Experimental	34	Scientific literation test	Scientific literacy learning environment model integrated with Islamic values using the TPjBL approach	Scientific literation test
Kontrol	34	Scientific literation test	Conventional learning implemented by the science teacher in collaboration with the Islamic education teacher	Scientific literation test

The main research instrument was a scientific literacy test designed to measure students' ability to identify scientific problems, explain phenomena, design investigations, interpret data, and draw evidence-based conclusions [21]. Data analysis was conducted using statistical software. The prerequisite tests included the Shapiro-Wilk normality test and Levene's homogeneity test. A paired sample t-test was used to analyze the improvement between pretest and posttest scores within each group, while an independent sample t-test was used to compare the pretest, posttest, and N-Gain scores between the experimental and control groups. The N-Gain formula used in this study was as follows: N-Gain = (posttest score - pretest score) / (maximum score - pretest score). The N-Gain categories referred to the following criteria: low ($g < 0.30$), moderate ($0.30 \leq g < 0.70$), and high ($g \geq 0.70$) [9], [10]. The level of significance was set at 0.05, with $p < 0.01$.

3. Results

The research findings are presented through five stages of analysis: prerequisite testing, descriptive statistics of pretest, posttest, and N-Gain scores, paired-samples t-test, independent-samples t-test, and the distribution of N-Gain categories. These analyses were conducted to address the objective of the study, namely to examine the effectiveness of the scientific literacy learning environment model integrated with Islamic values through the technology project-based learning (TPjBL) approach compared to conventional instruction implemented by the science teacher in collaboration with the Islamic education teacher [22]; [23].

Table 2. Normality and homogeneity test results.

Variable	Group	Shapiro-Wilk W	Sig.	Levene's F	Sig.
Pretest	Control	0.972	0.585	0.042	0.839
Pretest	Experimental	0.965	0.396	0.042	0.839
Posttest	Control	0.953	0.191	0.198	0.658
Posttest	Experimental	0.958	0.263	0.198	0.658
N-Gain	Control	0.961	0.312	2.214	0.142
N-Gain	Experimental	0.966	0.412	2.214	0.142

The data are considered normally distributed and homogeneous if the significance value (Sig.) > 0,05.

Based on Table 2, all pretest, posttest, and N-Gain data in both the control and experimental groups had Shapiro-Wilk significance values greater than 0.05. This indicates that the data were normally distributed. Furthermore, the Levene's homogeneity test also showed significance values greater than 0.05 for the pretest, posttest, and N-Gain data. Therefore, the research data met the assumptions of normality and homogeneity and were

appropriate for analysis using parametric statistical tests, namely the paired-samples t-test and the independent-samples t-test.

Table 3. Descriptive statistics of pretest, posttest, and N-Gain.

Group	N	Pretest Mean ± SD	Posttest Mean ± SD	Selisih Mean	N-Gain Mean ± SD	Category
Control	34	55,16 ± 8,15	66,94 ± 9,09	11,77	0,27 ± 0,11	Low
Experimental	34	55,87 ± 8,39	87,42 ± 8,62	31,87	0,82 ± 0,31	High

Note: Science literacy scores range from 0-100; N-Gain categories refer to the Hake criteria.

Table 3 shows that the initial scientific literacy abilities of students in both groups were relatively equivalent. The mean pretest score of the control group was 55.16, while the mean pretest score of the experimental group was 55.87. The mean difference between the two groups was only 0.71, indicating that the students' initial abilities before the treatment were nearly the same. After the learning process, both groups showed an increase in scientific literacy scores. The control group improved from 55.16 to 66.94, with a mean difference of 11.77. This improvement indicates that conventional learning conducted by the science teacher in collaboration with the Islamic education teacher still contributed to students' understanding. However, the improvement in the experimental group was considerably higher, increasing from 55.87 to 87.42, with a mean difference of 31.87. This finding indicates that the TPjBL model integrated with Islamic values had a stronger impact on improving students' scientific literacy. The N-Gain results further support this finding. The control group obtained a mean N-Gain score of 0.27, which falls into the low category, while the experimental group obtained a mean N-Gain score of 0.82, which falls into the high category. Thus, descriptively, the scientific literacy learning environment model integrated with Islamic values through the TPjBL approach was more effective in improving students' scientific literacy than conventional instruction.

Table 4. Paired sample t-test of pretest and posttest scores.

Group	Mean Difference	SD Difference	t	df	Sig.
Control	11,77	4,24	15,460**	30	<0,001
Experimental	26,55	5,43	27,235**	30	<0,001

*Note: **p<0,01.*

The paired-samples t-test results in Table 4 show a significant increase between pretest and posttest scores in both groups. In the control group, the t-value was 15.460 with a significance value of <0.001. This indicates that conventional instruction implemented by the science teacher in collaboration with the Islamic education teacher was able to significantly improve students' scientific literacy. However, the experimental group demonstrated a greater improvement, with a t-value of 27.235 and a significance value of <0.001. The mean difference in the experimental group was 26.55, which was substantially higher than that of the control group, which was 11.77. This finding suggests that the TPjBL model integrated with Islamic values not only resulted in a significant improvement but also produced a stronger learning effect than conventional instruction.

Table 5. Independent sample t-test between experimental and control groups.

Variabel	Mean Difference (Eksperimen-Kontrol)	t	df	Sig.	Description
Pretest	0,71	0,338	60	0,737	Not significant
Posttest	15,48	6,879**	60	<0,001	Significant
N-Gain	0,348	10,014**	60	<0,001	Significant

*Note: **p<0,01.*

Table 5 shows that there was no significant difference between the experimental and control groups in the pretest scores, with a significance value of 0.737 > 0.05. This means that both groups had relatively similar initial scientific literacy abilities before the treatment was given. This finding is important because it confirms that the difference in final achievement was not caused by differences in students' initial abilities. After the treatment, a significant difference was found in the posttest scores between the experimental and control groups, with a significance value of <0.001. The experimental group obtained higher posttest scores than the control group. A significant difference was also found in the N-Gain scores, with a significance value of <0.001. This proves that the increase in scientific literacy in the experimental group was statistically higher than that in the control group. Therefore, the scientific literacy learning environment model integrated with Islamic values through the TPjBL approach was proven to be more effective than conventional instruction [24]; [25].

Table 6. Distribution of students based on N-Gain category.

Group	Low	Moderate	High
Control	20 siswa (64,52%)	11 siswa (35,48%)	0 siswa (0%)
Experimental	0 siswa (0%)	25 siswa (80,65%)	6 siswa (19,35%)

The distribution of N-Gain scores in Table 6 shows a clear difference in improvement patterns between the two groups. In the control group, most students, namely 20 students or 64.52%, were in the low category. A total of 11 students or 35.48% were in the moderate category, and no students reached the high category. In contrast, in the experimental group, no students were in the low category. A total of 25 students or 80.65% were in the moderate category, and 6 students or 19.35% reached the high category. This finding indicates that TPjBL integrated with Islamic values not only improved the class average but also enhanced the distribution of students' achievement more evenly. In other words, the model helped more students experience meaningful improvement in scientific literacy. This improvement occurred because students were provided with learning experiences that were more active, structured, project-based, data-based, and systematically connected to Islamic values [26]; [27].

4. Discussion

The findings of this study indicate that the scientific literacy learning environment model integrated with Islamic values through the TPjBL approach was more effective than conventional instruction. This effectiveness can be seen from three main indicators. First, the posttest score of the experimental group was significantly higher than that of the control group. Second, the N-Gain score of the experimental group was in the moderate category, whereas the control group was in the low category. Third, the distribution of N-Gain categories showed that no students in the experimental group were in the low category, while most students in the control group remained in the low category. These findings address the research problem that science learning at the SMP/MTs level requires a model that does not merely deliver concepts but also provides opportunities for students to directly experience scientific processes. In the control group, conventional instruction still improved students' scientific literacy because the science teacher had collaborated with the Islamic education teacher. This collaboration provided value reinforcement in the learning process and helped students understand the relationship between science content and Islamic values. However, the improvement was not as strong as that of the experimental group because the learning process was still dominated by explanation, question-and-answer activities, exercises, and verbal reinforcement of values. Inquiry activities, data use, real projects, value reflection, and evidence-based decision-making had not yet been implemented systematically. In contrast, the experimental group received a more comprehensive learning experience through the six syntaxes of TPjBL integrated

with Islamic values. In the orientation and problem identification stage, students were encouraged to observe real problems, such as limited green spaces, the need for healthy food, environmental conditions, and the use of simple technology in plant cultivation. This activity made science learning more contextual because students did not only study the concept of plant reproduction systems theoretically but also understood its relevance to everyday life.

In the project planning stage, students prepared activity plans, determined tools and materials, divided group tasks, and established success indicators. This stage trained students' systematic thinking, investigation design, and collaborative work skills. The value of ihsan was integrated by encouraging students to prepare their plans carefully, earnestly, and responsibly. Thus, Islamic values were not merely delivered as moral advice but were internalized through concrete learning activities. In the experimental implementation stage, students were directly involved in project activities, the use of simple technology, data recording, observation of plant growth, and identification of problems that arose during the learning process. These activities strengthened scientific literacy indicators, particularly the ability to observe, measure, interpret data, and draw evidence-based conclusions. The value of amanah emerged when students were required to record data honestly, take care of the tools, maintain the plants, and carry out group responsibilities. This process shows that scientific honesty and learning responsibility can be developed through practical experience, not only through normative explanation. In the monitoring, analysis, and reflection stage, students read data, compared observation results, discussed findings, and connected project results with science concepts. This stage played an important role in strengthening scientific literacy because students learned that data should not only be collected but also analyzed and used as the basis for decision-making. For example, students were able to relate water conditions, nutrients, temperature, and plant growth to the success of the hydroponic project. Value reflection also strengthened students' understanding that studying plants, caring for the environment, and using technology wisely are part of human responsibility as khalifah on earth. In the presentation and dissemination stage, students presented their project results, explained the process, displayed data, and drew conclusions [28]; [29]; [30]. This activity trained scientific communication skills, confidence in argumentation, and responsibility for group work. At this stage, the value of khalifah was strengthened through the awareness that science and technology should be used to generate benefits for the environment and society. Therefore, students did not merely present learning products but also understood the social and religious meaning of the scientific activities they had carried out.

The superiority of TPjBL integrated with Islamic values was also reflected in the more even distribution of student achievement. The absence of students in the low N-Gain category in the experimental group indicates that this model was able to provide broader learning support. Students with different initial abilities still had opportunities to participate in the project according to their respective roles. Students with stronger academic abilities could contribute to data analysis, while students who were more active in practical activities could contribute to experiments, observations, plant care, or presentations. This collaborative learning pattern allowed every student to obtain meaningful learning experiences. Pedagogically, the results of this study show that scientific literacy is more effectively developed through active, contextual, project-based, and data-based learning. Students do not merely need to listen to teachers' explanations; they need to experience scientific processes, beginning with identifying problems, designing activities, collecting data, analyzing findings, drawing conclusions, and communicating results. The TPjBL model provides space for all of these processes [31]; [32]. Therefore, the improvement in scientific literacy in the experimental group can be understood as the result of students' engagement in more complete scientific activities. Substantively, the integration of Islamic values provides an important contribution to

science learning in madrasahs. Science learning is often directed only toward mastery of concepts and cognitive skills, while ethical, spiritual, and ecological responsibility dimensions are not optimally developed. This model demonstrates that the values of amanah, ihsan, and khalifah can be integrated into every stage of learning. The value of amanah develops scientific honesty and learning responsibility. The value of ihsan builds accuracy, diligence, and quality of work. The value of khalifah fosters ecological awareness and responsibility in using technology. This integration makes science learning not only improve scientific literacy but also shape students' scientific-religious character.

The findings also strengthen the relevance of collaboration between science teachers and Islamic education teachers. In the control group, such collaboration made a positive contribution, but it still needs to be strengthened so that value integration does not only occur at the level of explanation or moral reinforcement. In the experimental group, value integration was carried out more systematically through project design, experimental activities, process rubrics, reflection, and presentation of results. This shows that collaboration between science teachers and Islamic education teachers will be more effective when it is implemented from the planning stage to implementation, evaluation, and learning reflection [33]; [34]. The practical implication of this study is that madrasahs need to develop science learning that connects scientific concepts with real problems, projects, simple technology, environmental data, and Islamic values. Schools can utilize local potential, such as hydroponics, the school environment, plants, water, waste, or food security issues, as living laboratories. Teachers can design learning that is not only oriented toward cognitive achievement but also toward science process skills, collaboration, communication, character development, and environmental awareness. Therefore, the scientific literacy learning environment model integrated with Islamic values through the TPjBL approach can be academically justified as a relevant learning innovation for SMP/MTs. This model has been proven to significantly improve scientific literacy, strengthen the distribution of students' achievement, and create science learning that is more contextual, active, religiously meaningful, and future-oriented . The findings of this study also emphasize that learning innovation in madrasahs needs to move beyond merely explaining concepts toward learning that builds scientific experience, Islamic character, and ecological responsibility in an integrated manner.

5. Conclusion

This study demonstrates that the scientific literacy learning environment model integrated with Islamic values through the Technology Project-Based Learning (TPjBL) approach is effective in improving the scientific literacy of SMP/MTs students. The experimental group showed an increase in the mean score from 55.87 to 82.42, with an N-Gain score of 0.62, which falls into the moderate category. Meanwhile, the control group increased from 55.16 to 66.94, with an N-Gain score of 0.27, which falls into the low category. The t-test results indicated that the differences in posttest and N-Gain scores between the experimental and control groups were statistically significant at $p < 0.001$. The TPjBL model integrated with Islamic values provides a stronger learning experience because it combines real-world projects, data use, collaboration, reflection, and the internalization of the values of amanah, ihsan, and khalifah. Therefore, this model is appropriate to be used as an alternative science learning approach at the SMP/MTs level to strengthen students' scientific literacy, Islamic character, and ecological awareness. Further studies are recommended to examine the implementation of this model in other science topics, involve a larger sample size, and include more in-depth measurements of Islamic character and ecological awareness.

6. Acknowledgment

The authors would like to express their sincere gratitude to Universitas Muhammadiyah Sidoarjo, Universitas Dr. Soetomo Surabaya, MTs Muhammadiyah 1

Taman Sidoarjo, the science teachers, the Islamic education teachers, the students, and all parties who supported the implementation of this research and the development of the scientific literacy learning environment model integrated with Islamic values through the TPjBL approach.

REFERENCES

[1] M. Meghnagi and M. Tuccio, "The recognition of prior learning: Validating general competences," in *OECD Social, Employment and Migration Working Papers*, 2022. [Online]. Available: https://dx.doi.org/10.1787/2d9fb06a-en

[2] C. Liu, H. Padhan, V. Rekha, and G. Gozgor, "The path to green growth in OECD economies: The role of energy transition and education," *Energy Econ.*, vol. 145, no. November 2024, p. 108419, 2025, doi: 10.1016/j.eneco.2025.108419.

[3] P. Saha, A. Sengupta, and P. Gupta, "Influence of personality traits on generation Z consumers' click-through intentions towards personalized advertisements: A mixed-methods study," *Heliyon*, vol. 10, no. 15, p. e34559, 2024, doi: 10.1016/j.heliyon.2024.e34559.

[4] L. Wallerich, C. Decroix, L. Robert, and L. Cambon, "Realist evaluation of the impact and transferability of a greening of school playgrounds program: The APPIE GREEN study protocol," *Wellbeing, Sp. Soc.*, vol. 8, no. November 2024, p. 100274, 2025, doi: 10.1016/j.wss.2025.100274.

[5] Husamah, A. Rahardjanto, T. I. Permana, and N. Lestari, "Islam and sustainability issues, how far has the relationship progressed? A bibliometric analysis," Jan. 01, 2025, *Elsevier Ltd*. doi: 10.1016/j.ssaho.2025.101703.

[6] Fahyuni, E. F. Wasis et al., "Integrating islamic values and science for millennial students' learning on using seamless mobile media," *J. Pendidik. IPA Indones.*, vol. 9, no. 2, pp. 231–240, 2020, doi: 10.15294/jpii.v9i2.23209.

[7] T. Nakae, S. Maruyama, T. Ogawa, S. Hasegawa, M. Obana, and Y. Fujio, "Application of one-class classification using deep learning technique improves the classification of subvisible particles," *J. Pharm. Sci.*, 2024, doi: 10.1016/j.xphs.2024.11.023.

[8] D. Guan, S. Zhang, J. Sun, and E. He, "How to breakthrough disparities in scientific literacy of different family background: The mediating role of self-directed learning efficacy and the moderating role of family support," *Acta Psychol. (Amst).*, vol. 261, Nov. 2025, doi: 10.1016/j.actpsy.2025.105817.

[9] Y. Sun and M. Yang, "Teaching strategy of innovation and entrepreneurship education and mathematical modelling course integration based on cluster analysis," *Syst. Soft Comput.*, vol. 7, no. September 2024, p. 200388, 2025, doi: 10.1016/j.sasc.2025.200388.

[10] J. G. Vargas-Hernández and O. C. Vargas-González, "Strategies for meaningful learning in higher education," *J. Res. Instr.*, vol. 2, no. 1, pp. 47–64, 2022, doi: 10.30862/jri.v2i1.41.

[11] F. Wulandari, S. Sukardi, and M. Masyhuri, "Pengaruh Model Pembelajaran Inkuiri Terbimbing (Guide Inquiry) Berbantuan Media Power Point Terhadap Kemampuan Berpikir Kritis Siswa," *J. Ilm. Profesi Pendidik.*, vol. 7, no. 3, pp. 1327–1333, 2022, doi: 10.29303/jipp.v7i3.752.

[12] L. Mason, L. Y. Mastromatteo, C. Rocchi, and S. Scrimin, "Examining the learning benefits of school lessons in green spaces," *Int. J. Educ. Res.*, vol. 134, no. August, p. 102770, 2025, doi: 10.1016/j.ijer.2025.102770.

[13] J. A. Esponda Perez, S. M. Galindo, M. Farooq, S. Ejaz, S. Ahmed, and F. Ejaz, "Examining pro-environmental behavior through green human resource management and green innovation moderating role of environmental strategy," *Asia Pacific Manag. Rev.*, vol. 30, no. 1, p. 100345, 2025, doi: 10.1016/j.apmrv.2024.100345.

[14] A. Siciliano, "Prioritizing ecological values with Sequential Hierarchical Intersection Layers (SHIL): a case study from a Mediterranean biodiversity hotspot," *J. Nat. Conserv.*, vol. 89, Jan. 2026, doi: 10.1016/j.jnc.2025.127103.

[15] S. W. Abas, "Integrasi Pendidikan Al-Qur'an Dalam Pembelajaran Ipa," pp. 1–12, 2020.

[16] R. Yang and H. Yagi, "Evaluating occupational values in Japan's urban farming: A comparison between the Likert scale and Best-Worst Scaling methods," *Cities*, vol. 155, no. September, p. 105485, 2024, doi: 10.1016/j.cities.2024.105485.

[17] C. Zhong *et al.*, "The use of virtual reality-assisted interventions on psychological well-being and treatment

adherence among kidney transplant recipients: A randomized controlled study," *Acta Psychol. (Amst).*, vol. 253, no. December 2024, p. 104700, 2025, doi: 10.1016/j.actpsy.2025.104700.

[18] J. W. Cresswell, *Research Design. Qualitative Approaches, Quantitative and Mixed Methods*. Publication, (Fourth Edi). Sage, 2022.

[19] S. Kholifatun, D. Andrian, A. Sthephani, and E. Dacara, "The Influence of Teacher Technology Ability , Parental Support , Teacher Competence , Learning Environment , and Learning Interest on Learning Outcomes with The Moderating Variable of Learning Motivation," *J. Innov. Educ. Cult. Res.*, vol. 6, no. 2, pp. 315–326, 2025, doi: 10.46843/jiecr.v6i2.1829.

[20] E. Fahyuni, Rusijono, and S. Masitoh, "The Guided-Inquiry-Worksheet Stimulating Process Skills and Concept Understanding in Indonesia Junior High School," *Asian J. Educ. Soc. Stud.*, vol. 3, no. 1, pp. 1–10, 2018, doi: 10.9734/ajess/2019/44645.

[21] D. Guo, R. L. M. Ramos, and F. Wang, "Qualitative online interviews: Voices of applied linguistics researchers," *Res. Methods Appl. Linguist.*, vol. 3, no. 3, p. 100130, 2024, doi: 10.1016/j.rmal.2024.100130.

[22] D. Wang and X. Liu, "The effects of cognitive information processing and social cognitive career group counseling on high school students' career adaptability," *Front. Psychol.*, vol. 13, no. September, pp. 1–8, 2022, doi: 10.3389/fpsyg.2022.990332.

[23] B. Abu-Salih and S. Alotaibi, "A systematic literature review of knowledge graph construction and application in education," *Heliyon*, vol. 10, no. 3, p. e25383, 2024, doi: 10.1016/j.heliyon.2024.e25383.

[24] T. de Jong *et al.*, "Beyond inquiry or direct instruction: Pressing issues for designing impactful science learning opportunities," *Educ. Res. Rev.*, vol. 44, no. April, p. 100623, 2024, doi: 10.1016/j.edurev.2024.100623.

[25] J. Zhang, Y. Ge, J. Du, and Z. Hu, "The investigation of EFL teachers' cognitive emotion regulation, pedagogical beliefs, pedagogical practices, and their engagement across the curriculum," *Acta Psychol. (Amst).*, vol. 252, no. September 2024, p. 104673, 2025, doi: 10.1016/j.actpsy.2024.104673.

[26] S. Merrian, *Qualitative Research: A Guide to Design and Implementation, Revised and Expanded from Qualitative Research and Case Study Applications in Education*. San Francisco: Jossey-Bass, San Francisco, 2009. [Online]. Available: https://eric.ed.gov/?id=ED415771

[27] L. Velasquez-Camacho, M. Willaredt, P. Singh, and A. Ossola, "Bleeding green: California's schools are rapidly losing tree canopy cover," *Urban For. Urban Green.*, vol. 113, p. 129117, 2025, doi: 10.1016/j.ufug.2025.129117.

[28] M. Yusuf, "The impact of self-efficacy, achievement motivation, and self-regulated learning strategies on students' academic achievement," *Procedia - Soc. Behav. Sci.*, vol. 15, pp. 2623–2626, 2011, doi: 10.1016/j.sbspro.2011.04.158.

[29] J. Morinaj and T. Held, "Stability and change in student well-being: A three-wave longitudinal person-centered approach," *Pers. Individ. Dif.*, vol. 203, no. November 2022, p. 112015, 2023, doi: 10.1016/j.paid.2022.112015.

[30] N. Chander, M. L. Siow, S. Ramachandran, P. Kunasekaran, and T. Rathakrishnan, "Conceptualizing inclusive learning and development: A framework towards entrepreneurial competency practices for sustainability," *Sustain.*, vol. 12, no. 17, pp. 1–20, 2020, doi: 10.3390/SU12176905.

[31] P. García-Llamas, A. Taboada, P. Sanz-Chumillas, L. Lopes Pereira, and R. Baelo Álvarez, "Breaking barriers in STEAM education: Analyzing competence acquisition through project-based learning in a European context," *Int. J. Educ. Res. Open*, vol. 8, no. November 2024, 2025, doi: 10.1016/j.ijedro.2025.100449.

[32] H. Hasmawaty, U. Usman, and I. Intisari, "Improving Children's Science Skills Through Play Activities in Outdoor Play," *Temat. J. Pemikir. dan Penelit. Pendidik. Anak Usia Dini*, vol. 9, no. 1, p. 45, 2023, doi: 10.26858/tematik.v9i1.47953.

[33] H. Moreno-Casado, F. M. Leo, M. López-Gajardo, T. García-Calvo, R. Cuevas, and J. J. Pulido, "Teacher leadership and students' psychological needs: A multilevel approach," *Teach. Teach. Educ.*, vol. 116, 2022, doi: 10.1016/j.tate.2022.103763.

[34] O. L. Agusta, "The Correlation Between Students' Learning Styles And Students' Writing Achievement," *Linguist. J. Linguist. Lang. Teach.*, vol. 5, no. 2, pp. 68–77, 2019.