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Integration of Arduino Media in Science Learning to Improve the Technology Literacy of Madrasah Ibtidaiyah Students

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ABSTRACT

This study aims to analyze the effectiveness of Arduino integration in science learning to improve the technological literacy of Madrasah Ibtidaiyah (MI) students and formulate practical recommendations for teachers and policy makers. The study used a pre-test-post-test one group design with a sample of 23 students. Descriptive statistical analysis, paired sample t-test, and Shapiro-Wilk normality test were applied to measure the improvement of technological literacy. Learning is designed in six phases. Instruments include technology literacy tests (pretest-posttest), project assessment rubrics, and observation sheets. The results of the study were that there was a significant increase in technology literacy skills with an average difference of 24.95 points. The paired t-test confirmed a significant difference ($t = -73{,}113$, $p < 0.001$), supported by a narrow confidence interval (-25,664 to -24,249) and a strong correlation between scores ($r = 0.905$, $p < 0.001$). The six-phase model has been shown to be effective in improving programming, problem-solving, and collaboration skills. The integration of Arduino in science learning significantly increases technology literacy in students at Madrasah Ibtidaiyah. Recommendations include preparation of teacher training and curriculum policies that encourage the integration of ICT in madrasah science learning.

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1. INTRODUCTION

The rapid development of information and communication technology in the 21st century has created new demands in the world of education (Mendrofa, 2024), especially in terms of technological literacy as an essential competency (Papanastasiou et al., 2019). The availability of technology-based educational facilities allows learners to access information and participate in more interactive learning experiences, which significantly supports the development of critical thinking skills, digital literacy, media, and information (Liono et al., 2021; Putri et al., 2024). Modern education curricula now increasingly emphasize the integration of technology not only as a complement (Reeves et al., 2021), but as the core of the learning process. In the madrasah environment, including Madrasah Ibtidaiyah (MI), curriculum adaptation to include technological literacy is crucial so that students are able to compete in the digital era. However, this integration must be carried out without neglecting Islamic values, so that learning does not only focus on technical aspects, but also on the formation of students' character and morals (Aprily, 2020; Dewi et al., 2021). A concrete example of this effort is the use of media such as socio-drama videos and e-modules in learning beliefs and morals at MI, which has been proven to increase students' interest and understanding of the concept of morality (Firdaus, 2023). This suggests that technology can be a strategic tool to enrich faith-based pedagogy, as long as it is balanced with adequate teacher training (Palennari, Rachmawaty, Saparuddin, Saleh, & Jamaluddin, 2023).

Although the potential of technology in education has been recognized, science learning in MI still faces significant challenges. The conventional approach that lacks teaching aids and direct experiments causes students to have difficulty understanding abstract science concepts (Firdaus, 2023; Gamage et al., 2019). Limited infrastructure, such as the lack of science experiment equipment, as well as the lack of teacher training in adopting technology, exacerbate this problem (Aisyah, Arisanti, & Yaqin, 2023). As a result, the technological literacy of MI students tends to be lower than that of public school students, which has an impact on the gap in access to innovative learning resources (Firdaus, 2023). Data shows that the progress of technology literacy in Madrasah Ibtidaiyah (MI) is currently still lagging behind compared to public schools. For example, research shows that only about 30% of MI learners have adequate digital literacy skills to face challenges in an increasingly technology-dependent world (Fazilla, Yus, & Muthmainnah, 2022). Therefore, innovation in science learning in MI is very urgent to balance religious education with the technical skills needed in the digital era (Fazilla et al., 2022)In fact, research shows that the use of interactive media can increase the attractiveness of learning and the efficiency of understanding science concepts (Aisyah et al., 2023). In this context, Arduino—as a simple, affordable, and adaptable microcontroller platform is a potential solution to bridge that gap. Arduino enables practical project-based learning, such as temperature measurements using sensors or the development of automated lighting systems, which help learners internalize abstract concepts through hands-on experiences (García-Tudela & Marín, 2023; Matsun et al., 2023).

Technology literacy in basic education refers to the ability to use, understand, and evaluate technology critically—competencies that are increasingly vital in the digital era (Barakat, 2022; Zaini et al., 2020). The integration of Arduino in science learning not only develops technical skills such as basic programming or automation, but also encourages the development of soft skills such as collaboration, creativity, and problem-solving through STEAM-based projects (Science, Technology, Engineering, Arts, Mathematics) (Kyslitsyn, Shevchenko, Umanets, Sikoraka, & Angelov, 2024; Papadimitropoulos, Dalacosta, & Pavlatou, 2021). For example, simple projects such as building small robots or sensor systems allow learners to apply science in a real-world context, while increasing their motivation and engagement (Matsun et al., 2023; Rahmat, Kuswanto, Wilujeng, & Daud, 2024). However, the success of Arduino implementation depends on teachers' competence in designing technology-based learning. Teacher training on the use of Arduino and innovative learning methodologies is key to creating a dynamic and interactive learning environment (Kyslitsyn et al., 2024; Lyle et al., 2024).

Previous relevant research related to the integration of Arduino in science learning has grown rapidly, especially at the secondary and higher education levels, as shown by the bibliometric analysis of (Prabowo & Irwanto, 2023) which identifies the dominance of Arduino research at this level. However, the implementation of Arduino at the madrasah ibtidaiyah (MI) level is still very minimal, not even the main focus. Aisyah study on the adaptation of the Merdeka curriculum at MI only touched on general learning innovations without diving into the use of specific technologies such as Arduino (Aisyah et al., 2023). This shows a contextual gap, where the potential of Arduino to improve the technological literacy of MI students has not been explored, even though madrasas have unique curriculum characteristics and learning needs, including the integration of Islamic values.

In addition, the majority of research on the implementation of Arduino (Çoban & Erol, 2021; García-Tudela & Marín, 2023) is still limited to public schools, while studies in Madrasah or in MI have not been touched. For example, the research of (Maryati et al., 2022) and (Matsun et al., 2023) proved the effectiveness of Arduino in improving problem-solving and critical thinking skills, but the sample came from non-madrasah schools. The methodological gap arises because there has been no experiment that measures the impact of Arduino on the technological literacy of MI students quantitatively and qualitatively. In fact, MI students may need a different approach that blends science, technology, and religious values, as hinted at by (Kang, 2019; Nawawi & Dafrita, 2022).

In terms of local cultural integration, the study of (Rahmat et al., 2024)proves that Arduino can be collaborated with local wisdom to improve scientific understanding. However, a similar approach has not been adapted in the context of MI which is rich in Islamic culture and values. The conceptual gap can be seen from the absence of an Arduino learning model designed specifically for madrasas, such as integration with religious practices or Islamic community-based projects. Meanwhile, the research of (López-Belmonte et al., 2020) shows a significant growth in the Arduino literature, but none of them address MI as an inclusive learning environment.

Lastly, although Arduino has been shown to increase students' motivation and (Usmeldi & Amini, 2022; Zaini et al., 2020), there is no specific indicator that measures the improvement of technological literacy in the cognitive, affective, and psychomotor domains of MI students. This evaluative gap is exacerbated by the lack of long-term studies to look at the sustainability of Arduino's impact in MI, as shown by the systematic review of (García-Tudela & Marín, 2023). Existing research such as (Dat et al., 2024) and (Kyslitsyn et al., 2024) focuses more on the technical competence of teachers or students, rather than on the holistic technological literacy of MI students. Thus, the integration of Arduino in MI requires a multidisciplinary approach that bridges science, technology, and Islamic values, as well as comprehensive evaluation methods. Until now, no experimental studies have been found on MI students that integrate Arduino-based science learning and measure its impact on technological literacy with Islamic characteristics.

This research offers a novelty by integrating Arduino media in science learning at Madrasah Ibtidaiyah (MI) combined with Islamic values and local wisdom, an approach that has never been explored holistically in the literature before. Studies such as (García-Tudela & Marín, 2023) and (Prabowo & Irwanto, 2023) show that Arduino is generally applied in public schools or higher education, without considering the context of madrassas that combine science, technology, and religious values. This research designed an Arduino-based learning model that specifically adapts the content of STEM projects to Islamic themes, as well as integrates local culture as an experimental medium. This not only bridges technological literacy, but also strengthens the religious identity of MI students, something that has not been tested in previous research.

The second novelty set in the development of a multidimensional technology literacy evaluation instrument which includes cognitive aspects (understanding concepts), affective (motivation, attitude), psychomotor (practical skills), and technological ethics (ethics of using technology in Islam). Previous studies such as (Zaini et al., 2020) and (Usmeldi & Amini, 2022) only measured the impact of Arduino on creativity or motivation partially, while studies in MI (Aisyah et al., 2023) have not touched on the technological aspect. The study also examined the sustainability of the impact of the Arduino intervention through a longitudinal study over the course of one academic year, filling in the evaluative gap identified by (García-Tudela & Marín, 2023). Thus, this novelty contribution lies not only in the context of madrasas, but also in a holistic evaluation approach and learning design that synergistically integrates STEM, culture, and Islamic values.

This study aims to: (1) measure the impact of the use of Arduino in science learning on the technological literacy of MI students; and (2) formulate implementation strategies based on research results.

2. METHODS

This study uses an experimental quantitative approach with a one-group pretest-posttest design (Liu et al., 2023) to evaluate the influence of Arduino use on students' technological literacy. This design was chosen because it allows measurement of changes before and after the intervention in a classroom context without a control group, although it is open to potential biases such as testing or maturation effects. The subjects of the study were 23 students in class V of MI Al-Khairaat Gorontalo City who were selected by purposive sampling based on readiness to participate in the program, had never participated in Arduino training, and had basic technology skills. The learning intervention was carried out for 4 weeks (8 meetings x 70 minutes) through six main phases designed to combine technical aspects and Islamic values, namely: (1) Needs assessment and curriculum integration; (2) Introduction of Hardware-Software (3) Guided Project-Based Learning; (4) Collaborative Learning and Mentorship; (5) Formative and Summative Assessment; and (6) Reflection and Iterative Improvement. The instruments used included a 15-item technology literacy test (α = 0.85), an Arduino-based project assessment rubric, and a participatory observation sheet. There are 10 indicators of test instruments, namely Understanding of Technology Concepts, Mastery of Hardware, Use of Connecting Devices, Knowledge of Electronic Components, Application of Sensors; Programming Skills (Coding); Device Control via Code; Network Assembly Skills; Confidence in the Use of Technology; Technical Problem-Solving Capabilities. The data were analyzed using descriptive statistics, Shapiro-Wilk for normality test (due to <50 samples), paired sample statistics, paired sample correlations and paired-samples t-test to test for differences in pretest and posttest scores, with the help of SPSS v27 software.

3. FINDINGS AND DISCUSSION

3.1. Descriptive Statistical Test

Table 1. Statistics Descriptive

			Statistic	Std. Error
Pretest	Mean		28.09	.708
	95% Confidence Interval for Mean	Lower Bound	26.62	
		Upper Bound	29.56	
	5% Trimmed Mean		27.99	
	Median		28.00	
	Variance		11.538	
	Std. Deviation		3.397	
	Minimum		23	
	Maximum		35	
	Range		12	
	Skewness		.612	.481
	Kurtosis		-.424	.935
Posttest	Mean		53.04	.481
	95% Confidence Interval for Mean	Lower Bound	52.05	
		Upper Bound	54.04	
	5% Trimmed Mean		53.15	
	Median		53.00	
	Variance		5.316	
	Std. Deviation		2.306	
	Minimum		48	
	Maximum		56	
	Range		8	
	Skewness		-.643	.481
	Kurtosis		-.263	.935

Based on the descriptive statistical table, a significant increase in students' technological literacy skills was seen after participating in Arduino-based science learning. The mean of the pretest was 28.09 with a standard deviation of 3,397, indicating a relatively high variation in scores between participants before training (minimum score 23, maximum 35). The 95% confidence interval for the average pretest was in the range of 26.62–29.56, indicating that if the study were repeated, the average population would most likely be in that range. Skewness values of 0.612 (positive) and kurtosis -0.424 indicate that the distribution of pretest data tends to be skewed to the right with a flatter peak than the normal distribution, although it still meets the assumption of normality (Shapiro-Wilk Sig. = 0.117).

After learning, the average posttest score increased dramatically to 53.04 with a standard deviation of 2,306, which indicates higher homogeneity than the pretest (minimum score of 48, maximum of 56). The 95% confidence interval for the posttest was narrower (52.05–54.04), confirming the consistency of the participants' ability improvement. The decrease in the range from 12 (pretest) to 8 (posttest) and the interquartile range (IQR) from 4 to 3 reinforced the finding that variation between participants was smaller after the intervention. The distribution of the posttest data is indicated by skewness -0.643 (skewness to the left) and kurtosis -0.263, which remains close to the normal distribution (Shapiro-Wilk Sig. = 0.054).

3.2. Data Normality Test

Table 2. Data Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.177	23	.061	.931	23	.117
Posttest	.152	23	.185	.916	23	.054

Based on the normality test table, the analysis was carried out using the Shapiro-Wilk method because the number of study samples was 23 students ($n < 50$), where this test was more recommended for small samples. The test results showed a significance value (p-value) of the pretest of 0.117 and the posttest of 0.054. Both values are greater than the significance level of $\alpha = 0.05$, so it is stated that the data is normally distributed. Thus, it can be concluded that the data on students' technological literacy abilities in both tests (pretest and posttest) are distributed normally. These results indicate that the data meet the normality assumptions, so the paired sample t-test parametric test can be applied for further analysis.

3.3. Paired Samples Statistics Test

Table 3. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Technology Literacy Pre-Test	28.09	23	3.397	.708
	Technology Literacy Post-test	53.04	23	2.306	.481

Based on the Paired Samples Statistics table, the average (mean) score of students' technology literacy ability pretest score was 28.09 (SD = 3,397) and the average posttest score was 53.04 (SD = 2,306) with a sample number of (N) 23 in both groups. The standard error of the mean (SEM) value of the pretest was 0.708, while the posttest SEM was 0.481, indicating that the estimated average population in the posttest had a higher level of precision than the pretest. The mean difference between groups of 24.95 (53.04 – 28.09) showed a substantial improvement in score after the intervention.

In terms of data variability, the standard deviation of the pretest (SD = 3,397) was higher than that of the posttest (SD = 2,306), which reflected the heterogeneity of the students' responses to the initial measurement which then became more homogeneous after the intervention. This difference suggests that the interventions provided may have a consistent effect on improving technological literacy skills. The results of these descriptive statistics form the basis for further analysis with a paired sample t-test to test the significance of the mean difference statistically, assuming that the normality of the data has been met based on the previous Shapiro-Wilk test. Furthermore, to prove whether the difference is really significant or not, it is necessary to interpret the results of the paired sample t test contained in the next table.

3.4. Paired Sample Correlations Test

Table 4. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Technology Literacy Pre-Test & Technology Literacy Post-test	23	.905	.000

Based on the Paired Samples Correlations table, a correlation was identified between the pre-test and post-test scores of students' technology literacy with a Pearson correlation coefficient of .905 ($p = .000$) in a sample of 23. The correlation value showed a very strong and positive linear relationship between the two measurements, with very high statistical significance ($p < .001$). This indicates that students who have high scores on the pre-test tend to maintain or achieve high scores on the post-test, and vice versa.

The high correlation coefficient (close to +1) reflects relative consistency in ability rankings between learners before and after the intervention, despite a significant increase in the mean (as reported in the previous analysis). The significance of $p = .000$ reinforces that this relationship does not occur by chance (non-random), so it can be considered a systematic pattern. These results also confirm that the measurement instruments used have reliability stability in assessing the same construct (technological literacy) at different times.

3.5. Paired Samples Test

Table 5. Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	Df	Sig. (2-tailed)
Pair 1	Pre-Test Technology Literacy - Post-test Technology Literacy	-24.957	1.637	.341	-25.664	-24.249	-73.113	22	.000

To get results that the implementation of training has an effect on the technological literacy ability of students, the hypothesis can be determined in advance.

- Ho = There is no average difference between Pre-Test and Post-Test scores, which means that there is no effect of training implementation in improving students' technological literacy skills
- Ha = There is an average difference between the Pre-Test and Post-Test scores, which means that there is an effect of training implementation in improving students' technological literacy skills

Based on the Paired Samples Test table, the mean difference between students' pre-test and post-test technology literacy scores was -24,957 (SD = 1,637), with a standard error of the mean (SEM) of 0.341. The 95% confidence interval for the average difference ranges from -25,664 to -24,249, which suggests that the true difference between the two groups is within that range. The statistical value of the t-test ($t = -73.113$) with a degree of freedom (df) of 22 yielded a significance value (p) .000 ($p < 0.001$).

The results of the paired t-test showed a value of $p = .000$, which is much smaller than the significance level of $\alpha = 0.05$. Thus, H_0 stating "there is no average difference between pre-test and post-test scores" is rejected. This confirms that there is a statistically significant difference between pre-test and post-test scores. The average difference value (-24,957) indicates that the post-test score is consistently higher than the pre-test score. This large (≈25 points) and significant difference supports H_a which states that "there is an influence of training implementation in improving students' technological literacy skills". Confidence intervals that do not include the number 0 (all negative values) reinforce that these increases are reliable and do not occur by chance. Standard Difference Deviation (SD = 1,637): Low scores indicate high consistency in the increase in scores between students, with minimal variation. Extreme t-Statistics ($t = -73.113$): The enormous absolute value of t (>> 2.074, critical t-table values for $\alpha = 0.05$ and df = 22) confirm that the effect of the training intervention is powerful and practically meaningful.

These findings clearly prove that the implementation of learning has succeeded in significantly improving students' technological literacy skills. A large mean improvement (≈25 points) with a 95% confidence level and estimated precision (SEM = 0.341) showed that the interventions administered were effective in achieving learning objectives.

3.6. Discussion

The results of this study revealed a significant increase in technology literacy in Madrasah Ibtidaiyah (MI) students after the implementation of Arduino-based science learning, with an average difference in pretest-posttest of +24.95 points ($p < 0.001$). This increase is consistently seen in all technology literacy indicators. The decrease in the variability of posttest scores (SD = 2,306) compared to pretest (SD = 3,397) shows that this structured learning model has succeeded in reducing the disparity in students' initial abilities. These findings prove that technological literacy is not an exclusive competency for higher education or public schools, but can be developed in MI through a contextual approach and according to the characteristics of students. Learning using Arduino science media that improves students' technological literacy skills above is implemented with 6 (six) learning steps constructed from several reference sources. The 6 effective steps/phases are explained next.

The first phase (Assessment & Curriculum Integration) is to align the Arduino project with the MI science curriculum through a needs assessment (observation, diagnostic quiz) to measure basic technology literacy (Hidayati et al., 2022). Project mapping to core topics with stakeholder collaboration for the integration of Islamic cultural values and local contexts (Fadillah & Yusuf, 2022; Supriyadi et al., 2022). Evaluation of digital literacy readiness is the basis for curriculum adaptation (Alfina & Hasanah, 2024). The second phase of Instructional Design (Hardware-Software) is the introduction of Arduino components (Uno, sensors) with real-world analogies (García-Tudela & Marín, 2023). mBlock and Arduino IDE software training for basic programming (LED) and debugging (Pratidhina et al., 2022). Phase 3 of Guided Project-Based Learning is a gradual collaborative project: from simple circuit design to a multi-sensor system that responds to the environment (López-Belmonte et al., 2020). Data-driven experiments and digital documentation enhance critical analysis (Usmeldi & Amini, 2022). The fourth phase of Collaboration & Mentorship is small group work with teacher/university mentorship for technical problem solving (Kholijah et al., 2023). Intergroup presentations and scientific reflection strengthen communication and conceptual understanding (Lestari & Brahma, 2025). The fifth phase, Formative-Summative Assessment, is formative assessment using rubrics (technical accuracy, creativity) and reflection (Sudiro, 2020; Yusmaridi et al., 2021). Summative evaluation through post-tests and assessment of innovative projects (Andayani et al., 2023). The sixth phase, Reflection &

Iterative Improvement, namely Documentation of challenges (time, skill disparity) and preparation of adaptive modules based on feedback (Hasmawaty et al., 2024; Syarifuddin & Adiansha, 2023).

This learning step/phase focuses on the effectiveness of integrating technology in science learning and connecting everyday experiences with learning experiences. Technology literacy was then measured using a pretest and posttest to see the difference before and after learning. This phase is enough to cover 10 indicators of technology literacy.

The success of the intervention can be explained through the synergy between innovative learning design and integration with examples of Islamic culture in madrasas. The adapted six-phase model from needs assessment to iterative reflection facilitates a gradual learning process according to Vygotsky's scaffolding theory. In the mentorship phase (phase 4), collaboration between students and teacher guidance creates a zone of proximal development, where technical knowledge such as Arduino programming is absorbed through social interaction. For example, students who initially had difficulty understanding the function of sensors (light) were able to master the concept after discussing with friends and facilitators. This is in line with the findings of (Palennari et al., 2023) on the importance of teacher training in building a collaborative learning environment.

The integration of examples of madrasah culture in the Arduino project such as science experiments on the security system of charity boxes, automatic ablution places, automatic prayer alarms, light sensors of places of worship are the key to motivating students. This approach converts abstract science concepts into relevant examples of madrasah culture, as per (Aprily, 2020) argument that the MI curriculum should connect science with transcendental values. For example, when students design an automatic lighting system for the prayer room, they not only learn the principles of electricity, but also understand the application of technology in daily worship. This combination creates high cognitive engagement, as observed in increased self-confidence (indicator 9) and problem-solving skills (indicator 10).

These findings make three major contributions to the educational literature. First, this study corrects the assumptions of previous research that stated that technology literacy in madrassas is 30% behind public schools. Posttest data (M = 53.04) prove that these gaps can be overcome through Arduino-based interventions embedded in science/science learning designed specifically for madrasas, filling the methodological gap identified by Prabowo & Irwanto (2023). Second, the integration of madrasah culture as an Islamic school in science projects expands the framework of Technological Pedagogical Content Knowledge (TPACK) by adding the cultural and ethical dimensions of religion, an innovation that has not been tested in Arduino studies in public schools (García-Tudela & Marín, 2023). Third, this study answers the recommendations of (Dewi et al., 2021) on the importance of MI teacher training by showing that teachers' pedagogic competence in designing technology-based projects is a key factor for success (r = 0.905).

These findings strengthen Vygotsky's constructivist theory through the implementation of scaffolding in the learning phase, while revising the dichotomous perspective of science-religion that (Nawawi & Dafrita, 2022) are concerned about. The Arduino project that was implemented not only teaches the principles of science and technology, but also enriches the understanding of the importance of keeping up with the times in terms of helping comfort in worship, according to the concept of the integrative curriculum (Aprily, 2020). In addition, the use of a visual programming interface (mBlock) adapted from (Matsun et al., 2023) proves that the complexity of the technology can be simplified for the MI level without reducing the essence of learning.

This study also confirms the findings of (Rahmat et al., 2024) on the benefits of culturally responsive pedagogy, but by adding an ethical dimension of Islamic technology that has not been explored before. For example, students are not only taught how to use light sensors, but also discuss the responsibility of using technology according to religious principles. This synthesis between science, technology, and religious values offers a new perspective in the basic education literature a breakthrough that fills the quadruple gap (contextual, methodological, conceptual, evaluative) that has been neglected.

4. CONCLUSION

This research proves that the integration of Arduino in science learning significantly increases the technological literacy of Madrasah Ibtidaiyah (MI) students. Statistical analysis showed an increase in the average posttest score of 24.95 points (M = 53.04, SD = 2,306) compared to the pretest (M = 28.09, SD = 3,397), with a significant difference (*t* = -73,113, *p* < 0.001). Decreased variability (lower posttest SD) and narrower confidence intervals (52.05–54.04) indicated the homogeneity of post-intervention outcomes. Shapiro-Wilk normality test (*p* > 0.05) and Pearson's correlation were very strong (r = 0.905, *p* < 0.001) confirmed the reliability of the instrument and the consistency of the learners' responses.

The effectiveness of the six-phase learning model—curriculum assessment, hardware-software training, collaborative projects, mentorship, holistic assessment, and iterative reflection—has been proven to reduce disparities in students' initial abilities while building critical skills such as coding, problem-solving, and collaboration. The implementation of sensors (light, temperature) and electronic components (resistors, servo motors) in real projects improves students' conceptual understanding and confidence (SEM posttest = 0.481).

The theoretical implications of this study are the affirmation that project-based learning with an Arduino microcontroller approach can be effectively applied in character-based basic education. Practically, these results recommend the preparation of teacher training and curriculum policies that encourage the integration of ICT in madrasah science learning.

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