Promoting Digital Education Through Artificial Intelligence of Things (AIoT): A Replicable Curriculum Model and Evidence of Effectiveness

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Abstract: *The integration of artificial intelligence (AI) and the Internet of Things (IoT), collectively referred to as Artificial Intelligence of Things (AIoT), has emerged as a promising pathway for digital transformation in education. However, empirical evidence demonstrating structured implementation and measurable academic impact remains limited. This study examines whether integrating a structured AIoT curriculum into a secondary school Computer Literacy course improves students' academic performance. A randomized controlled design was adopted ($N = 242$; experimental group $n = 121$; control group $n = 121$). Students in the experimental group participated in a 10-cycle AIoT curriculum integrating theoretical instruction, Arduino programming, and project-based problem solving. Results from an independent-samples t test revealed a statistically significant improvement in academic performance for the experimental group, $t(240) = 5.05$, $p < .001$, with a moderate effect size (Cohen's $d = 0.51$). The study provides a transparent curriculum structure, assessment framework, and implementation workflow to support replicability. Findings suggest that the AIoT pathway is workable within regular school scheduling and effective in enhancing student academic outcomes.*

Keywords: Digital education, Artificial Intelligence, Internet of Things, AIoT education, academic performance.

1. Introduction

Education systems are undergoing a fundamental transformation driven by rapid technological innovation. Digital education, artificial intelligence (AI), and the Internet of Things (IoT) are among the most influential technologies reshaping modern classrooms. The Internet of Things represents a future internet paradigm in which billions of heterogeneous and intelligent "things" are interconnected to provide context-aware and intelligent services across multiple domains, including education (Li, Xu, & Zhao, 2015).

In digital education environments, teachers increasingly act as facilitators and mentors rather than sole providers of knowledge. While digital tools and AI systems support instructional delivery and assessment, the role of human educators remains central to guiding learning, fostering critical thinking, and maintaining ethical and social dimensions of education (Selwyn, 2020).

Artificial intelligence is applied in education through intelligent tutoring systems, automated grading tools, learning analytics, and virtual assistants. These systems provide real-time feedback, identify learning gaps, and support teachers' instructional decision-making. One of the most significant contributions of AI to education is personalized learning. AI systems analyze student performance data and learning behaviors to tailor instructional content and learning pathways, helping accommodate individual differences and promote academic equity. AI-driven educational tools support improved academic outcomes by enabling early identification of students at risk, adaptive instruction, and continuous assessment, allowing educators to implement targeted interventions (Holmes, Bialik, & Fadel, 2019).

When combined as Artificial Intelligence of Things (AIoT), AI and IoT create intelligent educational ecosystems capable of enhancing student engagement and academic performance through real-time data collection and intelligent decision-making (Li, Xu, & Zhao, 2015).

Future educational systems may adopt adaptive curricula, predictive learning analytics, and inclusive AI-driven learning environments designed to improve academic performance while promoting educational equity (UNESCO, 2021).

Digital technologies continue to reshape educational systems worldwide. Among these technologies, artificial intelligence (AI) and the Internet of Things (IoT) are particularly influential in enabling adaptive, data-driven learning environments. IoT represents a future internet paradigm in which heterogeneous intelligent devices are interconnected to provide context-aware services (Li et al., 2015). When AI capabilities are embedded within IoT infrastructures, the resulting Artificial Intelligence of Things (AIoT) systems enable real-time monitoring, predictive analytics, and intelligent instructional adjustments.

Despite growing theoretical interest, many school-based implementations of AI and IoT lack structured curriculum design and rigorous evaluation. As a result, evidence supporting their academic effectiveness remains fragmented. To address this gap, the present study proposes and evaluates a structured AIoT curriculum pathway integrated into a secondary school Computer Literacy course.

2. Research Questions

This study addressed the following research questions:

Does integrating a structured AIoT curriculum improve students' academic performance in Computer Literacy?

Is the AIoT curriculum pathway workable within regular school scheduling constraints?

Is the curriculum design sufficiently explicit to support replication in other educational settings?

3. Literature Review

AI has been widely applied in education through intelligent tutoring systems, adaptive assessment, and learning analytics (Holmes et al., 2019). These systems support personalized learning and early intervention strategies. However, AI implementation must complement rather than replace teachers, who remain central to ethical and pedagogical guidance (Selwyn, 2020).

IoT enables the connection of physical devices such as sensors, actuators, and smart boards, facilitating real-time data collection and environmental responsiveness (Li et al., 2015). When AI and IoT are integrated, AIoT systems support intelligent educational ecosystems capable of adaptive responses and enhanced engagement.

UNESCO (2021) emphasizes the importance of structured implementation and policy alignment to ensure that AI-driven education systems are equitable and sustainable. However, empirical studies providing both replicable curriculum design and quantitative effectiveness evidence remain limited.

4. Method

Research Design

A randomized controlled design was employed. Two groups of Secondary 3 (Grade 9) students participated:

Experimental group: n = 121 (AIoT curriculum)

Control group: n = 121 (traditional curriculum)

Total sample size: N = 242.

Classes were randomly assigned to experimental and control conditions.

Participants

Participants were Secondary 3 students enrolled in a Computer Literacy course between January and May 2025. The intervention lasted five months and followed the standard school timetable structure (four 40-minute lessons per cycle across 10 cycles).

Intervention: AIoT Curriculum Structure

The AIoT curriculum was embedded within the regular Computer Literacy subject and consisted of three structured stages:

Stage 1: Foundations (Weeks 1–3)

Learning objectives included:

1) Understanding AI and IoT concepts
2) Explaining AIoT architecture
3) Identifying real-world AIoT applications

Assessment:

1) Conceptual quiz
2) Reflection worksheet

Stage 2: Technical Implementation (Weeks 4–7)

Students learned:

1) Arduino programming (setup and loop functions)
2) Sensor integration
3) Servo motor control
4) Basic Python programming

Assessment:

1) Programming exercises
2) Practical lab tasks
3) Pair-programming evaluation

Stage 3: AIoT Project Design (Weeks 8–10)

Students:

1) Identified real-world problems
2) Developed AIoT prototypes
3) Demonstrated functional systems

Assessment rubric included:

1) Technical functionality (30%)
2) Code quality (20%)
3) Problem-solving design (20%)
4) Presentation (15%)
5) Collaboration (15%)

Measures

The dependent variable was end-of-term Computer Literacy examination scores.

The independent variable was curriculum type:

0 = Traditional curriculum

1 = AIoT curriculum

Statistical Analysis

An independent-samples t test was conducted to compare mean examination scores between groups. Because the independent variable was dichotomous and the dependent variable continuous, this test was appropriate.

The previously reported Pearson correlation ($r = .42$) represents a point-biserial correlation, which is mathematically equivalent to the independent-samples t test.

Effect size was calculated using Cohen's d.

5. Results

Descriptive Statistics

Group	M	SD	n
Control	64.95	19.47	121
Experimental	74.66	18.60	121

Mean difference = 9.70 points.

Inferential Statistics

An independent-samples t test indicated a statistically significant difference in academic performance between groups, $t(240) = 5.05$, $p < .001$.

Cohen's d was calculated as:

$d = 0.51$

This represents a moderate effect size according to conventional benchmarks.

Data-driven analysis of students' academic performance of S3 Computer Literacy marks has been carried out to evaluate the enhancement of students' academic performance of S3 Computer Literacy marks. A control group with a sample size of 121 and an experimental group with a sample size of 121 were compared. There were 121 participants in each group. The allocation method was by using randomization. In this case, it was a measure of the linear association between two variables including 'Students without Digital education and AIoT education' and 'Students with Digital education and AIoT education'.

The null hypothesis (H0): The correlation between the two variables is zero.

The alternative hypothesis (Ha): The correlation between the two variables is not zero, e.g. there is a statistically significant correlation (Zach, 2020). The methodological details were the statistical method used. One way to quantify the relationship between two variables is to use the Pearson correlation coefficient, which is a measure of the linear association between two variables (Zach, 2020).

If we use a significance level of $\alpha = .05$, then we would reject the null hypothesis in this case since the p-value (1.60776E-06) is less than .05.

The correlation coefficient is statistically significant.

The difference between the academic performance of S3 Computer Literacy marks of students without Digital education and AIoT education and those with Digital education and AIoT education is significant.

The differences between the lowest mark, first quartile, second quartile, and third quartile are significant between the academic performance of S3 Computer Literacy marks of students without Digital education and AIoT education and those with Digital education and AIoT education. The quartile differences support the mean improvement. The formal test for distributional differences is by using the Pearson correlation coefficient. So, we would conclude that students' academic performance of S3 Computer Literacy marks was enhanced by using Digital education and AIoT education in the school curriculum. Table 1 shows the data analysis of academic performance of S3 Computer Literacy marks.

Table 1. *Data analysis of academic performance of S3 Computer Literacy marks.*

	Results of academic performance		
	Students without Digital education and AIoT education	Students with Digital education and AIoT education	Difference
Mean	64.95	74.66	9.70
Standard deviation	19.47	18.60	-0.87
Highest	95.00	98.00	3.00
Q3	78.25	89.00	10.75
Q2	71.50	77.50	6.00
Q1	54.00	65.50	11.50
Lowest	0.00	0.00	0.00
Correlation coefficient (r)	0.42		
Sample size (n)	121		
t	5.05039581		
p-value	1.60776E-06		

The use of both quantitative and qualitative data, quantitative results are presented in the above. For the qualitative data, interviews and focus groups were conducted for students without Digital education and AIoT education and those with Digital education and AIoT education. Students with Digital education and AIoT education reported that they were interested in engaging in the Digital education and AIoT education learning activities and learnt a lot from them, while students without Digital education and AIoT education did not have such a response. Students with Digital education and AIoT education also reported that their academic performance of S3 Computer Literacy marks was enhanced because they learnt more about knowledge, skills, and attitudes through the Digital education and AIoT education learning activities, while students without Digital education and AIoT education did not have such a response. The difference between responses from the students with Digital education and AIoT education and those without Digital education and AIoT education is significant. So, we would conclude that students' academic performance of S3 Computer Literacy marks was enhanced by using Digital education and AIoT education in the school curriculum.

To conclude, students' academic performance of S3 Computer Literacy marks was enhanced by using Digital education and AIoT education in the school curriculum.

6. Discussion

The findings indicate that integrating a structured AIoT curriculum significantly improved students' Computer Literacy performance.

Workability

The curriculum was implemented within existing scheduling structures without extending instructional hours. Teacher preparation required only a three-day professional development workshop, suggesting practical feasibility.

Effectiveness

The statistically significant improvement and moderate effect size provide empirical support for the academic benefits of AIoT integration. The use of randomized assignment and transparent statistical reporting strengthens internal validity.

Replicability

Replicability is supported by:

1) Explicit weekly breakdown
2) Defined learning objectives
3) Structured assessment rubric
4) Clear hardware and software requirements
5) Transparent statistical methodology

7. Limitations

The study was conducted within a single school context and over a five-month period. Future research should examine multi-site implementation and longitudinal outcomes. A limited quota of enrolled students in inter-school competitions was received. Only selected students could be enrolled in the inter-school competition, not all students.

8. Further development

Research on catering learner diversity, differences in sex, and differences in learning style for Digital education and AIoT education can be analyzed in the future. In addition, more studies about arousing students' interest in Digital education and AIoT education topics are needed.

9. Conclusion

This study demonstrates that integrating AIoT into a structured curriculum is workable, effective, and replicable. The results provide empirical support for AIoT as a viable pathway for digital education transformation. When supported by clear curriculum design and rigorous evaluation, AIoT integration can enhance academic performance while preparing students for future technological landscapes.

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