Using Artificial Intelligence and Internet of Things (AIoT) in the School Curriculum to Enhance Students' Academic Performance

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Abstract: *This comprehensive study examines the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in educational settings, collectively termed AIoT. This research explores how AIoT can enhance students' academic performance through personalized learning experiences, improved engagement, real-time feedback, and collaborative learning environments. The analysis includes theoretical frameworks, benefits, challenges, practical applications, case studies, and future directions for implementing AIoT in school curricula. This study evaluates the effectiveness of AIoT education in curriculum in the way of academic performance. The broader implications show that the study focuses on the generalization of AIoT education in the curriculum of Computer Literacy, different teaching methods for AIoT education in the school curriculum can enhance students' academic performance.*

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

1. Introduction

In recent years, the educational landscape has undergone significant transformation due to technological advancements. Traditional teaching methodologies are increasingly being supplemented or replaced by digital tools that cater to diverse learning styles and paces. Among these innovations, the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) has emerged as a powerful force, capable of reshaping educational practices and enhancing academic performance. AIoT refers to the integration of AI technologies with IoT devices, creating an interconnected network that can collect, analyze, and act on data in real-time. In educational settings, this combination can provide personalized learning experiences, optimize classroom management, and enhance collaboration among students and educators. AIoT applications in education include smart classrooms, adaptive learning platforms, and real-time feedback systems that facilitate effective learning environments. This research aims to explore the potential of AIoT in the school curriculum, focusing on its impact on academic performance. It will delve into the theoretical underpinnings, practical applications, benefits, challenges, and future directions of AIoT in education. By analyzing various aspects of AIoT implementation, this study seeks to provide educators, policymakers, and stakeholders with insights into how to effectively leverage these technologies to enhance learning outcomes. In computer literacy lessons, students learned Artificial Intelligence (AI) and Internet of Things (IoT) education. Despite the emergence of AIoT as a popular pedagogical approach for enhancing students' creativity, problem-solving skills, and interest in AIoT fields, the definitions and purposes of AIoT education remain ubiquitous. Therefore, the review examined descriptions of the overall purpose of AIoT education. Leading expert in the application of AI in education proposed a framework for understanding the complexity of human intelligence by identifying the comparative limitation of AI when analysed using the same framework, and offers clear-sighted recommendations for how educators can draw on what AI does best to nurture and expand our human capabilities (Luckin, 2017). While integrating artificial intelligence (AI) into education brings benefits to the education landscape, there are also significant risks. To fully utilize AI's technological innovation for educational purposes, ethical considerations must be taken into account (Micheni et al, 2024). The effectiveness of AI-driven

educational tools and assess their implications for students, educators, and institutions had been analysed (Degni, 2024). However, the effect on the enhancement of students' academic performance by using AIoT education in the school curriculum was not mentioned in the research. So, this study evaluates the effectiveness of AIoT education in curriculum in the way of students' academic performance.

In the current situation, many secondary schools open AI courses or IoT courses as cross-curricular activities (CCA) because it is not a must to put into curriculum. However, in order to let AIoT education become generalized, we offer AIoT education in the S3 curriculum of computer literacy subject starting in January 2024 and ending in May 2024 with the cooperation and collaboration with AIphotonics Limited to promote AIoT education. Data-driven analysis of students' academic performance of S3 Computer Literacy marks enables the research to confirm the enhancement of students' academic performance of S3 Computer Literacy marks. A comprehensive approach was used by utilizing both quantitative and qualitative data to assess the impact of AIoT education on students. Methodological choices were based on a fair comparison between two groups, including a group of students with AIoT education and another group of students without AIoT education. The result is impressive and persuasive by comparing the data from these two groups. Pedagogical strategies used within the AIoT curriculum, including catering for learner diversity by using enhancement class, pair-programming, self-directed learning, cooperative learning, and inquiry learning, can facilitate students to develop their ideas and foster students' interest in and positive attitudes towards the AIoT curriculum. These strategies let students enjoy learning and contribute to students' performance enhancement.

2. Scope of AIoT education curriculum

In Figure 1, the AIoT education curriculum performed in S3 includes teaching concept of AIoT education, Introduction to AIoT education and Basic Electronic, Setup function and loop function and button states, Robotic arm kit, Metal arm assembly with base, Robot claw, 4 servo motors, Enhanced Arduino microcontroller platform with a serial bus architecture, Detached RGB camera, LCD colour monitor, Microphone and speaker, Transformer, Joy-stick components, Miscellaneous objects for robot arm manipulation, and Circuit board to support Python programming.

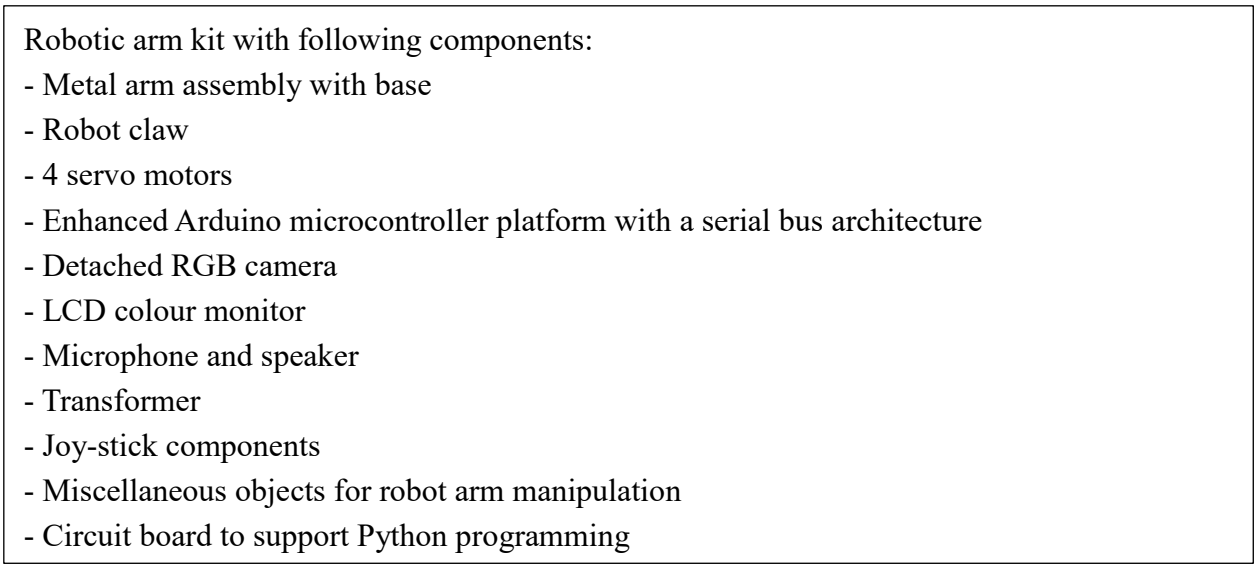


Figure 1.

In regular lessons, teachers use teaching materials and online resources provided by AIphotonics Limited to facilitate students' learning of AIoT education and promote AIoT education.

3. Timeline of AIoT education curriculum

3.1. Curriculum within regular AIoT education course

By referring to Figure 2, before starting to learn concepts of AIoT education and text-based programming (Python) in S3, students in S1-S3 are required to learn basic concepts of databases, multimedia, and block programming.

Students in S3 learn AIoT education in three stages. First, teachers teach theoretical concepts of AIoT education. Second, students learn text-based programming language for Arduino. At the final stage, students are asked to design a solution to solving daily problems by using AIoT education concepts.

3.2. Enhancement class outside curriculum

By referring to Figure 3, after learning the curriculum stated in section 2.1, top 16 students are chosen to take enhancement class for building useful application based on their designs.

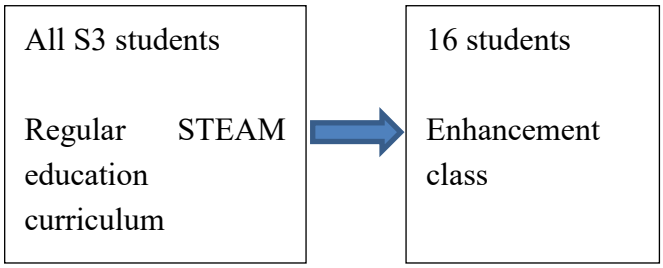


Figure 3.

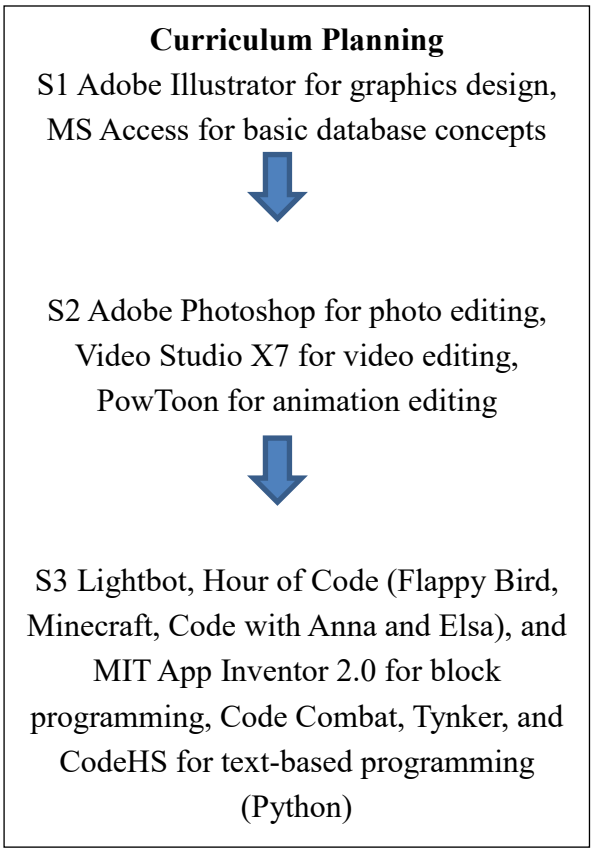


Figure 2.

Sixteen students in the enhancement class have applied the knowledge and skills of AIoT education to enrol in interschool competitions. They have got awards including:

(1) GWIN 2024 Smart City E&M IoT Application Challenge - Secondary School Category - Champion

(2) GWIN 2024 Smart City E&M IoT Application Challenge - Secondary School Category - Judges Commendation Award

(3) Smart Logistics (Bay Area Hong Kong Centre, Consultative Committee on Guangdong-Hong Kong Co-operation (Guangzhou Nansha)) - Hong Kong Division - Secondary School Group - Bronze Award

(4) Science Talent Cup (Secondary Division) - STEM Education Challenge 2024 - Merit Awards

(5) HKUSPACE Certificate for module (cloud computing elements) - 1 Merit, 4 Distinction

(6) "0 Bullying" Hong Kong Electric Painting Competition - Youth Category - 2rd Runner-up

(7) “XR Travel across Major Fields of National Security” Design Competition (Hong Kong Subsidized Secondary Schools Council) - Second Prize: trophy, certificates and $500 book coupons

(8) The 14th IEEE Integrated STEM Education Conference at Princeton University as shown in Figure 4 to Figure 11.

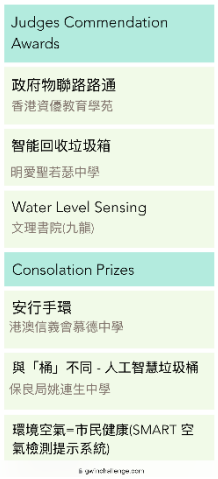


Figure 4.

GWIN 2024 Smart City E&M IoT Application Challenge, Secondary School Category, Champion

Figure 5.

GWIN 2024 Smart City E&M IoT Application Challenge, Secondary School Category, Judges Commendation Award

Figure 6.

Smart Logistics (Bay Area Hong Kong Centre, Consultative Committee on Guangdong-Hong Kong Co-operation (Guangzhou Nansha)), Hong Kong Division, Secondary School Group, Bronze Award

Figure 7.

Science Talent Cup (Secondary Division) - STEM Education Challenge 2024, Merit Awards

Figure 8.

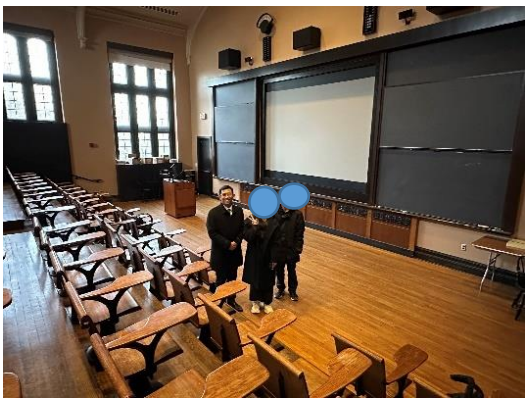
HKUSPACE Certificate for module (cloud computing elements), 1 Merit, 4 Distinction

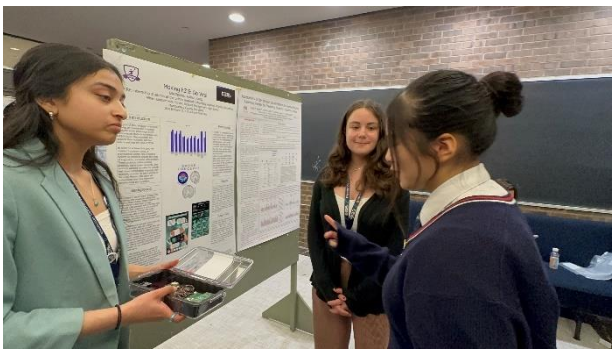
Figure 9.

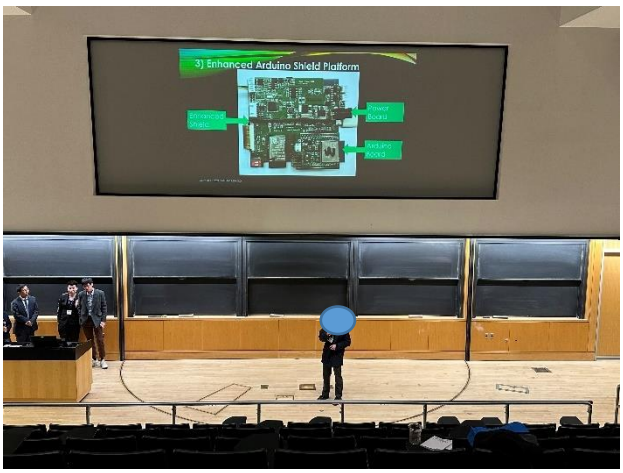
"0 Bullying" Hong Kong Electric Painting Competition, Youth Category, 2rd Runner-up

Figure 10.

“XR Travel across Major Fields of National Security” Design Competition (Hong Kong Subsidized Secondary Schools Council), Second Prize: trophy, certificates and $500 book coupons







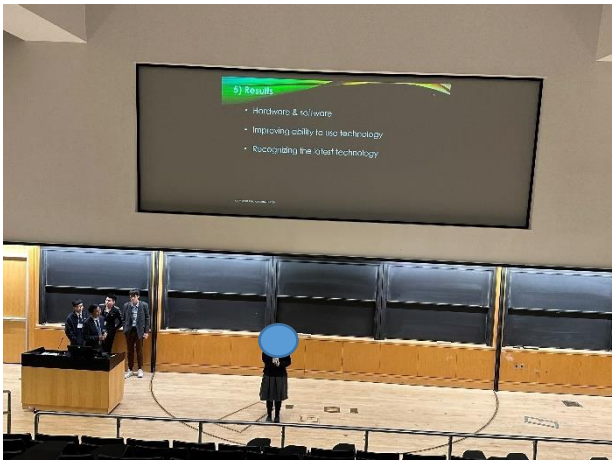


Figure 11. The 14th IEEE Integrated STEM Education Conference at Princeton University

4. Teacher training

Before teaching regular classes, 3-day training section was arranged for teachers to learn concepts of AIoT education and how to perform simple functions of sensors and servos, which are the AIoT education components controlled by microcontroller using Arduino.

5. Strategy of teaching and learning

In teaching AIoT education theoretical concepts, self-directed learning is emphasised, where students receive a preview worksheet and video before lessons, allowing them to engage with new knowledge outside the classroom. This preparation enables teachers to focus class time on assimilating knowledge through discussions and debates. Pair programming is implemented to address learner diversity in coding with Arduino, pairing higher-ability students with those needing support to foster mutual learning. Cooperative and inquiry-based learning approaches are utilized in projects, such as building a robotic arm kit, where students present and assess each other's work to create new knowledge collaboratively. Groups are tasked with developing ideas for using AIoT technology to solve real-world problems, requiring them to discuss, analyze, and design solutions, culminating in a demonstration.

The integration of AI in lessons by using pedagogical methods such as constructivism, differentiated instruction, and project-based learning emphasise active engagement and tailored approaches to diverse student needs. Strategies like scaffolding, cooperative learning, and direct instruction facilitate understanding and collaboration, while gamification and technology integration enhance motivation and access to resources. Tools like learning management systems (e.g., Google Classroom), interactive whiteboards by mirroring iPad using AirServer, and multimedia resources support dynamic teaching and assessment. By combining these approaches, students' academic performance of S3 Computer Literacy marks was enhanced by using AIoT education in the school curriculum.

6. Participants

This research starts in January 2024 and ends in May 2024. Only five teachers are involved in the teaching. There are four computer literacy lessons (40 minutes each) in each cycle (ten school days in one cycle). There is a total of 112 participants who are S3 students from four classes.

7. Response and Performance of Students

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 112 and an experimental group with a sample size of 112 were compared. There were 112 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 AIoT education' and 'Students with 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 (1.92084E-05) is less than .05.

The correlation coefficient is statistically significant.

The difference between the academic performance of S3 Computer Literacy marks of students without AIoT education and those with 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 AIoT education and those with 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 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 AIoT education	Students with AIoT education	Difference
Mean	64.95	84.68	19.72
Standard deviation	19.47	13.59	-5.89
Highest	95.00	100.00	5.00
Q3	78.25	94.00	15.75
Q2	71.50	89.00	17.50
Q1	54.00	78.00	24.00
Lowest	0.00	11.00	11.00
Correlation coefficient (r)	0.39		
Sample size (n)	112		
t	4.468477613		
p-value	1.92084E-05		

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 AIoT education and those with AIoT education. Students with AIoT education reported that they were interested in engaging in the AIoT education learning activities and

learnt a lot from them, while students without AIoT education did not have such a response. Students with 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 AIoT education learning activities, while students without AIoT education did not have such a response. The difference between responses from the students with AIoT education and those without AIoT education is significant. So, we would conclude that students' academic performance of S3 Computer Literacy marks was enhanced by using AIoT education in the school curriculum.

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

8. Limitation

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.

9. Further development

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

10. Conclusion

In this study, we focus on the generalization of AIoT education in the curriculum of Computer Literacy. We successfully adopt different teaching methods for AIoT education in the school curriculum. It is found that the students' academic performance of S3 Computer Literacy marks has been enhanced. More studies on the generalization of AIoT education in education are needed in the future.

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