How to Promote STEM Education by Using Internet of Things (IoT) Education in School Curriculum

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Introduction

- Students learned Internet of Things (IoT) technology in computer literacy lessons. The Internet of things (IoT) describes physical objects (or groups of such objects) with sensors, processing ability, software and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks by Gillis, Alexander (2021).
- The rise of “Internet of Things” is discussed by Shafiq, Muhammad; Gu, Zhaoquan; Cheikhrouhou, Omar; Alhakami, Wajdi; Hamam, Habib (3 August 2022).

- In current situation, many secondary schools open IoT courses as cross-curricular activities (CCA) because it is not a must to put IoT into curriculum.
- However, in order to let IoT education become generalized, we offer IoT education in S3 curriculum of computer literacy subject from Jan 2022 to May 2022 with the cooperation and collaboration with Alphotonics Limited to promote STEM education.
- The term “STEM education” refers to teaching and learning in the fields of science, technology, engineering, and mathematics.
- It typically includes educational activities across all grade levels—from pre-school to post-doctorate—in both formal (e.g., classrooms) and informal (e.g., afterschool programs) settings by Heather B. Gonzalez; Jeffrey J. Kuenzi (2012).

Scope of IoT curriculum

Introduction to IoT and Basic Electronic

Setup function and loop function and button states

PIR sensor tester

BH1750 Light Sensor

Connect device to Wi-Fi network with IP Address

Real time clock and relay

Serial Monitor and I2C bus on MCU

POC of the IoT Smart Light Switch

Timeline of IoT curriculum

Curriculum Planning

S1 Adobe Illustrator for graphics design, MS Access for basic database concepts

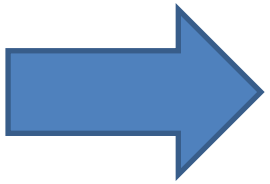
S2 Adobe Photoshop for photo editing, Video Studio X7 for video editing, PowToon for animation editing

S3 Lightbot, Hour of Code (Flappy Bird, Minecraft, Code with Anna and Elsa), and MIT App Inventor 2.0 for block programming, Code Combat, Tynker, and CodeHS for text-based programming (Python)

Enhancement class outside curriculum

All S3 students

Regular IoT curriculum



2 students

Enhancement class

Two students in enhancement class have built a STEM Smart Campus IoT Smart Light Switch.

They use it to enroll in competitions.

Junior Secondary School Category
Excellence Award
in "SHKP Read Good Books" X "Future Engineer Competition" with
Topic: Tech Ideas to Improve Lives


新地齊讀好書 x 未來工程師大賽
初中組優秀獎
IoT Smart Light Switch
文理書院(九龍)
潘苑寧
2022年
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Two students also use the STEM Smart Campus IoT Smart Light Switch to enroll in another competition.

Secondary School Category Judges Commendation Awards:
Certificate and Cash HK$1,000 each
in "Smart@GWIN" E&M IoT Application Challenge


智在Gwin
物聯網機電應用挑戰賽
EMSD
中學組
CCK IoT Team
馬子謙
評審嘉許獎
彭耀雄
機電工程署署長
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CASH
HK $

In this academic year, two students also use the STEM Smart Campus IoT Smart Light Switch to enroll in another competition.

Senior Secondary Division
Mathematics and Engineering
Merit Award
The 25th Hong Kong Youth Science & Technology Innovation Competition 2022-2023 organized by Hong Kong New Generation Cultural Association


合辦：
香港科技園 HKSTP
主辦：
香港新一代文化協會
Hong Kong New Generation Cultural Association
專項獎贊助：
EMERSON
香港檢測和認證局
The Hong Kong Council for Testing and Certification
職業安全健康局
Occupational Safety & Health Council
第25屆香港青少年科技創新大賽
25th Hong Kong Youth Science & Technology Innovation Competition
香港特別行政區教育局委託香港新一代文化協會主辦
Commissioned by Education Bureau, HKSAR


第25屆香港青少年科技創新大賽
高中組數理及工程
優異獎
主辦：
香港新一代文化協會
二零二三年四月

Teacher training

- Before teaching regular classes, 3 days training section was arranged to teachers for learning concepts of IoT and how to perform simple functions of motion sensor and light sensor which are the IoT components controlled by microcontroller using Arduino.

Strategy of teaching and learning

- (1) When teaching IoT theorical concept, self-directed learning is usually used. Students are given preview worksheet with video to do the preview before lessons starts. Students gain first exposure to new knowledge outside classrooms by reading or watching videos so that teachers can use class time to do work of assimilating that knowledge through discussion, or debates.

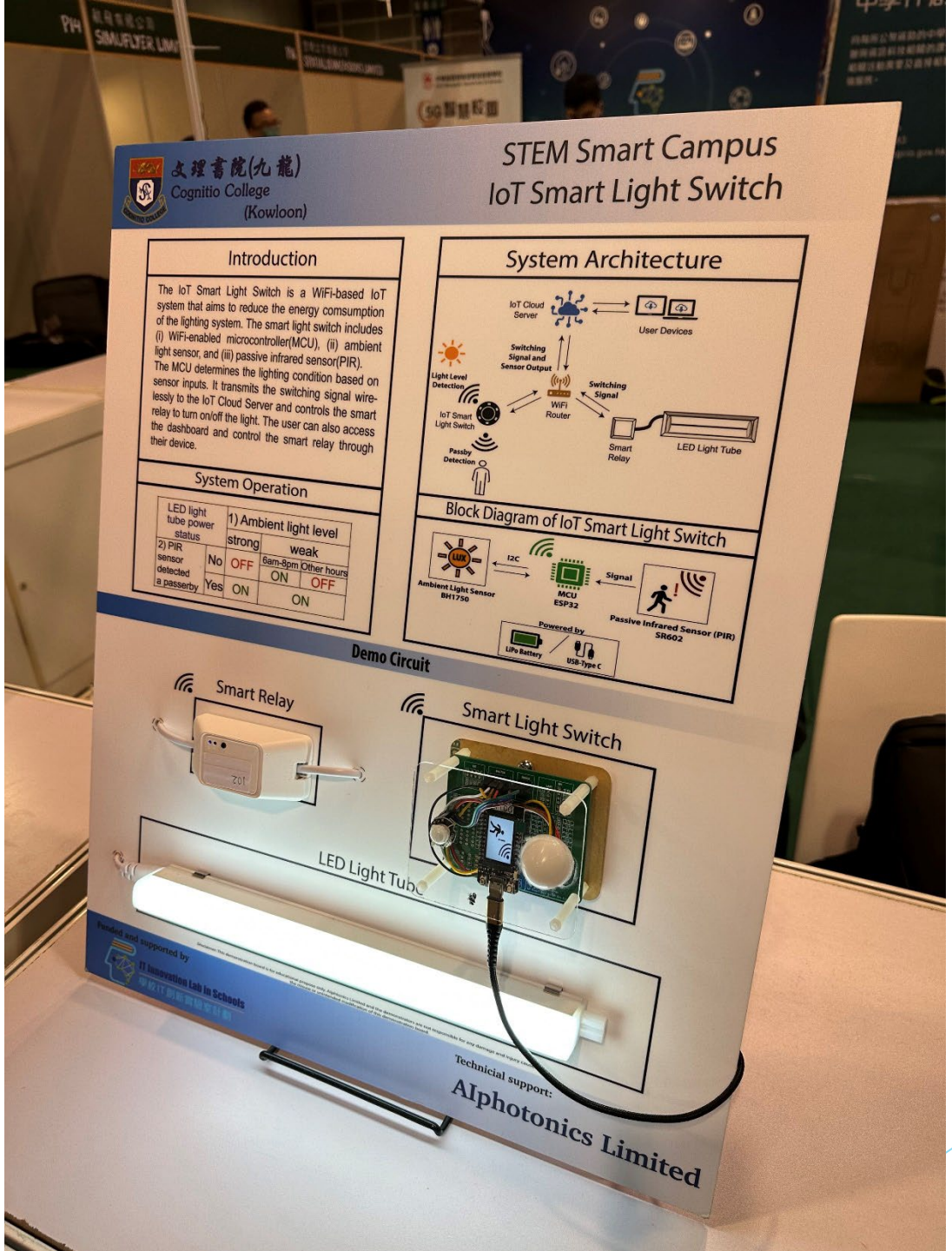
Strategy of teaching and learning

- (2) Pair-programming is used to cater learning diversities in teaching coding in Arduino to use the microcontroller to control motion sensor, light sensor and Wi-Fi connection. Students with higher ability are arranged to pair with students with lower ability to learning coding so that they can help each other.

Strategy of teaching and learning

- (3) Cooperative learning and inquiry learning are usually used when doing a project to make the STEM Smart Campus IoT Smart Light Switch. Learning occurs when students present information to and assess each other in order to create new knowledge by working on a shared project. Students are arranged in group and are assigned to create their own ideas of using IoT technology to solve a daily problem. Students in a group must discuss and analyze a problem, find a solution of solving the problem, design the solution and do demonstration.

Demonstration of using motion sensor, light sensor, Arduino, microcontroller (MCU ESP32), smart relay to let students apply IoT application in school. This activity aims to stimulate students' thinking on how to apply IoT technology in daily life.


文理書院(九龍)
Cognitio College
(Kowloon)
STEM Smart Campus
IoT Smart Light Switch
Introduction
The IoT Smart Light Switch is a WiFi-based IoT system that aims to reduce the energy comsumption of the lighting system. The smart light switch includes (i) WiFi-enabled microcontroller(MCU), (ii) ambient light sensor, and (iii) passive infrared sensor(PIR). The MCU determines the lighting condition based on sensor inputs. It transmits the switching signal wirelessly to the IoT Cloud Server and controls the smart relay to turn on/off the light. The user can also access the dashboard and control the smart relay through their device.
System Operation
LED light tube power status
1) Ambient light level
strong
weak
2) PIR sensor detected a passerby
No
OFF
6am-8pm
Other hours
ON
OFF
Yes
ON
ON
System Architecture
IoT Cloud Server
User Devices
Switching Signal and Sensor Output
Light Level Detection
IoT Smart Light Switch
WiFi Router
Switching Signal
Passby Detection
Smart Relay
LED Light Tube
Block Diagram of IoT Smart Light Switch
Lux
I2C
Signal
Ambient Light Sensor BH1750
MCU ESP32
Passive Infrared Sensor (PIR) SR602
Powered by
LiPo Battery
USB-Type C
Demo Circuit
Smart Relay
Smart Light Switch
LED Light Tube
Funded and supported by
IT Innovation Lab in Schools
Technicial support:
AIphotonics Limited

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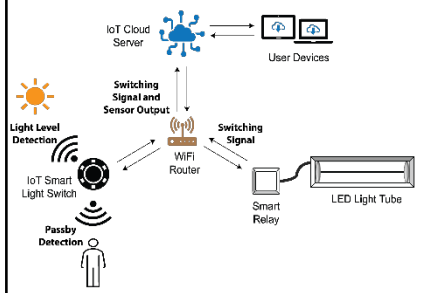
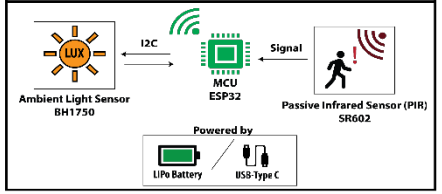
2) PIR sensor detected a passerby	No	OFF	6am-8pm ON / Other hours OFF
	Yes	ON	ON

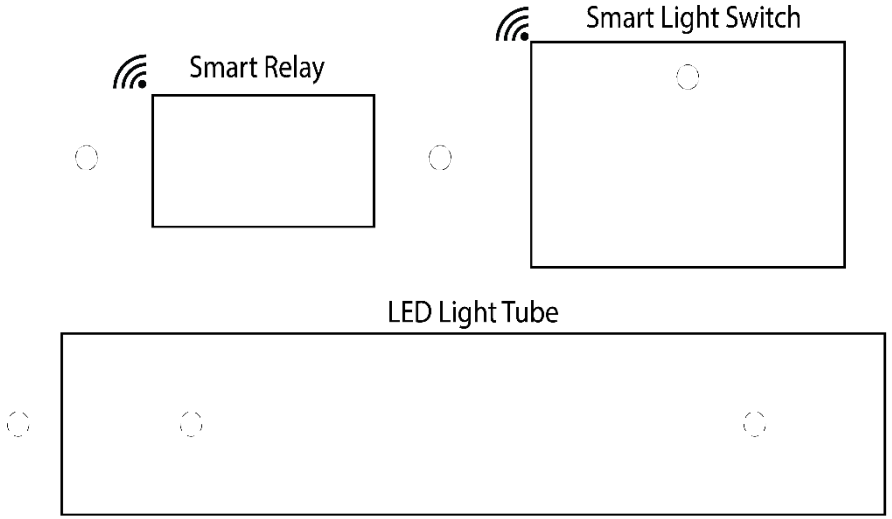
System Architecture



Block Diagram of IoT Smart Light Switch



Demo Circuit



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學校IT創新實驗室計劃

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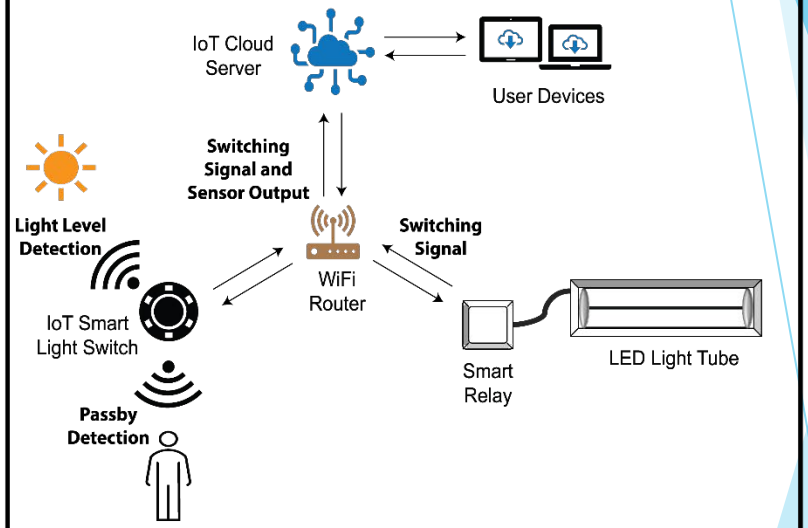
System Architecture



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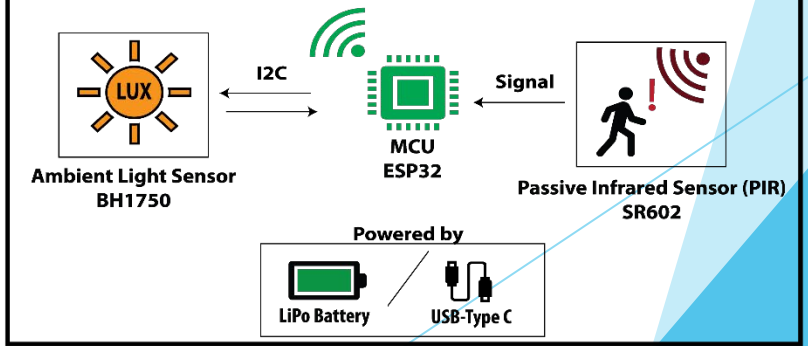
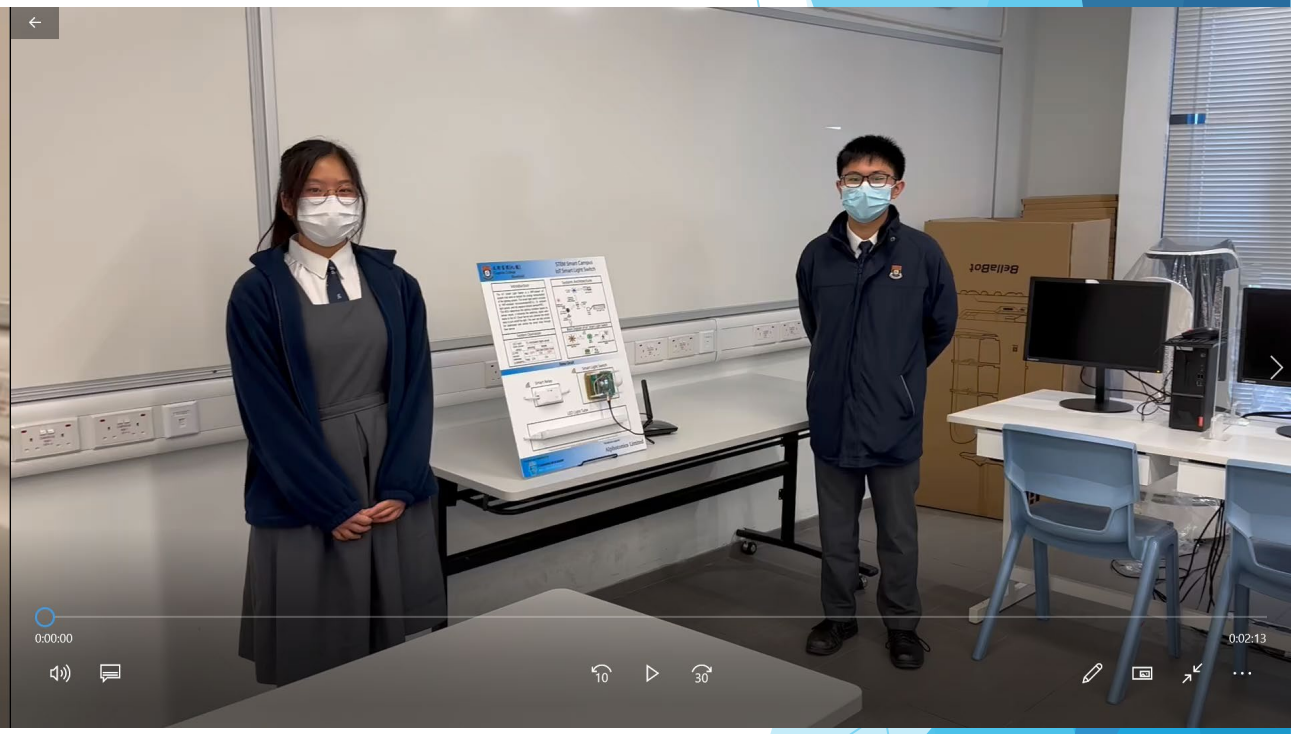


Demo Circuit

Videos prepared by students



Participants

- This research starts from Jan 2022 to May 2022.
- Only 5 teachers are involved in the teaching.
- There are totally four computer literacy lessons (35 minutes each) in each cycle (Ten school days in one cycle).
- There are totally 122 participants who are S3 students from 4 classes.
- Each student needs to complete a questionnaire after research period.

Response and Performance of Students

- Questionnaire are completed by four classes of S3 students for evaluating the motivation of studying IoT and methods of teaching IoT.
- There are totally 4 questions, question number 1-2 are about the motivation of studying IoT while question number 3-4 are about strategy of teaching IoT stated in section 4.
- Students are asked to give a score from 1-5 in each question.
- "1" means strong negative impression of learning IoT while "5" means strong positive impression of learning IoT.

Results of questionnaire			
	No. of participants	Mean of score	
		Q1-2	Q3-4
Class one	33	4.22	4.13
Class two	32	3.67	3.42
Class three	29	3.00	3.00
Class four	28	3.75	3.50
Overall	122	4.00	3.86

- From the above table, the overall scores are above average.
- This indicates that IoT education in school curriculum has successfully been adopted in this study.
- Scores of motivations of studying IoT in each class are all equal or above average, which indicate that correct methods of teaching are adopted to assist students' learning.
- However, scores of Strategy of teaching IoT in some classes are close to average, which means further investigation are required.

Limitation

- Due to outbreak of COVID-19 pandemic, hands-on activities can only be organized in face-to-face classes after class resumption.

Further development

- Research on catering learning diversity, difference in sex and difference in learning style for IoT education can be analyzed in the future.
- In addition, more studies about how to arouse students' interest of learning IoT topics after face-to-face class resumption are needed.

Conclusion

- In this study, we focus on generalization of IoT in education.
- We successfully adopt different teaching methods for IoT education in school curriculum.
- It is found that the students' motivation of studying IoT and teaching strategy of teachers are above average.
- More studies on generalization of IoT in education are needed in the future.

References

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Thank you