Capstone Project: The Use of Smart Technology or IoT in Schools

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Introduction:

In the 21st century, high-quality and advanced technology has entered into various areas of people's lives, such as work and school environments. These new advancements have helped to increase human productivity and created greater convenience. One of the most recent developments is the Internet of Things (IoT), which helps people to live extraordinary lives. More specifically, IoT devices collect people's data and provide better services to people. However, some poor people cannot access this type of advanced technology because of its high cost, resulting in a digital gap between those who are wealthy and others who do not have such privilege. This distinction was particularly felt during the COVID 19 Pandemic when students were forced to study and work on their computers. Because not all individuals have the same access to technology, the hole is growing larger and exacerbating the problematic situation. As such, the president and CEO of UNICEF Canada, David Morley, explains that COVID 19 is "a double shock" to the gap, growing into "a digital canyon" between students with economic support and poor students (Canadian Unicef Committee, 2020). However, learning how to use technology is essential for everyone to adjust to a rapidly developing society. People who do not know what technology is being used in society may find it more difficult to be successful in the future. Fortunately, schools are the perfect places for students to learn and adapt to future technology in the educational setting, enabling all people to access technology. For instance, using smart home devices in education brings more interaction and eventually motivates students at school. Students can access information through smart home devices. Moreover, an intellectual environment can provide safer sites for students and parents. Thus, schools should utilize smart home devices in the school environment to provide an educational and safe atmosphere for students, parents, and teachers.

One of the simpler forms of smart technology that can be applied in schools is tagged objects, which are usually non-IP objects. It does not support any internet protocols, which means it does not require WiFi to activate. Tagged objects are mainly based on Near-Field Communication (NFC) and Radio-Frequency Identification (RFID). This type of smart technology is already used in schools. For instance, Near-Field Communication (NFC) based student IDs are used to track students' activities. In Colorado's Adams 12 Five Stars Schools, students use the Radio Frequency Identification system when they ride school buses (Schaffhauser, 2018). In addition, the system makes time stamps and identifies locations as students scan their IDs, which contain tags. This type of technology should be applied in all schools because it increases student safety. The data collected on NFC or RFID allow students' activities to be monitored. As such, students' parents who want to be notified can access timestamps and areas for safety reasons and teachers and school staff are able to locate students based on their last location tag. Clearly, the implementation of tagged objects in school settings creates a safer environment.

In addition to devices such as NFC and RFID, schools can also implement WiFi-enabled devices. Currently, the WiFi service that people use has short-wide coverage. In other words, WiFi speeds get slower as people walk away from the router. A smart system places devices everywhere, and slow WiFi speed can affect their abilities. To address this problem in schools, the Mesh Network reduces this discomfort. The Mesh Network is a WiFi system "that works as a large home WiFi system" ("What is a Mesh Network and how does it work," 2022). Each router becomes a point that distributes the same WiFi signal. As a result, it provides a broader range than a single WiFi router. Most smart devices recommend using the Mesh Network because devices are spread over the houses. Thus, schools would need to have this type of network in

order to implement smart devices throughout the school. There are four types of smart devices, but the most common types are Wi-Fi, Z-wave, and Zigbee. Each type has its advantages and disadvantages. However, combining three types of devices in school can provide a comfortable and safer environment for both students and teachers.

WiFi-Type

The WiFi-type covers smart devices that use a WiFi signal. The devices are customizable and accessible through several platforms, such as Google Home by Google, Apple HomeKit by Apple, and SmartThing by Samsung. As a result, WiFi type devices could be easily placed in schools, using existing hardware. A benefit in schools is that everyone can access these services if they are connected to the same WiFi. These devices that can help students access information would be applicable in schools. For instance, Anne-Belfield school in Charlottesville uses Google Home Speaker as its librarian. Google Home Speaker connects to WiFi and answers students' questions about information about books, freeing up the school librarian's time (Schaffhauser, 2018). The implementation of this type of technology in education enables all students to find the answers to their questions quickly and easily.

However, WiFi-type smart devices have some limitations in school environments. WiFi-type smart devices use WiFi bandwidth to activate. Thus, when other devices connect to the WiFi, users may experience slower speeds. In a school setting, with potentially hundreds of students sharing the same bandwidth, internet speed is negatively affected, resulting in these smart devices activating slowly. Also, Wi-Fi-type smart devices may be a security risk for schools. Because everyone can access the system, it is vulnerable to hacking. This is particularly worrisome because schools keep personal information about students. This security issue is the most common and challenging issue to work on and solve. Nevertheless, experiencing how to

access information on devices connected to WiFi can teach students about the importance of online safety at an early age.

Z-Wave

To address the limitations of WiFi type devices, schools can combine them with Z-wave smart devices. This type is based on mashed internet and uses a radio signal to communicate with other devices. To control devices, it requires a hub that is the central control centre. According to Davies (2021), Z-wave type smart devices have a range of 100 meters (328 feet). Compared to WiFi-type smart home devices, it provides more safety and faster speed. Because Z-wave devices use radio signals instead of WiFi bandwidth, WiFi speed is not affected. In regards to security, the system is invulnerable to invaders. Z-wave type smart home devices use the same encryption that online banks use, providing better security. Although Z-wave type smart devices have better security and effectiveness features, there are disadvantages to using Z-wave. For instance, Z-wave is a closed protocol that is managed by Connectivity Standard Alliance. Thus, compared to Zigbee and WiFi-type smart devices, there may be compatibility issues as there are not as many devices that support Z-wave as other types of devices. This means that it would be more difficult to equip schools with the necessary devices. Moreover, in regards to price, Z-wave-type smart devices are more expensive than WiFi-type smart home devices.

Zigbee Type

A zigbee-type smart device is another form of IoT technology that uses low power, low data rates, and close proximity. According to “ZigBee Technology” (2022), ZigBee has a range of 10 - 20 metres. It uses a WiFi signal, but it requires a hub to control. Compared to WiFi-type, it prevents slow network service despite many connected devices. Since the Zigbee protocol does not require much bandwidth, it can save energy to activate. The devices with small battery

capacity can work well with Zigbee. Also, Zigbee Alliances provides open protocols for users. The protocols are fixable for other smart devices. Compared to Z-wave, more devices support Zigbee service due to the open protocol, making it easier to implement the devices in schools. The devices can be monitored through various platforms. However, there are disadvantages to the Zigbee type. To activate devices, it requires a hub that supports Zigbee to control. Also, Zigbee is planned for low-energy devices; the transmission rate is much lower compared to other smart automation systems.

Devices to Form Smart School

Using smart devices has the potential to change the school environment. Alcatel-Lucent Enterprise (2020) mentions various ways that smart devices can be implemented in schools: IoT devices in school "create new ways for students to learn," change how teachers deliver lessons and test achievement," and "provide a safer environment for students and teachers." (p.2) IoT devices in schools can give students more dynamic and safer school experiences. Also, it creates the interaction between students and teachers and brings deeper connections.

Smart Whiteboard

A whiteboard is one of the school supplies that students and teachers frequently use in the classroom. Replacing traditional whiteboards with smart whiteboards can bring closer interaction between students and teachers. Smart Whiteboards not only can be used as whiteboards for students and teachers to write on, but they also allow students to save their notes on their personal devices for later use. In addition, the activities that students do on the whiteboard are recorded and moved to the cloud and observable for students and teachers. Based on students ' activities and performance, Alcatel-Lucent Enterprise (2020) states that teachers can use the screen for students' understanding and "optimize instruction and improve learning outcomes" (p.

2). Students can realize what information they lack and prove their skills through what they have done on a Smart Whiteboard.

Also, Smart Whiteboards can be used remotely. When students and teachers are unable to be in class, whether due to sickness or appointments, students can access the cloud systems and learn what the class learned while they were away. Even if teachers are absent, they can observe what students have done in the class by using this cloud service. There is a similar software system, such as OneNote by Microsoft, that utilizes the concept of the Smart Whiteboard. Due to the pandemic, most teachers have started to use OneNote as a whiteboard. Teachers' writing is accessible to students either in school or at home. However, the Smart Whiteboard has not yet been commercialized and popularized. Although it is still in the development process, it will be a great device for educational purposes.

Smart Thermostats, Smart Lights and Smart Environmental Sensors

Smart devices should also be employed in schools because they can make the school environment more efficient. For instance, smart thermostats are a control center that can manage room temperature based on the data from environmental sensors. The Bruceville-Eddy Independent School District (ISD), located in rural Texas near Waco, applied smart thermostats in schools as a "cost-effective replacement for its old energy management" ("Smart Thermostats Keep Classrooms Comfortable," 2019) A smart thermostat observes energy usage and collects data from environmental sensors and provide efficient temperature to students and teachers. Also, smart thermostats can change the temperature remotely. Based on the collected data, the algorithm in the smart thermostat changes energy usage more efficiently and provides a comfortable temperature in the school. By adopting smart thermostats and environmental sensors, schools can be eco-friendly and comfortable places for students and teachers in schools.

Similarly, smart sensors are another IoT device that can make schools operate more efficiently. Metallidou et al. (2020) stated that environmental sensors "[test] humidity, temperature, carbon monoxide, [and] smoke presence" (p. 63682). Sensors gather information from outside and inside the building and send it to cloud systems. Similarly, smart lights are controllable remotely. School staff would be able to turn on or off the lights in one central location, saving power. Using smart thermostats, smart lights and smart environmental sensors can save energy by reducing energy consumption. According to Metallidou (2020), IoT based designs can increase "power efficiency up to 82.77% a day and minimize carbon emissions by cancelling the use of fluorescent and static power control" (p. 63682). For instance, the Nest thermostat created by Google is one of the most popular thermostats that users prefer. Users receive a "Nest Home Report " that describes energy usage hours every month. Moreover, room temperature and lighting are crucial to students during class. For instance, in summer, students sometimes lose focus because of the hot weather, and in winter, students lose focus because of the cold weather. With smart devices, these factors in the school building can be controlled through the use of sensors to ensure that students can learn in optimal environmental conditions.

Surveillance Camera/Wireless Door Locks

Surveillance Cameras and wireless door locks are the crucial devices for security. When students are at school, they need to be safe. Smart surveillance cameras support facial recognition and save videos into the cloud services. The videos can be observed at any time. Because everyone in the school can be monitored through surveillance cameras, it can prevent crime. When crimes occur in school, the videos recorded through surveillance cameras can be used as evidence. In addition, these cameras can enable school administrators to know the

identity of those who enter the school. In addition, wireless door locks can track what people enter the classroom and leave. Wireless door locks lock or unlock doors through mobile devices remotely. Some wireless door locks support NFC in phones and it can be unlock through mobile devices. If somebody who is not allowed to come in trespasses, it can send an alarm to teachers. Surveillance cameras and wireless door locks can provide security to all people in the school because it ensures that only those who are supposed to be in the building are in the school.

LMS Moodle

The essential point to forming a smart school system is the platform. Currently, students primarily use Microsoft Teams. Students use Teams to receive assignments, hand in projects, and earn marks from teachers. However, the Teams platform cannot track students' activities. LMS Moodle is a perfect platform to use. LMS Moodle is a Virtual Academic Communities (VAC) and an open-source learning platform where everyone can access learning sources. When the pandemic started in 2020, BC students used the LMS moodle platform to attend summer school. Students can use the app to show their progress or "interact with implemented objects." (Marquez et al., 2016), such as measuring elements and mediators. LMS Moodle collects and stores data in the database. Teachers can track the data from the LMS Moodle database and monitor the student's work.

Learning with IoT Devices

Marques et al. (2016) conducted surveys in "IoT in education: Integration of objects with virtual academic communities" (p.209). The first survey was about the usage of technological support in courses. They created test scenarios to check new objects in education. The devices that students used in the lab experiment were Arduino and Raspberry Pi, which are the prototype motherboards. Arduino and Raspberry Pi are common educational motherboards

because they are easy to control and open. After using these IoT devices, a total of thirteen students surveyed formed the sample and provided their responses to various questions about their usefulness in labs. The survey asked, “were the devices deployed to support the laboratory classes helpful for performing lab work activities?” 61.5 percent of the students strongly agreed, and 30.8% of students agreed that devices used in VAC were helpful during the lab. Also, 46.2 percent of students responded that it was always “easier to perform the laboratory class activities with this form of work supported by technology.” These results indicate that the devices used in the laboratory helped students to do and experience their learning in a more dynamic manner during the experiment. This is important because learning makes students enjoy and improve understanding.

In the study, the students found the devices and VAC helpful in their education even though it was the first time adapting these devices into their learning. More importantly, the majority of students found VAC helpful during class, highlighting the usefulness of Iot in school. Students can experiment and learn interactively by using IoT devices. Also, VAC can form a community with peers and create a space to chat with teachers. The survey asked about creating collaborative activities, such as forums and discussions and helped build knowledge through VAC. 23.1 percent of students strongly agreed, and 53.8 percent agreed that collaborative activities help students build insights. Creating a community allows students to communicate with others and share their education process, which develops their thinking and enables them to share different perspectives, allowing students to achieve better marks.

Conclusion

Overall, due to the Covid 19 pandemic, schools have encouraged students to bring their own devices to schools. However, not all students have the same access to devices. Smart

devices in schools are the solution to this inequality. While Smart home devices have made people's lives at home more efficient and convenient, they can also be adapted to help students learn. There are currently several types of smart home devices that people can use and experience. Adapting smart home devices in schools can give everyone opportunities to learn in a safe, efficient and helpful manner. Smart home devices and VAC can be used everywhere in schools, such as in the office, classrooms and laboratories. Students usually create forums to communicate with each other while using VAC. Utilizing smart home devices and VAC can create an atmosphere in which students and teachers communicate with one other. As a result, the use of IoT devices can lead to interactive learning. Most importantly, smart devices in schools help students feel more comfortable at school, enjoy studying and improve their education.

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