The Internet of Things (IoT) in Education

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ABSTRACT- The introduction of the Internet of Things (IoT) in education, which allows Internet based communications to happen between physical objects, sensors and controllers, has changed educational institutions massively. By embedding sensors in objects and integrating cloud computing, augmented reality, wearable technologies and big data in this platform, different parameters of the educational environment can be measured and analysed to provide useful information. It also has created a new interaction between people and the environment in educational organisation. In this research based on the recent IoT projects in education, we will categorize the application of IoT in education into four groups: energy management and real time ecosystem monitoring, monitoring student's healthcare, classroom access control and improving teaching and learning. We will investigate and analyse how this platform has changed the Education Business

I. INTRODUCTION

The Internet of Things (IoT) is a technological revolution that enables pervasive interaction between objects, people and environments. Data will be gathered by embedded sensors and actuators, which are then sent to specialised applications to create actionable information. IoT has been acknowledged as one of the foundation stones of Industry 4.0, due to its potential to change the existing industrial and business processes [1]. With the advent and growth of the IoT, physical environments are becoming smarter and more interconnected than ever before. This has changed the way we live by improving sustainability, efficiency, accuracy and economy in almost every aspect of our lives. IoT has been leveraged in many industries such as healthcare systems, traffic management, energy management, education, environment monitoring, smart homes and smart cities.

Governments and educational institutions are using IoT to streamline processes, leverage data and promote sustainability. The use of smart objects and wearable devices is well established in a number of universities [2].

Enabling technologies such as sensors, chips and other wearable devices which are all well understood, easily mass-produced, and inexpensive have become ubiquitous in education and used extensively in classrooms. This research focuses on the effect of IoT in education. The rest of this research is organized as follows: in section 2, we represent the background information on IoT in higher education and the education business model. Section 3, specifies the project aim and discusses the practical integration of IoT in higher education in the areas of campus energy management, classroom access control and campus security, student's healthcare and finally teaching and learning enhancements. It will then concentrate on the impact of IoT on the Education Business Model by introducing new value propositions based on the Canvas Business Model.

II. BACKGROUND
A. Internet of Things in Education

Education has changed from a knowledge-transfer model to an active collaborative self-directed model by the disruptive influence of technology in today's educational institutions. This has forced many institutions to rethink teaching and learning [3]. The influence of technology can be seen in many aspects of education from student engagement in learning and content creation to helping teachers provide personalized content and improving student outcomes. [4]. There are currently seven categories of technologies, tools and strategies that driving innovation in education: "Consumer Technologies, Digital Strategies, Enabling Technologies, Internet Technologies, Learning Technologies, Social Media Technologies and Visualisation Technologies"[2]. IoT is a subcategory of Internet technology, which supports education in many ways. IoT solutions enable educational institutions to collect a vast amount of data from sensors and wearable devices more easily and to perform meaningful actions based on these data. Such systems allow students to explore an environment by using embedded sensors, QR codes and other technologies. They can access learning materials and other information from anywhere at

any time. Teachers also can use wearable devices and smart phones in the classrooms to improve teaching and learning. A smart classroom can be defined as an intelligent environment equipped with different kinds of hardware and software modules. Video projectors, cameras, sensors and face recognition algorithms are examples of modules that monitor different parameters of the physical environment [5] or students' attributes such as concentration, performance and achievement [6].

Industry and higher education experts have given their perspectives on the IoT and its potential impact on higher education, the problems solved/created by the IoT, and security, privacy, and data ownership issues . For example Itai Asseo, strategic Innovation Executive at Salesforce, says that one of the biggest benefits of IoT in education is personalized and unique interaction with students. It helps students not only get personal recommendations and academic topics, but can also resolve learning issues when they are struggling academically by sending alerts to administrators . Maggie Johnson, Director of Education and University Relations at Google, mentions that the IoT is present in many universities in the form of "security cameras, temperature controls, and access to buildings, lights, power" . Bob Nilsson, director of solutions marketing at Extreme Networks, suggests that smart objects can be used in classrooms for improving teaching and learning. He also mentions to the role of the IoT in enabling remote presence for students, optimizing classroom and campus environments, students' health and safety and saving energy and resources. Chalapathy Neti, vice president, education innovation at IBM, says that IoT allows administrators to understand students' needs and manage buildings more efficiently. In the view of TJ Costello, Director IoT for Cisco U.S. Public Sector, IoT has provided an opportunity for students by improving their learning experience in connected campuses. It also helps administrators to connect everything on campus and facilitates campus management . According to the current application of IoT in education, in this paper we will categorise the ways in which IoT can benefit higher education into four groups and we will discuss how this new platform could shape smart education for the next generation.

B. Education Business Model

A business model is "a conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm" [7]. Osterwalder and Pigneur [8] proposed "A nine building block business canvas" (Value Proposition, Channels, Customer Relationships, Customer Segments, Revenue Streams, Key Activities, Key Resources, Key Partnership, Cost Structure). The development of different technologies results in changes and enhancements to the organization process and business model. For example, education has largely been influenced by the IoT development. Cisco predicts the increase of the global adaptation rate of IoE (Internet of Everything) in education from less than 5% in 2013 to 32% by 2022. This will happen through personalized instruction and data collection for making better decisions and could result in a 10-year net present value of US$175 billion. By incorporating IoT in education learners become co-creators of knowledge, Data-driven decision making replaces ad hoc decision-making. An interactive crowd-sourced customised curriculum with scalable, recordable and replicable instructions replaces rigid one size fits all static instructions. [3]. The growing adoption of IoT in education adds valuable features to the existing education business model. In the next part we will discuss these features.

III. RESEARCH AIM AND METHOD

This study is a qualitative research which focuses on the education business model. The aim of this research is to answer the following question: "How has the emergence of IoT affected the education business model in higher education?"

To do so, first a literature review in the current practical applications of IoT will be conducted to find best practices of IoT in higher education. Secondly, the current education business model will be analysed and the potential impacts of IoT on it will be discussed.

A. The applications of IoT in higher education
1. Campus Energy Management and Eco-System Monitoring

Internet of things has been applied in energy management and Eco-system monitoring to provide energy efficiency for a much more sustainable future. This has resulted in the introduction of Smart Grid, a specific form of IoT energy management application, by several national governments [9].The utility companies can effectively balance power generation and energy usage to provide more efficient operations by adding intelligence to the existing infrastructure. Through the use of specialized sensors and actuator systems, energy consumption information will be gathered automatically to improve economy, efficiency and reliability of the systems. System

operators use these analytics to predict many factors from grid status to weather conditions [10]. The same concept allows universities to create a green campus environment by reducing CO_2 emissions, monitoring and controlling energy and water usage to provide a healthy atmosphere for teaching and learning. The architecture of a green campus has been proposed in [11] to manage computers and air conditioning systems in order to save energy. As a practical example, COMFORTSENSE is another energy management project, which has been implemented in Campus Luigi Einaudi, University of Turin. This project takes advantage of IoT technologies to improve building energy efficiency and comfort [12]. The idea is to consider university buildings 436 and campus areas as a "living lab" to collect data through wearable devices and smart phones in addition to traditional data collection methods. This living lab is based on a codesign approach, which allows students to directly participate in the implementation of wearable device and mobile applications. Several fixed sensors have been set in classrooms, study rooms and the library to measure temperature, humidity, carbon dioxide and brightness. This allows the analysis of indoor comfort level and environmental variables to improve sustainability and comfort in the campus. In addition to these fixed sensors, staff and students are able to measure different attributes through wearable devices and visualise them in their mobile app. This app allows students to send feedback about air quality variables to show their degree of comfort. Building management can also use the data obtained from both fixed and wearable sensors to study and adjust energy management policies (such as heating, cooling and lighting) accordingly.

2. Secure campus and classroom access control

Creating a safe and secure place in universities and managing students' access to classrooms, laboratories and other places in the universities are some of the challenges which could be addressed by bringing new technologies into education. RFID (Radio-frequency Identification) and NFC (Near Field Communication) are the two enabler technologies for implementing IoT which can be used to simplify access control and improve university security. The authors in [13] developed a classroom access control method over NFC to create a real time classroom control tool. The classroom registration system is based on a network of connected sensors that collect classroom access information and display the status of the classroom on both a web based application and university TV panels. The author in [14]

proposed a method for monitoring student attendance by using RFID tags in student ID cards. This system records student IDs when they enter the classroom and tracks their current location in the campus by using geofencing technology. The Sookmyung Women's University (SWU) has implemented access control systems in the campus based on IoT architecture and transformed the university campus to a smart model by installing sensors and NFC tags. Students can open a mobile application called "Smart Sookmyung" to check the availability of free desks in the library and reserve appropriate seats. They can also record their class attendance or even register to enter certain buildings in the campus [15]. The Sookmyung Women's University has managed to cut their IT budget by using an integrating messaging system to send free notification messages to every student via this mobile application compared to the traditional services such as email [16]. The Bournville College is another example which has applied Cisco Physical Access Control Technology to control access to different areas of campus.

This technology has simplified the process of managing access to 400 doors in total on the main campus including classrooms, offices and other communal areas in the campus. It also monitors foot-traffic patterns and sends notifications to the building management system [3]. According to a survey carried by the Bournville College, 95% of the students agreed that the system creates a safer learning environment for them.

3. Student's health monitoring

The IoT plays a major role in a wide range of healthcare applications, from monitoring patients to preventing disease. This technology has not only improved access to a higher quality health care but also reduced the cost of care [17]. Since the student health state is a key factor in determining the student's overall academic performance, access to a quality health care service is vital in any educational establishment [18]. A common application of IoT in healthcare is the use of wearable technology. A wearable device monitors physiological signals over long periods of time in a non-invasive and non-obtrusive manner [19]. Smart watches and fitness bands are the most common use case examples of these wearable devices. A study [18] shows how RFID technology is used to implement an eHealth solution (called Electronic Medical Records or EMR) to monitor students at risk of high blood pressure through the use of wearable devices. The system takes into

consideration different students' health information such as their medical history, prescriptions, Electrocardiography (ECG) results, blood pressure and other vital signs by IoT technology. The Oral Roberts University is testing the use of wearable technologies to monitor satisfactory health and physical education progress for online students. Since online learners suffer more from back pain and neck pain and other similar problems, the wearable device will notify students to get up and move after long periods of sitting. The university will also analyse the gathered data to see if the smart watch has motivated online students to do more exercise [20] .

4. Improving Teaching and Learning
IoT can help institutions to improve the quality of teaching and learning by providing a richer learning experience and real-time actionable insight into students' performance. It can create a smart learning environment where students can customise the environmental variables such as room temperature to their optimal choice [21]. Bob Nilsson [28] argued that IoT devices such as e-books, tablets, sensors, fitness bands, virtual and augmented reality headsets are being used in education today to track and monitor students in different aspects such as understanding students' learning patterns. A smart classroom has been proposed in [22] which can measure the level of student's interest by monitoring their behaviour using cameras and microphones. The impact of different parameters in the physical environment such as temperature, environmental noise and CO_2 level on students' focus has also been 437 analysed. A smart classroom system will determine in realtime if the environment is optimised to maximise student's ability to concentrate on a lecture at any given time.

Wearable technology in the educational environment can enhance the lecturing process with minimum disruption in the classroom [23]. The author in [24] presented the possibilities of using wearable technology to acquire and process data to enhance knowledge in higher education. For example, Google Glasses and Sony smartwatch are used in the Universitat Politecnica de Valencia classrooms to enable the lecturer to collect important information regarding student knowledge building process. This improves learning efficiency by providing a personalised explanation to student. This application helps the lecturer to automatically change slides while speaking and to control the timing needed for each concept and also the time consumed by each activity. Outside the campus, by embedded sensors in historical and urban locations or in the public gardens, students can receive information from nearby sensors.

5. Increasing student collaboration and engagement
IoT has changed the university classrooms by embedding sensors and mobile devices into the environment. This has created a unique opportunity for increased student engagement and collaboration in teaching and learning.

B. New relationship and new channel
Since IoT has provided new value propositions to education, the traditional communication channels aren't useful to deliver these values to the customer. IoT has created new virtual channels through the use of mobile apps and graphical web-based interfaces. These new channels have resulted in new form of relationships which are virtualised and more personalised than before.

V. CONCLUSION
This research details how the Internet of Things (IoT) can shape smart campuses and classrooms. We have categorised the application of IoT in education into four groups: campus energy management and eco-system monitoring which provides energy efficiency for a sustainable future; access control systems which create a safe and secure place in universities; student's health monitoring which provides access to a quality health care service for university students; teaching and learning enhancement which provides a richer experience for learners. We have also shown the potential influence of IoT on the education business model. The analyses of the Canvas business model show that IoT has a big impact on value propositions. These include reducing cost, personalised learning, time saving, enhanced safety, improved comfort and collaboration. This has also resulted in new customer relationship and channels by forming a virtual and personalized relationship.

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