USE OF A BLENDED LEARNING APPROACH FOR AN INTERNET OF THINGS COURSE

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Abstract - Internet of Things (IoT) is a truly auspicious and challenging field of study and business. The advance in communication technology and the promising 5G development aiming at lower battery consumption and lower frequencies will have high impact on spreading IoT services which enhances mobility and portability in different fields like e-health e-banking, entertainment and others.The universities, proved to be aware of the importance of this emerging topic, are introducing an IoT course in their programs. Blended learning is suitable to use in an IoT course since the student has to build his knowledge from different fields of studies and because of the discrepancies that exist among students. Some learners fromtechnical background will not put effort on connecting hardware but rather in learning programming while other learners fromprogramming background will need more assistance in setting up the infrastructure. So it is a course with different paces and speeds. The unified class lecture will tackle the common points between learners and the online part will be at the pace of each learner.

Keywords - Internet of Things, Blended Learning, Course Design, Innovation.

I. INTRODUCTION

The Internet of Things technology became a hot topic in the media and industry forums. The standards, security, privacy, and different communication protocols are debated but none of these is a real obstacle to the market success. IoT is being applied and it found already its way to the market. Washing machines, refrigerators, ovens, shoes, cars, locks, toothbrushes, even pots are being "smart." Worth looking at some IoT topics will make us understand that this project is unlikely to fail and certainly it will be adopted by all consumers, which undoubtedly will include IoT in their daily lives. The data collected from the connected things is much more valuable than the network itself. The value of the IoT products is not derived from the technology, the Internet or the things but rather it is created by the concentration, interaction and interpretation of the transformeddata into knowledge and effective actions[1], [2]. The parking sensor is not important for the ecosystem, but finding a parking space quickly and accurately is.Nowadays, many universities are offering IoT courses for their students. The content of an IoT course is very rich and of great variety. Programming languages, cloud computing, business and management, communications and networks, security and safety are some of the components of an IoT course. Learning the different components imposes the use of different approacheslike face-to-face learning, project-based learning, online learning, blended learning and others. This paper will describe in short the blended learning model and the IoT in sections 2 and 3. Section 4 describes the different existing courses in some universities and section 5 summarize sa new proposed course outline.

II. BLENDED LEARNING

In the literature there is a disagreement about blended learning meaning. Some believe that it is an old teaching practice adapted to e-learning;others do believe that it is an attempt to impress with no content just made for marketing purposes but many think that it is a new attractive and important methodology. Blended Learning is actually a complex field of pedagogy and has many definitions. According to the definition of the Institute of Clayton Christensen, blended learning combines face-to-face teaching in school with learning online, aimed at personalized learning experience and thereby reducing the monitoring time in the traditional class[3].

This definition gives off concerns about the degree of mixing between the 2 dimensions in blended learning. Training environments that implement blended learning mix the face to face teaching with online learning so that one method is an operational support for the other [4]. The activities done in the classroom (in person) are paired with those made remotely. So it is not class learning supported by online resources neither an online learning enhanced by classroom [5].

The degree and methodologies of mixing between online learning and brick-and-mortar learning lead to have four main categories of blended learning which are Rotation, Flex, A La Carte, and Enriched Virtual**Fig.1.**

In blended learning both environments, physical and digital, are aiming for a student-centered approach. Learning activities with the active involvement of student in the online environment should be combined with those provided in the traditional class. The online material is not a simple post of the class lecture enriched with communication tools, but rather it is a part of the structured course with specific content, design and instructions, delivered via Internet [6]. The effectiveness of blended learning

lies in the active participation and interaction of students in different learning environments.

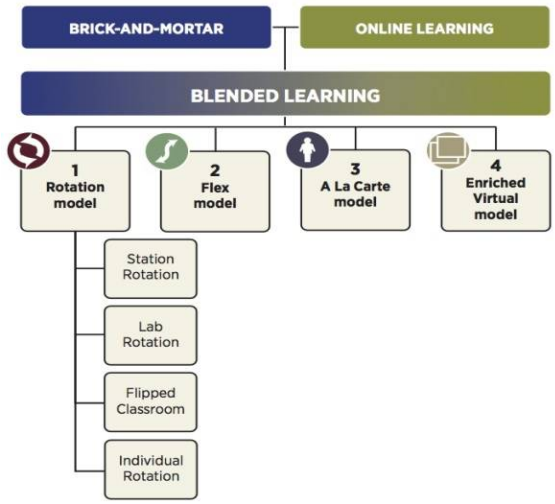

Fig.1. Blended Learning categories.

III. INTERNET OF THINGS

Internet of Things is the network of devices that transmit or utilize data from the physical environment to provide a service and can communicate through the Internet [7], [8]. A "thing" could be a smart phone or a soil moisture sensor in a fieldsending measurements to a web service via the GSM network. All those connected devices that make up today the Internet of Things, are used to obtain information from the environment and human activity. The aim is to improve the quality of life of people and to avoid unforeseen events.

The data collection is essential in the following areas:

- Monitoring environmental conditions to avoid extreme natural disasters, to draw conclusions on the quality of water or air, etc.
- Construction and industrial sectors for full automation and control of the manufacturing process.
- Management of energy resources to optimize energy consumption.
- Control and monitoring transportation systems such as intelligent traffic lights, automatic parking system, etc.
- Remote medical assistance in cases where the patient is in critical condition.
- Automated homes for the control of all electric appliances.

Therefore, finding a solution for the management of such large volumes of data is imperative.

As seen in **Fig.2,** between 2015 and 2021the number of devices connected is expected to increase by 23% annually, with the largest growth being located on the mobile IoT**.** Of the 28 billions connected devices in 2021, nearly 16 billions would represent IoT devices [9].

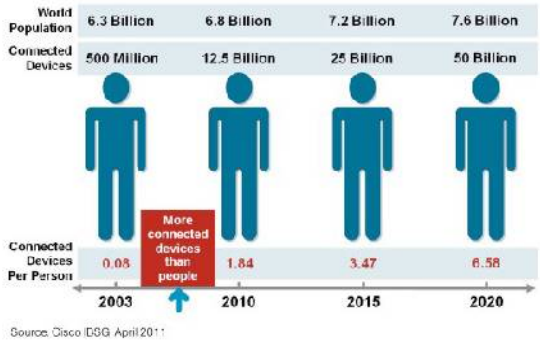

Fig.2. Internet of Things evolution.

The decrease in cost of the connected devices will increase the number of those devices. New applications will be developed to synchronize, analyze and offer the desirable solutions. The commercial implementation of 5G networks will offer additional features critical for the IoT, whose number will be exponentially greater than today.

IV. IoT SYLLABI STUDY

The IoTcourse is offered in engineering schools and in computer science schools. In the below table we show different courses offered in some top universities. Each record in the table shows the course title, the corresponding department (computer science or computer engineering or online), the link to the course web resources and the content of each course.Although all courses are about IoT, we can notice a high discrepancy between theircontents.

We can notice that some courses focus on the programming dimension like courses 2 and 3 while others concentrate on communications technologies and connection protocols like courses 1 and 4. Also there are courses that tackle the issue of market and security and business aspect like course 5 and 6. The study of behavioral change and influence of IoT in society is an integral part ofcourse 6.Other subcategories of internet of things appear in courses 1 and 6 like RFID technologies and big data.

Course 1: ***The Internet of Things***
computer science course
https://web.cs.wpi.edu/~rek/IoT/Fall2015.htmlcourse
Primer on TCP/IP Stack
Network Protocols
Primer on Wireless Sensor Networks
RFID Technology
LTE and IEEE802.11p for vehicular networking: a performance evaluation
Integrating Wireless Sensor Networks with the Web
Course 2: ***A developer's guide to the Internet of Things (IoT)***

online course https://www.coursera.org/learn/developer-IoT/#syllabus Introduction to the course Rapid application development in the cloud Rapid application development on a Raspberry Pi Lower level programming for the Internet of Things
Course 3: ***Secure and Intelligent Internet of Things*** computer science course https://www.eecs.harvard.edu/htk/courses/ Overview of IoT technology and services Networking for IoT Security and Privacy for IoT Machine Learning in Small-Data for the local context and for Wearables in IoT Course projects formulation and execution
Course 4: ***Internet of things*** computer science course https://polytechnic.purdue.edu/courses/cnit-58100-IoT Emergence of technologies and vertical solutions in the Internet of Things (IoT) domain. Top-level problems that IoT promises to solve, the business drivers, the attributes of IoT enabled enterprise and consumer markets. How IoT is different from the contemporary Internet. IoT components such as the "things", the data, the people and the processes, as well as vertical markets. Types of architecture, reference models, and standards (both open and proprietary). Technologies, commercial products, issues (such as security).
Course 5: ***Industrial Internet of Things: Applications*** engineering course http://web.stanford.edu/class/ee392b/ Introduction into Industrial Internet of Things Applications The Industrial Awakening: The Internet of Heavier Things IoT: Key Use Cases, Adoption Patterns, and Challenges Using Aircraft Fleet data to Improve Operations Physical Analytics Data Science at Scale for IoT on the Pivotal Platform Enterprise Internet of Things IoT applications in Energy Data Science at Scale for IoT on the Pivotal Platform
Course 6: ***IoT: Foundations and Applications*** computer science course http://courses.ischool.berkeley.edu/i290-IoT/s16/ IoT and Web of thins Layering in the networking domain Technologies of connecting small devices Business value of the IoT IoT ecosystem as company IoT business issues and models Behavioral change Semantic technologies Big data Implication for society

Table 1: IoT existing courses

V. PROPOSED IoT SYLLABUS OUTLINE

The different courses described above have different content; moreover the focus is on the content and not on the methodology of delivery. We propose to design an IoT course which covers the urgent basic needs of learners and taking into consideration the blended learning approach to maximize the benefits.
The different topics and skills vary from software to hardware and connectivity and are part of the curricula of computer engineering program or computer science program. In some computer engineering programs there is some lack in computing or programming skills while in some computer science programs the hardware dimension is weak. Moreover there is no textbook to cover the topic of IoT projects.

The heterogeneity of learners ‘ groups and the variety of skills needed make blended learning a suitable solution for learning an IoT course. The Flipped Classroom Model and the Enriched Virtual Model seem to be the most adequate models. In both models, a major part of the content is online but in Flipped Classroom, the students meet more frequently face-to-face with the instructor while in Enriched Virtual Model the students meet occasionally and have a minimal brick-and-mortar school experiences. In blended learning all learners take the basic knowledge during the face-to-face lectures in class but each learner will acquire the skills needed at his pace during the on line learning stage. The online content of the course is not a simple posting of the materials on Moodle or other course management platform but it is a collection of papers, videos, project simulation and sketches. The learner will have to read, toanalyze andto understand the added value of an IoT project.

There are different modules and tasks that should be achieved to develop an IoT project:

- Low level hardware: most of the hardware devices are low powered sensors and relays or different small circuit controllers. These devices are mainly powered by batteries or

by some kind of renewable energy. The devices transmit and may receive signals.

- Connectivity and middleware: The devices described above are connected to each other's or to some processor that collects signals and may transmit instructions to the devices if needed. The processor is connected to the internet and it is programmable.
- The applications and the Cloud: The data broadcasted from the middleware processor is gathered in the cloud or in different servers. Analysis is made and information is supplied, also some results may be transmitted back through the middleware to the low level hardware controllable devices.
- From the above description the skills needed to develop an Internet of Things project are defined below as learning outcomes which are deliverable using a blended learning approach:
- The knowledge about low level circuit is an essential part that should be acquired: The learners should make use of different sensors and relays. During the face-to-face meetings, the students will learn the basic skills of electronic circuits and later they are forwarded to online resources to build their needed circuits.
- Programming of the small processors i.e. Arduino or Raspberry Pi etc:A good knowledge in programming to understand the code written and to be able to include and develop the desired code. As for the technical dimensions, the learner is not asked to re-invent the wheel but rather to use some existent code for simple projects and to modify it to build his own solution. During the face-to-face meetings the students are exposed to the Arduino programming and to the integrated Development Environment (IDE) setup and later they are asked to continue through online videos and existing online code.
- Connectivity and networking between sensors and processors and between processors and internet: The theoretical part about communication protocols is explained in class while the code needed is retrieved from online resources.
- Cloud management and Cloud utilities to come up with the desired information or actions: There are different Cloud Service providers (AZURE, AWS, Google) that have IoT enablers. Also other none IoT services are used in the Clouds like Databases to store data and data mining to exploit data and extract information. The learners are asked to follow the online tutorials handed by the Cloud Service suppliers. In class they will acquire a broad knowledge about Cloud Services.
- Innovation: The course learning basic outcome is that the learner will have a proper use of the IoT that delivers a potential market value project. The learner will be able to identify opportunity and strive to be an entrepreneur.

CONCLUSION

The evolution of the IoT courses could be similar to the evolution of the Management Information Systems (MIS) courses.The MISstarted as a computer science course and now it is being considered as acomplete university degree where its holders are present in all contemporary enterprises. The diversity of the IoTdifferent modules and its expecting high use in the near future will urge all universities to integrate the topic in their programs. The needed skills span across different competencies like business knowledge, business values, computer science, engineering and entrepreneurship. Blended learning is a suitable approach when dealing with an IoT course due to the variety in the content of the course and the heterogeneity of the learners.

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