Learning IoT without the "I"- Educational Internet of Things in a Developing Context

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ABSTRACT
To provide better education to children from different socio-economic backgrounds, the Thai Government launched the ''One Tablet PC Per Child'' (OTPC) policy and distributed 800,000 tablet computers to first grade students across the country in 2012. This initiative is an opportunity to study how mobile learning and Internet of Things (IoT) technology can be designed for students in underprivileged areas of northern Thailand. In this position paper, we present a prototype, called OBSY (Observation Learning System) which targets primary science education. OBSY consists of i) a sensor device, developed with low-cost open source singled-board computer Raspberry Pi, housed in a 3D printed case, ii) a mobile device friendly graphical interface displaying visualisations of the sensor data, iii) a self-contained DIY Wi-Fi network which allows the system to operate in an environment with inadequate ICT infrastructure.

Keywords
ICT4D, Internet of Things, ubiquitous computing, mobile learning, tablet computer, local wireless networks, Computer science education

1. INTRODUCTION
Thailand is a developing country which is facing the difficulty of improving educational standards and equality due to insufficient teaching resources and under-staffing problems [1]. Thailand's education was ranked below average when compared to 65 countries, i.e. 48th in reading and science and 50th in mathematics [2]. To address this, in 2012, the Ministry of Education provided tablet computers with pre-installed learning contents to first grade primary students nationwide as part of the "One Tablet Per Child" (OTPC) initiative. Recently, the project was discontinued due to the lack of empirical study to show the effectiveness of OTPC. Therefore, there are currently huge amounts of schools' tablets not being used by teachers or students. This provides us with an opportunity to study how mobile learning and IoT can be designed for students in underprivileged areas in Thailand using low cost wireless sensor device. We believe that IoT based educational technology can empower students to have personalised, rich and interactive learning, anytime anywhere when they need it. Hence, the learning process can become more active, through collaborative engagement beyond the classroom. Moreover, the integration of IoT and the use of sensors enable students to become digital citizens who have a better understanding of, and knowhow in, annotating real-world information through smart sensors [3].

2. BACKGROUND AND CONTEXT
In 2014, we carried out a study examining the use of tablet computers in four Thai schools, in order to enable us to identify how a tablet-based learning system can be best designed to support learning. This study involved 213 students and 8 teachers in urban and rural schools in northern Thailand. We found that students in rural schools had difficulty acquiring learning contents from the internet due to the lack of ICT infrastructure (out of date school network equipment and unreliable government supported internet connection). Therefore, they could only use the tablet computer for reading static e-book content which is simply the digitised version of the books they already have in the classroom. Teachers also claimed that it would be better if tablet computers can support a broader range of teaching and learning activities instead of just reading. We also found that visual learning style (learn best by seeing through picture or video) was the most preferred learning style. Our result also showed that students had positive attitudes towards tablet computer use demonstrating enjoyment and productivity and they had high scores on acceptance of tablet computers [4].

3. DESIGN CHALLENGES
From the study, it is clear to us that in order to design effective IoT based educational technologies for these user groups, we need to address the following issues:

- Provide science related learning activity with the aim to improve students' motivation and learning performance and prepare them for the key skills required for the 21st century workplace (problem solving, critical thinking, content creation and collaboration).
- Provide low cost sensor devices which work with existing schools' tablet computers. This is especially true for rural schools to ensure wider access of IoT by the most underprivileged student population.
- Reliable local wireless domain: the system should work within a self-contained wireless network as a result of the limited and unreliable rural schools' internet connection. Moreover, it is important to consider data privacy issues among children.
- Child-friendly and attractive user interface: friendly, colourful user interface and visualisation need to be designed to ensure that school aged children are able to make sense of the sensor data
- Customisable and personalised learning experience: increase in mass-produced affordable 3D printing technology can allow students to customise the OBSY's sensor device with a variety of 3D parts. Such printing services may be supported by small and medium-sized

enterprises (SME) or local universities in Thailand and are likely to become increasingly available as the price of these technologies drops.

4. PROTOTYPING

To address the challenges, our prototype "OBSY" system consists of i) low cost sensor device, ii) mobile interface, and iii) self-contained Wi-Fi network

4.1 Sensor device

The form factor of the sensor device's (see figure 1 left) is designed for second grade students around 6-9 years old. OBSY's form is inspired by the shape of an octopus with many tentacles representing the variety of sensors which acquire data from the environment. With the advancement of 3D printing technology, we can now allow the students to personalise OBSY "Octopus" by decorating it with various 3D-printed plastic parts like "Mr Potato Head." OBSY's hardware (figure 1 right) is built on a low-cost, single-board computer called "Raspberry Pi" (Model B+) which connects to a camera, Wi-Fi USB adapter and sensors including temperature, humidity and light sensors. These enable the students to monitor and acquire real world data within range of the Wi-Fi access point.

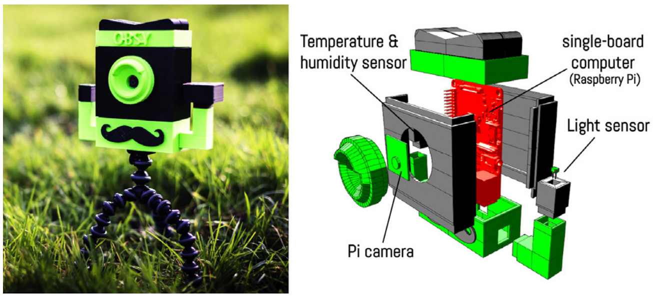

Figure 1. OBSY's design 3D printed housing (left) details of OBSY's hardware (right)

Figure 2. OBSY's mobile web application

4.2 Mobile interface

OBSY's software (see figure 2) is developed based on standard mobile web application technology so that it is accessible to users on a mobile device web browser. Students can easily observe the video images and real-time sensor data through the web application. The mobile interface is designed to be simple and attractive to children with simple icons and colourful visual style. There are three main pages, namely a status page (displaying real-time sensor data), camera page (for taking pictures) and gallery page (view and manage the stored captured images and sensor data).

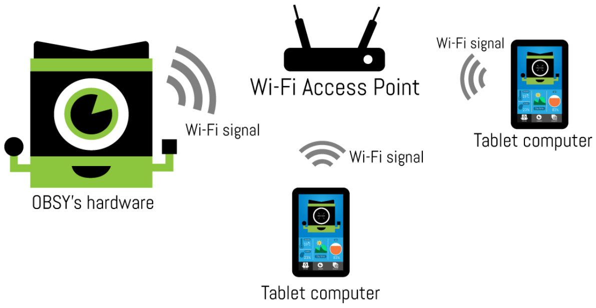

Figure 3. Self-contained WIFI network configuration

4.3 Self-contained WIFI network

OBSY's system works directly within a simple local wireless connection with a Wi-Fi access point (see Figure 3). OBSY's Wi-Fi connection can be configured through Raspberry Pi operating system. OBSY hardware will act as web server and provides services for client tablet devices through a Wi-Fi access point. All connected devices in the same network connection can access to the OBSY hardware through the OBSY's web address.

5. SCENARIO

We envisage a scenario for demonstrating how OBSY can be used for creating science experiment activities alongside the national curriculum. This can encourage young students to learn and build new ideas based on their own understanding. The scenario is the study of growing plants. Students learn how plants, as living things, grow and change. They will plant their own seeds in order to make careful observations of their growth over a period of time and share their findings with a group of fellow learners. They will learn that plants are living things and that they need certain conditions in which to grow healthily. They will learn to treat growing plants with care and will describe how this has been done during the course of the experiment. They will be able to carry out investigations, record their observations in the system, and finally draw conclusions.

6. PRELIMINARY USER TESTING

The system is to be used by students and teachers in collaboration to achieve an enhanced learning experience. In order to understand whether students and adults (teachers) are able to use the system, two Thai children, a seven-year-old girl and a nine-year-old boy and one adult were tested. We encouraged them to experiment with the topic of living and non-living things by observing real-time sensors data and videos/images of growing beans (living things) and rocks (non-living things) through the OBSY system. The children enjoyed observing the experiment conditions in different rooms of their house, far away from growing containers, especially at night before bed. However, they still had some difficulties reading and understanding the visualisation of temperature and humidity data. This is certainly an important aspect we will look into in the next iteration of prototyping. The system ran smoothly on a tablet computer in the local Wi-Fi network we set up. However, when trying to connect the OBSY's sensor device with more than four tablets, web page loading and real-time video were slightly slowed down. It was due to video streaming requiring a high volume of bandwidth. We also tested the Wi-Fi network setup with an adult with no technical knowledge. Although the adult was able to set up the network with relative ease, she still faced some problems physically connecting the mouse, keyboard and monitor using the current version of OBSY's 3D case. These preliminary results are of limited significance, as they do not fully reflect the number and age range of the target users. However, a future empirical research study will be conducted in a precise education scenario in Thailand.

7. FUTURE STUDY

The initial user testing has provided us with valuable information on improving the prototype. Currently, we are revising the system, initially based on the preliminary user study, before planning to conduct a deployment study in two Thai schools in June 2015. The study will investigate how students interact with the OBSY system and how well it supports learning in science experiments. A research scenario will be formulated to allow students to learn the topic of living and non-living things by observing real-time sensory data and videos/images of growing beans (living things) and rocks (non-living things) through the OBSY system. The observation research method will be conducted with the purpose of understanding how students interact with their friends, teachers and OBSY. Questionnaires and interview sessions will be employed to assess students' engagement in learning and the usability of the OBSY system. Additionally, the reliability, robustness and user-friendliness of the sensor device, mobile app and local Wi-Fi network will be tested.

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