Technology in the Development of Learner-centric Education

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ABSTRACT

Traditionally, education has been teacher-centred rather than learner-centred. The teacher-centred model of education places all responsibility for decision-making about what is taught, how it is taught and when it is taught on the teacher. Current education theory, however, argues for a learner-centred rather than teacher-centred approach. Learner-centred education places the student at the centre of education, with the teacher only playing the role of facilitator. Learner-centred education benefits learners in a number of ways: students are actively engaged with the subject; they are motivated as learners and they learn more skills including collaboration, communication and discipline knowledge.

This research proposes an architecture based on the Internet of Things (IoT) technologies for primary school learners to know about various parameters in their environment, that is, the temperature, light, vibration, sound and gas levels. This particular system can be integrated into, not only a formal teaching environment but can also be an additional learning platform outside school. The platform can work in, for example, a physical science class, environmental science class or a geography class.

The architecture under design has the Arduino as one of its components. The Arduino is a tool for the design and development of embedded computer systems consisting of a simple open hardware design for a single microcontroller with embedded input/output support. It is designed to make the process of using electronics in multidisciplinary projects more accessible. The Arduino will be fitted with various sensors that can detect the temperature, light, vibration, sound and gas levels. It is portable enough to be moved from one location to the next. The Arduino can connect to a computer, even wirelessly. The information that is generated by the Arduino is fed to Twitter social network which is popular with learners. The learners can then access their Twitter accounts via mobile phones. The component that is responsible for enabling tweeting is called the Beachcomber. The Beachcomber is a system that allows easy communication between things and humans. The learners can then discuss and compare the reasons for the variations in the temperature, light, vibration, sound and gas levels for various locations and objects as detected. The discussions can occur both in the field and in the class, with the teacher taking the role of a moderator of the discussions.

The learner-centric model creates an environment that is conducive to learner participation and collaboration and the learners take the data and deduce their own meaning from it. In his works, Vygotsky places emphasis on interaction between a learner and the environment. The electronically-mediated learning presented here is effectively applied to a constructivist-based approach to learning. The question that this research answers is, "What is the architecture of an Internet of Things technology that can support learner-centric education?"

Although the prototype Beachcomber system is in its final stages of development as a separate project and can now send messages from various IoT components to Twitter accounts, work on the Arduino is still in its infancy. The merging of Beachcomber and the Arduino will occur once the development phase is completed.

Keywords

Learner-centred education, Internet of Things, Arduino, learner-centred education, constructivism

1 INTRODUCTION

In a learner-centred environment, students are actively engaged in creating, understanding and exercising control over their learning. Therefore learner-centred education is grounded in a constructivist perspective where teachers centre their planning, teaching and assessment according to the different capabilities of learners. So instead of teachers being the sole instructors, they become collaborators with students in creating knowledge[7].

At the heart of 'learner-centred", "constructivism" and "problem-based" learning is the idea that people

learn best when engrossed in the topic and are motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand. The goal is active exploration, construction and learning rather than the passivity of lecture attendance and textbook reading [4]. Traditionally, focus was on structured content which was taught according to lesson plans. Learner-centred learning focuses on the needs, skills and interests of the learner. It is accompanied by a problem-based approach rather than on the structured curriculum.

This paper describes an IoT – based architecture that supports learner-centric education. It supports the idea of active participation by learners in the learning process. The next section is on the methodology adopted in the research. The next section thereafter gives an overview of learner-centred education, the IoT technologies, the Arduino, and the Beachcomber. The next section describes the architecture of the proposed system. At the end is the discussion on the technology and conclusion.

2 METHODOLOGY

The research is in the area of software and hardware development in a laboratory set-up to incorporate IoT technologies and learner-centric education concepts.

2.1 Purpose of study

The paper reports on an architecture towards the development of a technology that supports learner-centric education. The research question therefore would be:
"What would be the architecture of an Internet of Things-based technology that can support learner-centric education?"
The objective would be to incorporate technologies such as the Arduino, Twitter, the internet and sensors into a system that would lead to a constructivist approach to children learning about their environment.

2.2 Process

This research is on the design of a technology to enable learners to detect temperature, light, vibration, sound and gas levels at various locations. The locations in which the system will be used by learners will vary from taxi ranks, school grounds, classrooms to the shopping mall. The information generated will then be sent to their Twitter accounts and subsequently they can access the information via mobile phones. The students would then discuss the information among themselves and give explanations for the variations in the various parameters under the teacher's moderation.

In this research, the Arduino and the Beachcomber are designed and developed separately and will subsequently be merged to produce a whole system

3 BACKGROUND AND RELATED WORK

This section gives an overview of learner-centred education, IoT technologies, the Arduino and the Beachcomber.

3.1 Learner-centred education

ICT-enhanced learning promotes increased learner engagement and "just-in-time" learning in which learners can choose what to learn and when they need to learn it. It also encourages interaction and cooperation among learners apart from real-world interactions [1].

Instruction changes from being teacher-centred and content-driven to learner-centred and learning-process driven. The student's role changes from that of being a passive recipient of the teacher's knowledge to that of an engaged learner and active agent in the learning process. The instructor's role expands from that of a knowledge-laden teacher who disseminates factual information, to that of a mediator or facilitator who assumes the role of designing learning tasks, coaching students, evaluating student outcomes and creating an environment that is conducive to student participation. In the learner-centred paradigm students spend less time being "instructed" and more time engaged in learning activities that involve them doing activities other than writing notes [2].

A learner-centred approach to teaching incorporates teaching strategies that focus on the needs, preferences and interests of the learner. This approach is desirable because it helps learners to become actively engaged in the learning process, take responsibility for their learning and enhances their skills to learn "how to learn". One way to help learners learn "how to learn" is to develop learning tasks that actively engage them and help them develop high order skills such as problem-solving and critical-thinking skills. Active learning is grounded in the constructivist theory that emphasises hands-on, activity-based teaching and learning during which students develop their own frames of thought. Constructivist theory assumes three basic principles that include: (a) learners forming their own presentations of knowledge; (b) learning through active experience and exploration that uncovers inconsistencies between current knowledge representation and their own experiences; and (c) learning within a social context, with interaction between learners, peers and other members of the learning community [3]

The benefits of learner-centred education according to [5] [6] are:

- The instructor is a facilitator and coach, not a teacher
- The students are responsible for their own learning
- Emphasis is put on the learning process rather than the content
- The learner is an active participant in the learning process
- Emphasis is put on the ability of the learner to judge and evaluate
- Learners gain a strong knowledge base and develop learning skills and independent decisions. Students construct knowledge through gathering and synthesizing information and integrating it with the general skill
- Emphasis is on communicating knowledge effectively to address enduring and emerging issues and problems in real-life contexts
- Learners are motivated to actively participate in the learning process
- Different learning styles are accommodated since the learner-centred classroom offers a tailored program for each student
- Each learner's contribution is an integral part of their classroom experience

Constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own rules and mental models, which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences [8]. Constructivist teaching is based on the belief that learning occurs as learners are actually involved in a process of meaning and knowledge construction rather than passively receiving information. Constructivism draws on the developmental work of Piaget. Piaget [9] asserts that learning occurs by an active constructing of meaning rather than passive recepience. He explains that when we, as learners encounter an experience of a situation that conflicts with our current way of thinking, a state of disequilibrium or imbalance is created. We must then alter our thinking to restore equilibrium or balance. To do this, we make sense of new information by associating it with what we already know, that is, by attempting to assimilate it into our existing knowledge. When we are unable to do this, we accommodate the new information to our old way of thinking by restructuring our present knowledge to a higher level of thinking.

3.2 The Internet of Things

The IoT is what happens when everyday ordinary objects have Internet-connected microchips inside them. These microchips help not only keep track of other objects, but many of these devices sense their surrounding and report it to other machines as well as to the humans. Also called M2M, standing for Machine to Machine, Machine to Man, Man to Machine or Machine to Mobile, the IoT intelligently connects humans, devices and systems. The International Telecommunications Union (ITU) states that the goal of information and communications technologies (ICT) is to connect all objects on the basis of networked individuals to form a ubiquitous network which is called the IoT. This network covers all everyday objects such as watches, keys, household appliances, cars and buildings [21]. When embedded with chips and sensors, these objects can think, feel and talk with each other. Together with the infrastructure of the Internet and mobile networks, these objects can communicate with humans and enable the humans to monitor and control them anytime, anywhere and enjoy their intelligent service.

[22] defines the IoT as "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental and user contexts". A different definition that puts focus on the seamless integration could be formulated as "Interconnected objects having an active role in what might be called the Future Internet". Semantically, the IoT means "A world-wide network of interconnected objects, uniquely addressable, based on standard communication protocols"

The IoT is likely to have a staggering impact on our daily lives and become an inherent part of areas such as electricity, transportation, industrial control, retail, utilities, management, healthcare, water resource management, etc. Real time monitoring of water quality in the ocean through sensors connected to a buoy that sends information via the GPRS network, to the monitoring of computers being shipped around the world, and smart power grids that create conditions for more rational production planning and consumption will all be achieved via microchips implanted in objects that will communicate with each other. The use of technology to track objects, appliances, applications and even people is a fact of business for many companies. Using tags, sensors and chips paired with wireless technology, they are gathering loads of data about the location, status and other features of objects, ranging from a patient's whereabouts in hospital to cars backed up on the highway. Once connected though, there's the even bigger job of analysing information and getting it to the right recipients who can put it to use. This is the nascent IoT, where wireless networks of objects are being created using Radio Frequency Identification (RFID), Bluetooth, Global Positioning Systems (GPS) and other technologies, working in tandem with cloud computing environments, web portals and back end systems that seek out patterns of activity among the connected objects that promise to help enhance a range of business and other processes. RFID reads information contained in a wireless device called a tag and provides a method to transmit and receive data from one point to another. Bluetooth is a proprietary open wireless

protocol for exchanging data over short distances from fixed and mobile devices. GPS is a system of satellites, computers and receivers that is able to determine the exact location of a receiver on earth.

Some applications related to the IoT aren't new: toll collection tags, security access key cards, devices to track stolen cars and various types of identity tags for retail goods and livestock. More sophisticated tools such as embeddable chips, wireless RFID readers, GPS and cellular phone technology adapted to tracking are providing new forms of visibility. Other monitoring and tracking systems have more business uses such as solving or averting problems like sending a cell phone alert drivers that traffic is backed up at a particular exit ramp, and increasing efficiencies such as enabling a utility to remotely switch off an electric meter in a just-vacated apartment.

The IoT deals with three additional areas of technology [23]. To start with, there is telemetry, i.e. the remote reading of sensors and activities with the aid of such communication technologies as Global Packet Radio Service (GPRS). GPRS is a packet-oriented mobile data service available to users of the 2G cellular communications systems, global systems for mobile communications (GSM), as well as in 3G systems. Secondly, the development within sensor networks and ubiquitous data systems or systems that are integrated into their surroundings and easily accessible at anytime; this is the technology behind, e.g. intelligent houses and offices. The final piece of the puzzle is the Internet and mobile telephony communications technologies that make it possible to build low-cost Internet-based solutions and services. When technologies from all these areas are combined, the result is the IoT.

3.3 The Arduino

The Arduino [10, 11, 30] is an open-source electronics prototyping platform based on flexible and easy-to-use hardware and software. It is a single-board microcontroller, designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open hardware design for the Arduino board with an Atmel AVR processor and on-board I/O support to facilitate programming and incorporation into other circuits. An important aspect of Arduino is the standard way that connectors are exposed, allowing the processor to be connected to a variety of interchangeable add-on modules (known as shields). The software is written in a C-like programming language. A boot loader on the board allows later changes to the software. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring [20]). An Arduino-integrated development environment (similar to that used for the Processing language [19]) simplifies the development and debugging process. Arduino projects can be standalone or they can communicate with software running on a connected computer. The Arduino system easily interfaces with a computer via USB when programming is required.

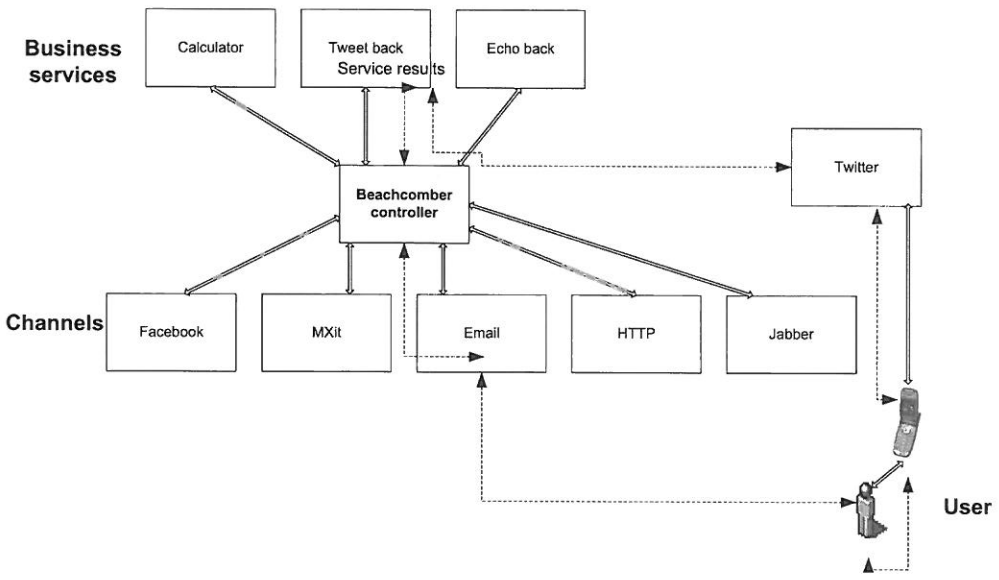

Figure 1: Architecture of beachcomber

3.4 Beachcomber

Beachcomber is a project of the South African Council for Scientific and Industrial Research's Meraka Institute [29]. It is a system that allows easy communication between things and humans via a number of protocols or communication channels such as E-mail [18], Extensible Messaging and Presence Protocol (XMPP) [26], Hyper Text Transfer Protocol (HTTP) [14], Facebook [15], Jabber (Instant messaging) [12], MXit [13], Radio Frequency Identification (RFID) tags [24], Quick response (QR) codes [25], Short Messaging Service (SMS) [27], Multimedia Messaging Service (MMS) [28] and Twitter [16] as shown in Figure 1.

The main component of Beachcomber is the Beachcomber controller. It is the interface between business services and the channels. These business services can range from a calculator, to a tweet back on dam levels or the temperature of an object, to the determination of a plant's moisture levels, etc. The business services in the Beachcomber architecture are developed using the Mobicents platform. Mobicents [17] is an open-source implementation of the JAIN/SLEE specifications that enables developers to create, monitor and manage services that integrate voice, data and video. Jabber [12] is an open source project component for instant messaging that uses XMPP protocol. MXit [13] is an instant messaging service that communicates through the MXit protocol. HTTP [14] is the underlying protocol used by the WWW and it defines how messages are formatted and transmitted and what actions web servers and browsers should take in response to various commands. Facebook [15] is a popular free social networking website that allows registered users to create profiles, upload photos and video, send messages and keep in touch with friends. Twitter [16] is an instant messaging system that lets a person send brief text messages of up to 140 characters in length to a list of followers. Email [18] is a system of sending and receiving messages electronically over a computer. RFID uses radio waves to identify items. They can be read away from the line of sight and track items in real-time to yield important information about their location and status. A QR code is a 2D bar code that allows its contents to be decoded at high speed. QR codes storing URLs appear in many places about any object a user might need information on, for example.

Requests for services in Beachcomber come from the user is via any of the above-mentioned channels. They are routed via the Beachcomber controller to the business services. The results of the request are sent to Twitter which in turn forwards them to the user's cell phone. Figure 1 shows the architecture of Beachcomber.

4 THE PROPOSED ARCHITECTURE AND ITS FUNCTIONALITY

The proposed system can sense the environment using a variety of sensors. Sensor probes are connected to the Arduino to measure the amount of temperature, light, vibration, sound and gas levels. (See Figure 2). Readings are sent to a microcontroller built into a unit which translates the data into information that is in turn sent over the Internet through an embedded Ethernet connection to Beachcomber. Beachcomber sends this information to a Twitter account. Twitter in turn sends the information via a message to the learner's mobile phone.

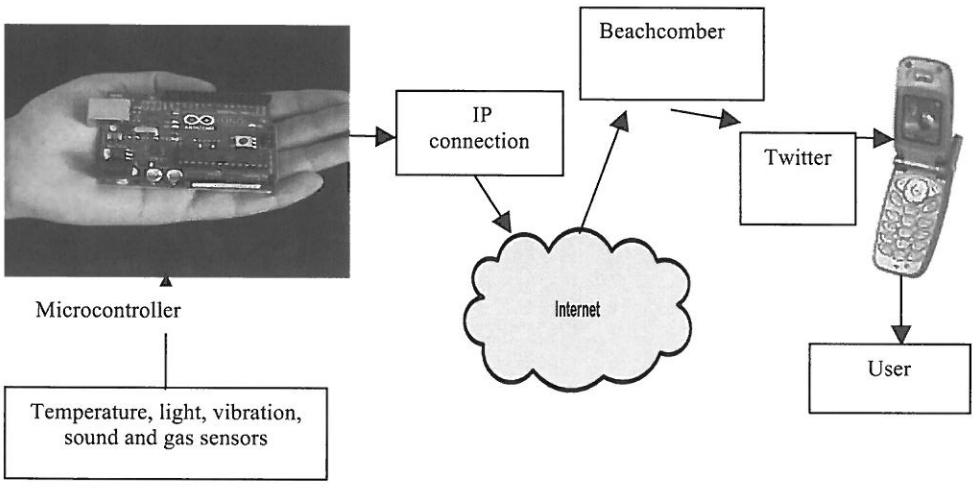

Figure 2: Architecture for learner-centric system

The architecture can also be expanded to affect its surroundings by controlling lights, motors and actuators. In the proposed system, the Arduino is attached to an Ethernet shield (Figure 3), plus temperature, light, vibration, sound and gas sensors. A battery pack allows operation in areas where access to electricity is limited. For total wireless operation, the Ethernet shield may be replaced by either Bluetooth or Wi-Fi shields.

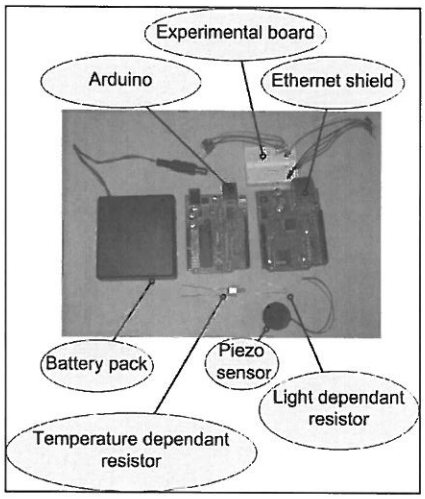

Figure 3: Components of proposed sensor

Since the intricate components (Arduino and Ethernet shield) can be purchased pre-assembled, the system is simple to put together and modify later, even for a novice. In addition, the open source and free software development environment was engineered to be easy to use, making it an ideal learning tool for children. (See Figure 4).

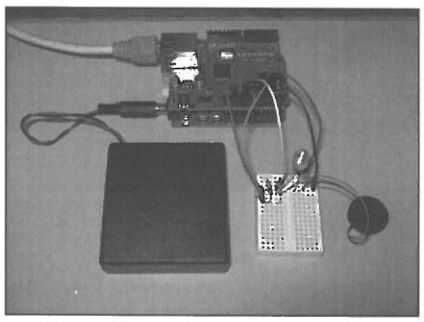

Figure 4: The assembled sensor subsystem

5 DISCUSSIONS

The trend nowadays is towards a learner-centred education. In this model of education learners gain knowledge through active participation in the learning process. The architecture of the technology proposed in this paper supports active participation of the learner. The learners move the subsystem from one location to the next, receive the results on their cell phones and then discuss the differences among themselves with the teacher as a moderator. In the process they build frameworks of knowledge through experience and collaboration with others.

To obtain optimum learning we must tap into the youth culture. Youth culture nowadays is about social networking. The cell phone is the most commonly used and available gadget among the youths in South Africa at least. Actually, cell phone coverage in South Africa is fast approaching 100%. Youths can access Twitter via their cell phones.

The IoT technologies offer vast benefits. Not so long ago we were speaking of the Internet of computers, now it is about the IoT. The proposed architecture uses low-cost technologies. The Arduino is about electronics made-easy. To program the Arduino, no serious programming experience is required. It is a question of plugging components together. The Beachcomber is a locally developed component

6 CONCLUSION

This paper reports on an architecture that supports learner-centred education. It operates in the sphere of the IoT which is an emerging research area that offers many opportunities. The architecture takes advantage of low-cost and locally-developed technologies. It taps into the youth culture of cell phones and social networks to stimulate interest in learning.

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