Research Article

Design of an Effective WSN-Based Interactive u-Learning Model

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Wireless sensor networks include a wide range of potential applications to improve the quality of teaching and learning in a ubiquitous environment. WSNs become an evolving technology that acts as the ultimate interface between the learners and the context, enhancing the interactivity and improving the acquisition or collection of learner's contextual information in ubiquitous learning. This paper presents a model of an effective and interactive ubiquitous learning environment system based on the concepts of ubiquitous computing technology that enables learning to take place anywhere at any time. The u-learning model is a web-based e-learning system utilizing various state-of-the-art features of WSN that could enable learners to acquire knowledge and skills through interaction between them and the ubiquitous learning environment. It is based on the theory of connectivism which asserts that knowledge and the learning of knowledge are distributive and are not located in any given place but rather consist of the network of connections formed from experiences and interactions with a knowing community. The communication between devices and the embedded computers in the environment allows learners to learn in an environment of their interest while they are moving, hence, attaching them to their learning environment.

1. Introduction

Learning is everywhere. It is not only found inside the four corners of the classroom. It can be in homes, workplaces, playgrounds, libraries, and even in our daily interactions with others. People can learn anywhere and in any time convenient for them without any hassles to their routine works and activities. There are new things that do not need to be learned in formal classrooms, these can be learned at user-friendly interfaces. And people are eager to become educated, professional per se, even without attending formal school, and a new innovation in educational technology would be paramount to their goals, aims, and needs.

Ubiquitous learning is a new educational learner-centered paradigm characterized by providing intuitive ways for identifying the right collaborators, the right contents, and the right learning services in the right place and the right time based on the student's surroundings. That is, who are the learning collaborators that could provide the student's needs, what are the learning resources and services available, and when and where should the learning take place?

The ubiquitous learning environment utilizes a large number of cooperative small nodes with computing and communication facilities such as handheld terminals, smart mobile phones, sensor network nodes, contactless smart cards, RFID (radio frequency identification), and mobile IP.

In this paper, a ubiquitous learning environment is created based on the concepts of ubiquitous computing technology that enables learning to take place anywhere at any time. Various e-learning environments, architectural designs, and implementations are examined and considered to include the elements of m-learning and wireless sensor networks (WSNs), extending them to create a new u-learning environment.

The ubiquitous learning environment guided by principles of learning paradigms advances the computing capabilities allowing educators to become catalysts of learning, transforming students into a more active and collaborative participants in knowledge making. By modifying the traditional

role of education to embrace principles of connectivism as applied to the described u-learning environment, education can respond to and address the onset digital revolution for future development of ubiquitous learning.

This new ubiquitous learning environment is described as an environment that supports student's learning using digital media in geographically distributed environments. This learning environment is the basis for the design of an effective WSN Based Interactive u-Learning model where learning takes place between students within campus/home and teachers as facilitators in u-space.

The u-learning model is a web-based e-learning system utilizing various state-of-the-art features of WSN that could enable learners to acquire knowledge and skills through interaction between them and the defined ubiquitous learning environment. Students are allowed to be in an environment of their interest wherein the communication between devices and the embedded computers in the environment allows learners to learn while they are moving, hence, attaching them to their learning environment.

2. Relevant Researches

The beneficial effects of learning enhanced by technology have been discussed and demonstrated by researchers in the past decades. The use of technology can make learning easier and more effective that could provide a lifeline for isolated and helpless learners.

The benefits and features of applying the context-aware ubiquitous learning which includes the provision of a more adaptive and active learning supports, the integration of real-world and digital learning scenarios, and the accomplishment of real-world practice environments with portfolio-recording functions have been recently indicated and focused on by researchers [1–4].

The following related researches have been dealing with the technical aspect of ubiquitous learning focused on the use of context-aware approach and wireless sensor networks.

To develop context-aware and seamlessly integrated Internet environments, a variety of new techniques and products concerning ubiquitous computing have been developed in recent years, such as sensors and actuators, RFID (radio frequency identification) tags and readers, wireless communication, mobile phones, PDAs, and wearable computers [5, 6].

In [7], anyone can make use of computers that are embedded everywhere in a public environment at any time in a ubiquitous computing environment. A user equipped with a mobile device can connect to any computer and access the network using wireless communication technology [8]. Moreover, not only can a user access the network actively, but computers around the user can recognize their behavior and offer various services according to their situation, the mobile terminal's facilities, and the network bandwidth. User assistance via ubiquitous computing technologies is realized by providing users with proper decisions or decision alternatives. That is, a ubiquitous computing technology-equipped system supplies users with timely information

and relevant services by automatically sensing their various context data and effectively generating the proper results [9].

The attention of researchers has been attracted by the advent of u-computing techniques from the fields of both education and computer science.

Developing context-aware toolkits which can provide functionalities that enable adaptive service based on personalized contexts were also given attention in the recent years [10]. Also, several context models have been proposed to record and analyze user behaviors in the real world such that high-quality service can be provided [11]. The use of RFID tags and floor-mounted weight sensors to detect the spatiotemporal relationship between a human user and various objects has been demonstrated. A model that represents the user's state, in which people's activities are described in terms of time sequence aspect in addition to location aspect, was proposed.

The next set of related researches have been dealing with the pedagogical aspects of ubiquitous learning focused on the use of context-aware approaches and theories of connectivity.

Based on surveys and researches, most students prefer "authentic activities" in which they can work with problems from the real world [12]. The importance of providing necessary "scaffolding" for novices to operate within the complex realistic context has been emphasized. Moreover, the need for the provision of supports that enable teachers to track progress, assess information, interact knowledgeably and collaboratively with individual students or cooperating groups of students, and prepare situated learning activities to assist the students in improving their ability in utilizing skills or knowledge has also been recognized [13].

Context-aware u-learning is an approach that places the students in a series of designed lessons that combine both real and virtual learning environments. The connection between learner-centered and real world-situated learning has been clearly revealed in the relevant research.

Context-aware u-learning has provided an adequate environment with cognitive apprenticeships. The features of cognitive apprenticeships include situated learning, coaching, scaffolding, reflection, and exploration. That is, a learning system of applying cognitive apprenticeships should be situated in real-life context. Also, it should provide systematic teaching and guidance for the learners, and opportunities of practicing learning tasks as well as reviewing learning processes.

Context-aware u-learning is able to provide personalized and active support to assist students to learn in the real world, which is very important from both the learning attitude and the learning effectiveness aspect. Also, it can deliver the provision of more opportunities for practicing and the saving of manpower in assisting and monitoring the learners.

3. Background/Rationale

3.1. What Is u-Learning? u-learning involves creating learning activities, tasks, projects, and resources that encourage students to discover learning themselves without consciously
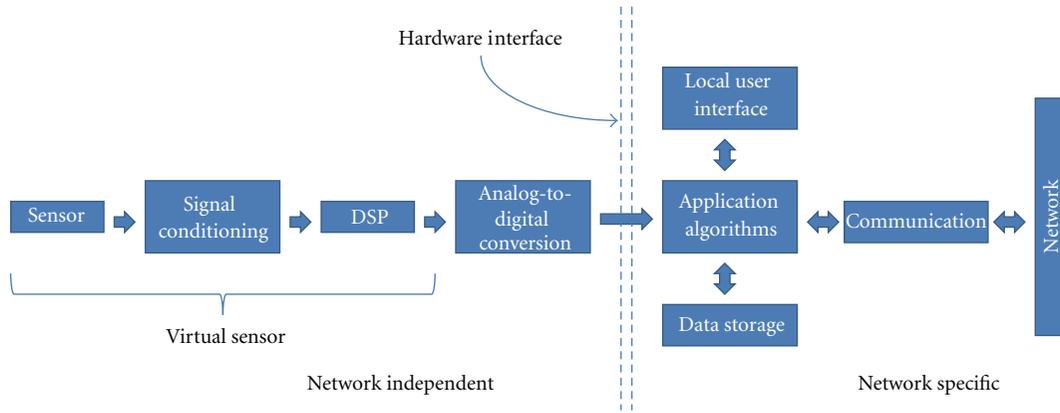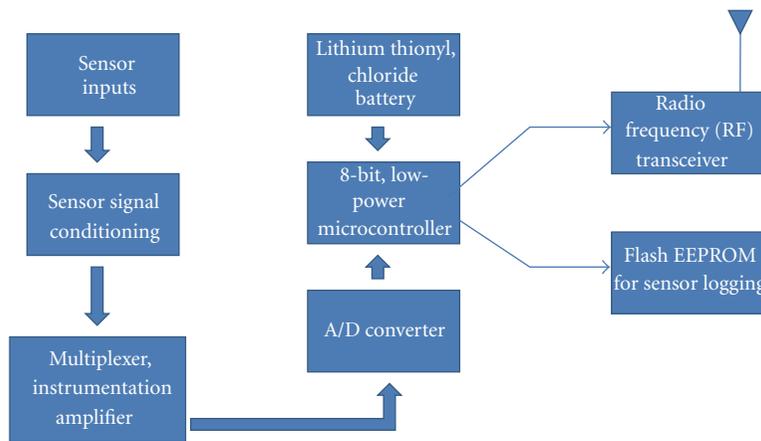
Figure 1: Sensor model.

Figure 2: Wireless sensor node functional block diagram.

realizing they are learning, so that they learn automatically and independently.

"Ubiquitous learning is ideas without barriers, inspiration without limits, innovation without boundaries." "Ubiquitous learning requires no less than a fundamental reinvention of the science of education for our modern society" [14].

Tony Stockwell author of Accelerated Learning in Theory and Practice and The Learning Revolution says, "To learn anything fast and effectively, you have to see it, hear it and feel it." This means the learners need to have mental links (pictures, sound, videos, actions, and so forth) to help them visualize learning fast and effectively [15].

u-learning system is an environment supporting student learning using digital media in a geographically distributed environment. This environment proposed the implementation of student learning between students within campus/at home and teacher of content producer in u-space, which is not limited to traditional learning system [16, 17].

Ubiquitous learning is a learning style in which the learner can smoothly commence the learning process anytime, anywhere [18].

3.2. What Is Wireless Sensor Networks (WSNs)? Sensor networks are the key to gathering the information needed by smart and ubiquitous environments, whether in buildings, utilities, industrial, home, shipboard, transportation systems, automation, education, or elsewhere. Figure 1 depicts the model of a smart wireless sensor.

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion, or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bidirectional, enabling also to control the activity of the sensors. WSN development was initially motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control and machine health monitoring.

Wireless sensors are networked and scalable, consume very little power, are smart and software programmable, capable of fast data acquisition, reliable and accurate over the long term, cost little to purchase and install, and require no real maintenance [19]. They generally consist of a base station (or "gateway") that can communicate with a number of wireless sensors via a radio link. Data is collected at the wireless sensor node, compressed, and transmitted to the gateway directly or, if required, uses other wireless sensor nodes to forward data to the gateway. The transmitted data is then presented to the system by the gateway connection. Figure 2 depicts the functional block diagram of a wireless sensor node.
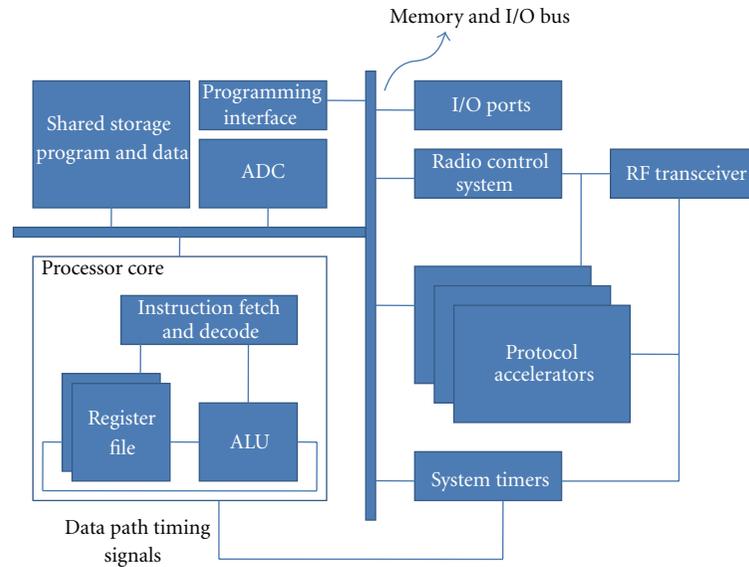
Memory and I/O bus

FIGURE 3: Wireless sensor architecture.

WSNs can be deployed anywhere with the IEEE802.15.4 as its communication protocol [20], and utilize star and mesh topologies enhancing the dynamic of such type of networks. Each device is called a mote or sensor node and each network has one powerful node called Sink Node. The Sink Node is the interface to the exterior of the network. Each mote is capable of sensing parameters such as light, temperature, humidity, pressure, acceleration, and position.

Figure 3 describes the general architecture for an embedded wireless sensors device.

3.3. Mobile IP. Mobile IP is a standard that allows users with mobile devices whose IP addresses are associated with one network to stay connected when moving to a network with a different IP address. When a user leaves the network with which his device is associated (home network) and enters the domain of a foreign network, the foreign network uses the mobile IP protocol to inform the home network of a care-of address to which all packets for the user's device should be sent [21].

Figure 4 describes the general operation of a mobile IP protocol. The mobile IP protocol allows location-independent routing of IP datagrams on the Internet. Each mobile node is identified by its home address disregarding its current location. While away from its home network, a mobile node is associated with a care-of address which identifies its current location, and its home address is associated with the local endpoint of a tunnel to its home agent. Mobile IP specifies how a mobile node registers with its home agent and how the home agent routes datagrams to the mobile node through the tunnel [22].

Mobile IP is most often found in wireless WAN environments where users need to carry their mobile devices across multiple LANs with different IP addresses.

Mobile IPv6 is a version of mobile IP—a network layer IP standard used by electronic devices to exchange data across a packet switched internetwork. Mobile IPv6 allows an IPv6 node to be mobile—to arbitrarily change its location on an IPv6 network—and still maintain existing connections [22]. IPv6 (Internet Protocol version 6) is the successor to the well-known IPv4 protocol, commonly known as IP.

3.4. The Theory of Connectivism. The learning theory flows through communication theory (communication consists of information that flows through a channel) that is, information (audio music and video images, for example) is transmitted from a sender to a receiver. The effectiveness of communication is improved through interaction. The viewing of communication should not be done only as a one-time event, in which information is sent by teachers and received by the learners; the transfer of information is enabled through a series of communications, such that the receiver sends messages back to the sender, or to third parties.

3.4.1. The Network Analogy. The process of learning as a whole operates more like a social network than a digital computer. The analogy with the network of computers is a good example in which the actual social network itself—a set of distributed and interlinked entities, usually people, as represented by websites or pages—constitutes a type of distributed representation. Specific mental operations, therefore, are like thinking of functions applied to this social network. Based on these mental operations, the following implications are derived: knowledge is subsymbolic (mere possession of the words does not mean that there is knowledge; the possession of knowledge does not necessarily result in the possession of the words); knowledge is distributed across a network of people; knowledge is interconnected; knowledge is personal (self-organized); knowledge is an emergent phenomenon.

Networks consist of three major elements: entities—the things that are connected that send and receive signals;
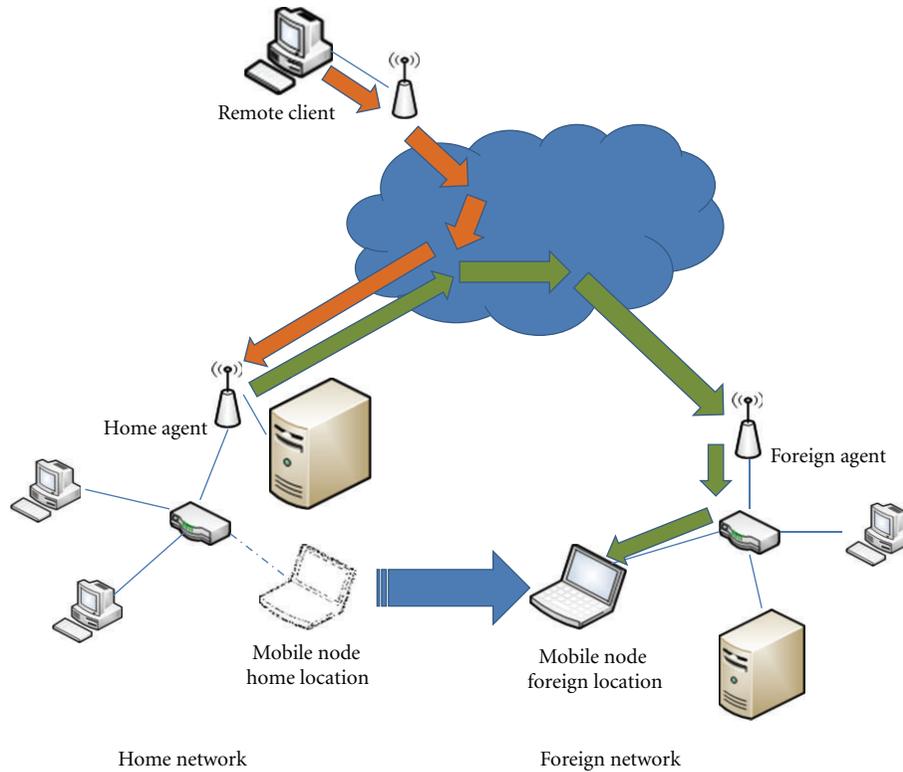
FIGURE 4: Mobile IP protocol general operation.

connections—the link or channel between entities; signals—the message sent between entities.

A network is defined as connections between entities. Computer networks, power grids, and social networks all function on the simple principle that people, groups, systems, nodes, and entities can be connected to create an integrated whole. Alterations within the network have ripple effects on the whole.

Networks are classified according to the following set of properties: density—the number of entities the other entity is connected to; speed—the measure of how long a message moves from entity to entity; flow—the measure of how much information an entity processes, which includes messages sent and received in addition to transfers of messages for other entities; plasticity—the measure of how frequently connections are created or abandoned; the degree of connectedness—a function of density, speed, flow, and plasticity.

The objective of learning the theory of networks is to describe the manner in which resources and services are organized in order to offer learning opportunities in a network environment. Learning networks are not therefore a pedagogical principle, but rather, a description of an environment intended to support a particular pedagogy.

Social network analysis is an additional element in understanding learning models in a digital era. Within social networks, hubs are well-connected people who are able to foster and maintain knowledge flow. Their interdependence

results in effective knowledge flow, enabling the personal understanding of the state of activities organizationally.

3.4.2. What Is Connectivism? Connectivism is the theory that knowledge is distributed across a network of connections, and therefore that learning consists of the ability to construct and traverse those networks. It shares with some other theories a core proposition, that knowledge is not acquired, as though it were a thing. Knowledge is, in this theory, literally the set of connections formed by actions and experience [23].

From the article of George Siemens [24], connectivism is the integration of principles explored by chaos, network, and complexity and self-organization theories. Learning is a process that occurs within nebulous environments of shifting core elements—not entirely under the control of the individual. Learning (defined as actionable knowledge) can reside outside of ourselves (within an organization or a database), is focused on connecting specialized information sets, and the connections that enable us to learn more are more important than our current state of knowing. Connectivism is driven by the understanding that decisions are based on rapidly altering foundations. New information is continually being acquired. The ability to draw distinctions between important and unimportant information is vital. The ability to recognize when new information alters the landscape based on decisions made yesterday is also critical.

The following are the principles of connectivism as discussed by Siemens.

(i) Learning and knowledge rests in diversity of opinions.

(ii) Learning is a process of connecting specialized nodes or information sources.

(iii) Learning may reside in nonhuman appliances.

(iv) Capacity to know more is more critical than what is currently known.

(v) Nurturing and maintaining connections are needed to facilitate continual learning.

(vi) Ability to see connections between fields, ideas, and concepts is a core skill.

(vii) Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.

(viii) Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.

Connectivism also addresses the challenges that many corporations face in knowledge management activities. Knowledge that resides in a database needs to be connected with the right people in the right context in order to be classified as learning.

Information flow within an organization is an important element in organizational effectiveness. In a knowledge economy, the flow of information is the equivalent of the oil pipe in an industrial economy. Creating, preserving, and utilizing information flow should be a key organizational activity. Knowledge flow can be likened to a river that meanders through the ecology of an organization. In certain areas the river pools, and in other areas it ebbs. The health of the learning ecology of the organization depends on effective nurturing of information flow.

4. Interactive WSN-Based u-Learning Model

4.1. What Is an Interactive u-Learning Model? u-learning is a learning paradigm which takes place in a ubiquitous computing environment that enables learning the right thing at the right place and time in the right way. It is an expansion of previous learning paradigms as we move from conventional learning to electronic learning to mobile learning and now to ubiquitous learning (thus, the meaning of "e" is not just limited to "electronic" but expands to "everywhere," "extending", "enhancing," and "enabling."

u-Learning enables us to change our current learning processes to be more efficient and more effective. If done right, u-learning becomes a critical force to improve the performance of our workforce and our organization as a whole [25].

Table 1: WSN Measurable items.

Quantity	Description
Sound	Sound intensity and velocity recognition
Temperature	Heat measurement, source recognition
Light	light intensity measurement, source recognition
Air	Air quality identification, different types of gases identification
Water	Water components, minerals, levels, source identification
Humidity	Humidity measurement

4.2. Wireless Sensor Networks for u-Learning. Educational activities when integrated with wireless sensor networks can help learners improve learning, by becoming more active and making it an easier and more enthusiastic and interactive activity. Learners can interact with the real context obtained from WSNs which could help enhance understanding and learning in specific areas. Table 1 depicts some of the quantities that can be measured and evaluated using WSNs.

WSNs can show learners the different measurements, values, and other characteristics of some parameters of the environment. Learners can be able to observe, collect, and experiment with these parameters with enhanced excitement, and interactivity. For instance, the study of properties like sound, temperature, light, or humidity can be easily supported using WSNs.

Figure 5 shows the infrastructure for the deployment of various Wireless Sensor Networks described in Table 1. The data collection utilizes Zigbee or 802.15.4/6LoWPAN lows-powered mesh topology which is then transmitted to a secured IPs-based infrastructure. WSNs make learners interact with everything in their context, anytime anywhere (context-aware learning triggered by the learner).

4.3. Connectivism for u-Learning Model. The starting point of connectivism is the individual learner. Personal knowledge is comprised of a network, which feeds into organizations and institutions, which in turn feed back into the network, and then continue to provide learning to individual. This cycle of knowledge development (personal to network to organization) allows learners to remain current in their field through the connections they have formed.

The amplification of learning, knowledge, and understanding through the extension of a personal network is considered as the epitome of connectivism.

The following are the implications of connectivism to the u-learning model.

(i) Management and leadership. The management and marshalling of resources to achieve desired outcomes are a significant challenge.

(ii) Innovation: diverse teams of varying viewpoints become the critical structure for completely exploring ideas.

Figure 5: WSN deployment with IP support for interactive u-learning.

(iii) An organization's ability to foster, nurture, and synthesize the impacts of varying views of information is critical to knowledge economy survival, thus, the speed of "idea to implementation" is improved in a systems view of learning.

(iv) The trend of media, news, and information are being challenged by the open, real-time, two-way information flow of blogging.

(v) Personal knowledge management in relation to organizational knowledge management.

(vi) The design of the learning environments.

The theory of connectivism describes a model of learning that acknowledges the tectonic shifts in society where learning is no longer an internal, individualistic activity. How people work and function is altered when new tools are utilized. The field of education has been slow to recognize both the impact of new learning tools and the environmental changes in what it means to learn. Connectivism provides insight into learning skills and tasks needed for learners to flourish in a digital era.

4.4. Proposed Interactive u-Learning Model. u-learning as an interactive social learning model is designed in consideration of some factors that mainly influence the learning process of a learner—member of the net generation. Management systems and structures, competencies, culture, and technology have a direct impact on the learning process of the learners. The media influence in learning plays a big role in the advancements of the learning processes. Media evolved from print to nonprint that could direct attention, arouse motivation, increase student's concentration, and help them to be actively involved in the learning process [26] (Figure 6).

The advancement of computing technologies together with the enhancement of wireless communication technologies nowadays help out to support the expansion of ubiquitous computing, hence, lead to the advancements of the learning processes. A variety of computing and communication technologies have been developed, such as

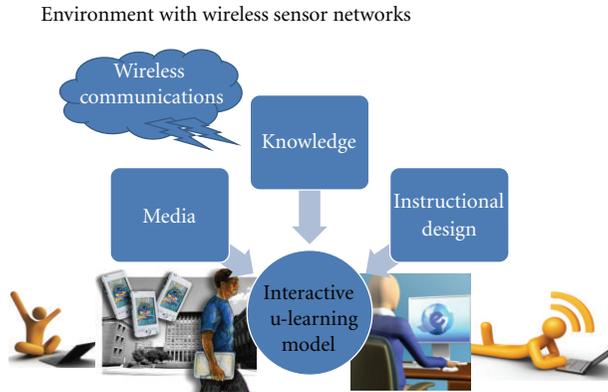Environment with wireless sensor networks

FIGURE 6: WSN-based interactive u-learning model.

sensors and actuators, RFID (radio frequency identification) tags and cards, wireless communication equipment, mobile phones, PDAs (personal digital assistants), and wearable computers.

This model aims for accommodating learners in their learning style by providing adequate information anytime and anywhere as they wish for it. To promote a more effective application of u-learning, a model for the design of an online learning environment is presented. This model guided by principles of learning paradigms advances the computing capabilities allowing educators to become catalysts of learning, transforming students into more active and collaborative participants in knowledge making.

Knowledge repository refers to a wide range of knowledge domains across various subject areas including math, physics, biology, social science, and language, it is being interacted upon by goal analysis, task analysis, learner characteristics, and other semantic rules to provide a design for knowledge representation for learners.

Media repository represents the different media to support the knowledge representation in u-learning. For example, learners can use multimedia tools to create a learning object that contains the new knowledge created by the learner and post it to the web to share with others. Media refer to the use of one medium (e.g., video) or a combination of several media (e.g., video, audio, textbook, etc.) in instruction.

Instructional design repository consists of all the design components in instructional design. This is the basis for the design and modality of the learning modules in the u-learning model.

The u-learning model described presents information in an interactive and informative way. This may include courses, student's information, and teacher's information. The development of the learning content is based on the instructional designs applied to the information stored on the knowledge repository.

Based on the inputs from the instructional design component and domain knowledge analyses in the knowledge repository, the knowledge representation is formed. Various learning modules are formulated to represent the knowledge identified, and at the same time the rules of reusability

and sharability are applied to the design and development of instructional modules. Unlike the traditional design, knowledge representation enables learners to experience the construction and creation of knowledge through multiple venues, thus promoting a learning process that focuses on the understanding of "how do people know it" rather than "what do people know."

An online instructional program is created to facilitate dynamic knowledge acquisition and creation as well as to promote learners' self-initiation and collaboration in learning. In the design of the instructional program, the current state and needs of the learner are determined, the end goal of each instruction is defined, and a learning intervention to assist the acquisition of new skills, knowledge, or expertise is developed.

4.5. Proposed Interactive u-Learning Characteristics. The interactive u-learning model was designed and developed considering the two major areas.

(i) Resources—students needed one place to find both internal (forms, FAQs, course offerings, etc.) and external information (RSS feeds, bookmarks, etc.).

(ii) Community—students needed a place to collaborate, communicate, and share information such as ideas, photos, videos, and news.

Characteristics of an interactive u-learning model [12].

(i) Permanency: the information remains and learners can never lose their work unless the learners purposely remove it.

(ii) Accessibility: the information is always available whenever the learners need to use it. Learners have access to their documents, data, or videos from anywhere.

(iii) Immediacy: the information can be retrieved immediately by the learners wherever they are.

(iv) Interactivity: the learners can interact with peers, teachers, and experts efficiently and effectively through different media in the form of synchronous or asynchronous communication.

(v) Adaptability: learners can get the right information at the right place with the right way.

(vi) Context awareness: the environment can adapt to the learners, real situation to provide adequate information for the learners.

(vii) Theory based: contents of the learning modules are based on contemporary approaches to teaching and learning.

(viii) Innovative and relevant: contents of the learning modules are designed based on the learning objectives.

(ix) Emergent: allowing (where appropriate) the interactions between course participants and enable them to actively explore the relevance and application of the course content.
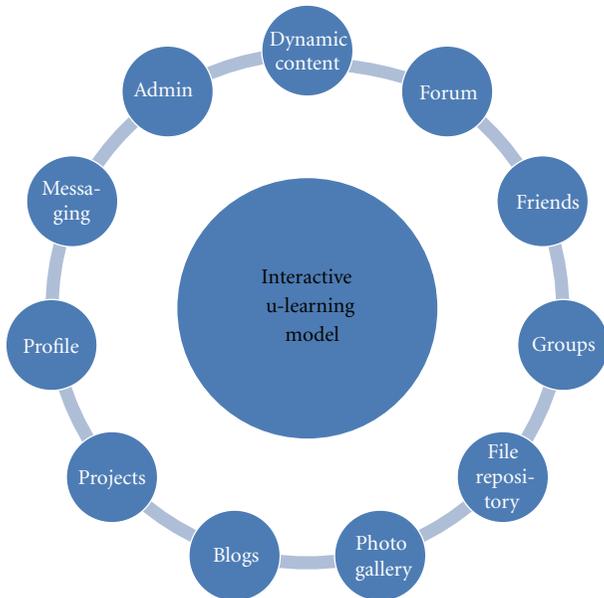
Figure 7: Interactive u-learning model functionalities.

(x) Personalized: participants are able to apply their own context and situation to the learning outcomes. The learning could be embedded in the learner's daily life.

Learners are offered the opportunity to increase the implements using the latest multimedia technology, equipment, and testing.

4.6. Proposed Interactive u-Learning Model Functionalities. Some of the major features and functionality of the interactive u-learning model include the following (Figure 7).

(i) Dynamic content—user-generated content can appear throughout the website in addition to automatically generated content such as RSS feeds of news, journals, and blogs.

(ii) Forums—registered users can create discussion threads about courses, research, administration, or just about anything.

(iii) Projects—registered users can create and manage all aspects of a project and invite others to join the project through an online project management tool. This function could be found on the user's profile.

(iv) Profile—registered users are automatically given a profile that can be edited and updated with personal and profession information.

(v) Messaging—registered users are allowed to send and receive private messages within the community.

(vi) Administration—allows admin users to maintain courses or instructional modules provided for students. This function is provided for teachers to allow them some administrative functions of the e-learning system.
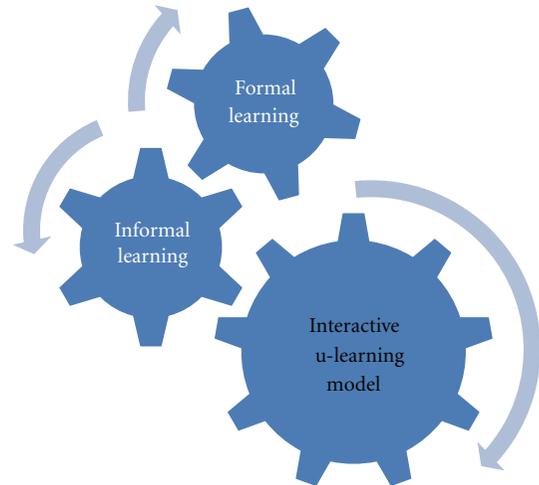

Figure 8: u-learning implementation model.

(vii) Friends—registered users can connect and create friendship networks by accepting and requesting friends within the u-learning community.

(viii) Groups—allows users with similar interests, or perhaps users as part of a research groups or a course/class, to have a more structured setting to share content and discuss ideas. Users can create and moderate as many groups as they like. Group activity could be kept private to the group or the "make public" option can be used to disseminate work to the wider public. Each group produces granular RSS feeds, so it is easy to follow group developments. Each group has its own URL and profile, and each group comes with a file repository, forum, pages, and a message board.

(ix) Blogs—users are allowed to publish entries of commentary, descriptions of events, or other material such as graphics or video.

(x) Photo gallery—allows users to manage and organize their photo collections by adding titles, rating, captions, and custom metadata tags to photos. Users can also see pictures that their friends have uploaded, or see pictures attached to a group. Clicking on an individual file shows a larger version of the photo.

(xi) File repository—allows users to upload any kind of file. The uploaded files can be filtered by tag and users can restrict access so that files are only visible to the people they want. Each file may also have comments attached to it.

4.7. u-Learning Implementation. u-Learning contents are developed based on two major areas as shown in **Figure 8**. One is the resources for the process of an academic study (formal learning). These include the academic calendars, the program descriptions and requirements, various forms for portfolio reviews, advance to candidacy, and graduation. The u-learning model provides one place to access all these

Figure 9: u-learning community implementation tools.

materials. WSNs were utilized to enhance mobility and interactivity and to create a new learning environment.

The other area is for the social needs of learners (informal learning), which can help to develop a learning community. These include access to forums, sites with RSS feeds, blogs, alerts, journals, and research threads, this is the place where learners collaborate, communicate, and share information such as ideas, photos, videos, and news.

The development of the u-learning web-based e-learning system is focused on open-source technology solutions with flexibility and scalability.

Some e-learning implementations are analyzed and the important features and elements needed to accommodate the learning process of the net generation learners are identified. Then, the different technology solutions are reviewed as suggested by the current trends in technology developments while looking at new open-source options available to determine the best solution for the development needs.

These technology options were chosen based on compatibility, having the required features, time and skill required for implementation, flexibility, ease of use, and future scalability (Figure 9).

It is suggested to use Joomla as the content management system (CMS) solution which has a strong administrative focus that allows nondevelopers to quickly install and manage the system. It also offered a large number of modules that can be easily installed to meet the needs of the community [27].

The integration to this content management solution of Moodle, an open source learning management system (LMS), allows even nontechnical teachers to set up and maintain where students can log in, access course information, interact, share, and teach others. Moodle's main focus and purpose are for managing learning activities and users, but it also has a built-in functionality for blogging, wikis, and many other applications similar to Joomla.

Moodle also known as course management system has several features typical of an e-learning platform, plus some original innovations (like its filtering system). Moodle can be used in many types of environments such as in education, training and development, and business settings [28].

Developers can extend Moodle's modular construction by creating plugins for specific new functionality. Moodle's infrastructure supports many types of plug-ins:

(i) activities (including word and math games),

(ii) resource types,

(iii) question types (multiple choice, true and false, fill in the blank, etc.),

(iv) data field types (for the database activity),

(v) graphical themes,

(vi) authentication methods (can require username and password accessibility),

(vii) enrollment methods,

(viii) content filters.

Integrating a CMS with the LMS—both web applications—makes a single sign-on solution for the u-learning community realistic. Another web application yet to be integrated is the Elgg social networking platform with support for blogs, wikis, communities, and other things that could be associated with the CMS.

Elgg provides the necessary functionality to allow you to run your own social networking site, whether publicly (like Facebook) or internally on a networked intranet (like Microsoft SharePoint) [29].

5. Discussions and Its Significance

In a conventional e-learning environment, students learn and practice in the cyber world wherein complex operations or problem-solving procedures are usually trained in a web-based learning environment that simulates the scenarios of the problem domain. These learning or training approachs are helpful to the learners in identifying the problem to be coped with, but it could be difficult for the students to learn the problem-solving skills without observing and practicing in the real world.

This paper of an efficient and interactive WSN-based ubiquitous learning model proposes a web-based interactive social learning model based on wireless sensor networks which are able to sense the personal and environmental contexts to provide adaptive supports to the learners.

An adaptive model of technology selection is a requirement to ensure that the needs of the learners are met. The interactive u-learning is a learning approach which asserts that knowledge and the learning of knowledge are distributive and are not located in any given place but rather consist of the network of connections formed from experience and interactions with a knowing community, and the digital-age learner is thinking and interacting in new ways (Figure 10).

The proposed WSN-Based u-learning model helps produce positive outcomes as they are delivered and evaluated, supported by holistic approaches that include appropriate policies, infrastructure, professional development, and curricula. It is also indicated that a more technology-rich environment delivers greater impacts.

For students, this model can provide an educationally-superior alternative to traditional lectures, in which learning can take place outside of the classrooms. It can also provide a model for students on how to become self-directed, independent learners, which may assist them to become "lifelong learners."
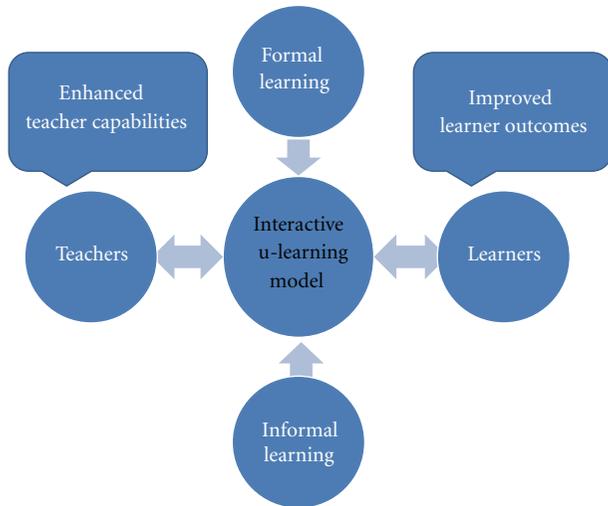
FIGURE 10: u-learning community significance.

The u-learning model can help increase student engagement, motivation, and attendance which are the key requisites for learning. It could effectively improve performance on core subjects and foster the development of 21st century skills. Thus, it has the potential of creating a sense of engagement, motivation, retention, progression, excitement, and involvement which could promote new forms of attainment which were not adequately measured by traditional assessment.

For teachers, this model provides them with the opportunity to test students in real business situations and new methods to evaluate each student's learning. These may cause changes in their work patterns and even change the teacher's entire approach to teaching and learning. It is not just a change of knowledge and content but the pedagogy and relationships between teachers and learners as well.

The u-learning model can improve communications between students, and between students and teachers, thus, it promotes interactivity, rapidity of response, and objectivity of marking, enabling personalized support, learner-led pacing, new forms of access to learning, and so forth. With this technology, teachers can access tools that enable them to deliver customized assessments and gain immediate feedback on individuals and class progress. With this feedback, they can provide learning opportunities using remediation and enrichment to deliver more differentiated instructions that meet each learner's needs, and thus, promote student-centered teaching and preparation.

The proposed model emphasized that the u-learning model is much more organized than traditional and conventional one-to-one instruction with its ability to interface learners with the real-world scenario, and such a systematic learning facility could increase learning efficiency. It can also indicate that students would prefer to learn with such a u-learning system because of its convenience and interactive and innovative system.

In addition, the u-learning model proposed in this study can effectively and efficiently improve the performance of training complex problem-solving skills in the real world. This model is highly recommended as an innovative approach to learning science environments, such as specific physics or chemistry experiments.

6. Conclusion

The ubiquitous learning concept has gone beyond portable computers. Technological innovations will be embedded and blended into our daily chores as new technology evolves and more pervasive forms of technology emerge. We tend to easily adapt to the use of technologies and pedagogies that emerge in this age of progress and great change.

The advantages of an adaptive learning environment combine with the benefits of ubiquitous computing and the flexibility of mobile devices through the development of ubiquitous learning environment. Students have the freedom to learn within a learning environment which offers adaptability to their individual needs and learning styles, as well as the flexibility of pervasive and unobtrusive computer systems.

u-learning is a learning paradigm which takes place in a ubiquitous computing environment that enables learning the right thing at the right place and time in the right way. It is an expansion of previous learning paradigms as we move from conventional learning to electronic learning to mobile learning and now to ubiquitous learning. This u-learning model is guided by the theory of connectivism which asserts that knowledge and the learning of knowledge are distributive and are not located in any given place but rather consist of the network of connections formed from experiences and interactions with a knowing community.

u-learning model is designed as an interactive social learning model based on wireless sensor networks that aim at accommodating learners in their learning style by providing adequate information at anytime and anywhere as they wish for it. Hence, u-learning model is web-based and incorporates e-learning, m-learning, wireless sensor networks, and the ubiquitous environment to provide mobility and flexibility to learners as well as the teachers.

In light of these developments, educators must update learning and ensure that their pedagogical theories are aligned with the active and collaborative nature of such technologies. They must consider the opportunities it provides for the delivery of enhanced learning.

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