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Ubiquitous computing: a learning system solution in the era of industry 4.0

Wildan Toyib[a,1,*], Delvis Agusmanb[,2], Hari Ramza[c,3]

[a] *Dep. of Informatics Engineering, The University of Muhammadiyah Prof.Dr. Hamka, Jakarta 13830, Indonesia*
[b] *Dep. of Mechanical Engineering, The University of Muhammadiyah Prof.Dr. Hamka, Jakarta 13830, Indonesia*
[c] *Dep. of Electrical Engineering, The University of Muhammadiyah Prof.Dr. Hamka, Jakarta 13830, Indonesia*
[1] *{wildan.thoyib*; [2]delvis.agusman; [3] hramza}@uhamka.ac.id*
** corresponding author*

ABSTRACT

Ubiquitous computing, which was initially advocated by Mark Weiser has become one of the keywords to express a vision of the near future of computing systems. The "ubiquitous world" is a ubiquitous computing environment with integrated networks; computer integrated manufacturing system (CIMS) and invisible computers which equipped sensor microchips and radio frequency identification systems. Anyone can access the ubiquitous computing systems anytime and anywhere broader, without individual awareness or skills. Ubiquitous computing is becoming crucial elements to organize the activities of groups of people by use of groupware under workforce mobility. The computer-supported cooperative work is transforming from telework to ubiquitous work with new information and communication technologies that support people working cooperatively. Ubiquitous learning is a demand for the knowledge workforce for more multi-skilled professionals. It is a new and emerging education and training system that integrating e-learning of cyberspace and mobile learning of physical space with a global repository that has the potential to be accessed by anyone at any place and anytime under ubiquitous integrated computing environment. In this paper, we discuss the study of emerging trends through the implementation of work and learning that influenced ubiquitous computing technology prospects. Furthermore, the perspective of ubiquitous work and learning system, gaining quality, and hence credibility with emerging information and communication technologies in education and training systems in the area of the education system are discussed. The experimental results showed that CIMS could improve the students learned more efficiently and achieved better learning performance.

Keywords:
Ubiquitous computing
Ubiquitous world
Computer-supported work
Cooperative work computer
Ubiquitous learning systems

I. Introduction

Over the last few decades, the information and communication technologies have improved greatly, and wireless network computing systems have become more widespread anyplace. The Internet and information technology are transforming every aspect of life in the world. We are living, online shopping, mobile banking, working, governing, studying, researching and communicating in new ways that are enabled by technology, they responded with a rich of collection of vision that offer of glimpse of a future in which learners could explore worlds and cultures beyond their own, in both distance and time as if they were there. Student can interact with historical figures, educators and trainers could have new high-wage job opportunities, and students, teachers, parents could collaborate in productive new ways, a few of these visions offer cautionary tales that should serve remind us that we must strive to apply the power of technology in ways that empower learners and teachers enlighten the mind and enrich the quality of lives [1].

Smartphones that we know as a powerful tool for computing today could be used for ubiquitous learning system at anyplace anywhere, The security of the Smartphone is the important issues in the field of informatics technology due to fast propagation of smart technology of our life [2]. The performance of smartphone applications is usually constrained in user interactions due to resource limitation, and it promises great opportunities to improve the performance by exploring the smartphone built-in and embedded sensing techniques. However, heterogeneity in techniques, the semantic gap between sensor data and usable context, and the complexity of contextual situations keep

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W : http://journal.uad.ac.id/index.php/JIFO
E : jifo@uad.ac.id

the techniques from seamless integration. Relevant studies mainly focus on the feasibility demonstration of emerging sensing techniques, which rarely address both general architectures and comprehensive technical solutions. Based on a proposed functional model, this investigation provides a general architecture to deal with the dynamic context for context-aware automation and decision supports [3], As a result, computer-supported cooperative work (CSCW) holds great promise for the organizations through the infusion of teamwork, effective networking and creating multilateral work environments. People who work together in cross-functional or even cross-organizational teams can establish quick work plan, divide up tasks, and determine means of coordination and self-regulation. Often team members work asynchronously, but their work can be coordinated effectively through CSCW [3-4].

With this, teachers and educators started to look at ways to use this technology in education and training. Computer-based education (CBE) was one of the initial stages, leading to online education and e-teaching and learning in the mid-1990s. E-learning offered new ways for students to access many resources anytime. This was a breakthrough in education and training systems leading to better management of both classroom and distance education and training [40]. With e- teaching and learning systems, blended teaching, and learning became effective. Mobile learning (m-learning) is often thought of as a form of e-learning, but m-learning is a new stage in the progress of e-learning and that it resides within its boundaries. M-learning is not only wireless or Internet-based e-learning, but it should include the concept of any time and anyplace without a permanent connection to physical networks. The advantages of m-learning compared to e-learning include (1) flexibility, (2) cost, (3) size, (4) ease of use, and (5) timely applications. The devices are mainly PDAs, mobile phones (iPhone), portable computers, and tablet PCs with wireless communication [5-7].

The ubiquitous revolution or the ubiquitous computing was advocated by Mark Weiser, who was a researcher of the Palo Alto Research Center (PARC) of Xerox Corporation, California, and the USA. He proposed the following four characteristics of ubiquitous computing [4], [8]. First, a computer which is not connected with the network is not the ubiquitous computer; second, its human-like interface is invisible; third, it is always possible to use a computer in a real-world, not a virtual world; and finally its service changes according to a user's context at any place, any device, any identification, any time, any temperature, or any weather. The word "ubiquitous" came from a Latin word meaning "being or seeming to be everywhere at the same time" or "omnipresent". Ubiquitous computing refers to a computing environment that access will be anywhere and anytime: wherever we go, whenever we want to use it, we can access the computing network and acquire the necessary information. The "ubiquitous world" is a ubiquitous computing environment with integrated networks and invisible computers which equipped sensor microchips and radio frequency identification (RFID) systems can be accessed everywhere, and anyone can carry out information transactions anytime, anywhere, without special awareness or skills [4]. The ubiquitous space is an integrated space of cyberspace in virtual places and physical space in practical places [9].

With this ubiquitous technology, it has been possible to work under ubiquitous work (u-work) service environment anywhere anytime. The u-Work environment is a new type of work circumstances of workers undertaking advantage of sophisticated wired and wireless computer network technologies. U-workers can conduct their routine business works at any time and any place by use of portable PC, PDAs, or smartphones (iPhone) with their mobility [10].

These days, since the work environment is becoming the primary source for learning, the relationship between working and learning has been fundamentally changed. We were learned to prepare the work. This means that learning preceded working. Now, learning might be considered as a direct consequence of working. Knowledge-based work, in which workers must combine and interpret information and knowledge under the CSCW environment to find solutions for new problems they encounter in their daily work, is replacing conventional work. Knowledge workers who demand cooperative work cannot get their job without learning and add value without collaborative learning [3-4], [40].

Ubiquitous learning (u-learning) for u-work is a new and emerging learning system integrating e-learning of cyberspace and mobile learning (m-learning) of physical space with a global repository which has the potential to be accessed by anyone at any place and anytime under ubiquitous computing environment [11], Distance learning has facilitated access to information and training, gaining quality and hence credibility [12]. On the other hand, the ubiquitous learning system is becoming a great ally

to the formation not only academic but also social. For reach these benefits were modeled and developed the Mobile system, which consists in a solution for accessing and sharing content for mobile devices, based on the characteristics of ubiquity and mobility, being provided with a subsystem that considers the semantic enrichment and provides customization of content to the user[13].

The goal of information technology, and especially ubiquitous learning system, must be to create an environment where every learner will have a series of resources and teachers in different discipline expertise and in different locations, with teachers or mentors to help organize the information, and help the student pursue some areas in depth. This is currently too expensive, but there is hope that several upcoming technologies listed below can be deployed in the future [4], [6], [14].

Future technologies live in a symbiotic relationship amongst teachers, students, parents, and society at large [15]. We view the technology as an enabler in several ways:

a) Help organize and provide structure for the teacher's material to students;

b) Help students, teachers, and parents interact (anytime and anywhere), in order to follow the progress of learning in each subject;

c) Facilitate and assist in the authentication, search and prioritization of the digital material available on the web, which in this case serves as a worldwide encyclopedia;

d) Simulate and visualize structures and processes which are the result of physical, chemical, biological and engineering (STEM) models and to interact in real-time with them in the area of higher education system curriculum development [31];

e) Help in learning history, and or future trends because technology can reconstruct the life and, hence facilitate visualization of going back and forth in time;

f) A tool for the handicapped population, technology, can serve as an extension and enhancer for their missing capabilities, being perceptual, physical, or cognitive, so that they can equally receive the delivered information for a given subject, just as the normal population. Several examples might be, for the visually impaired, one can have brail lettered terminals and input/output devices. For paraplegic subjects, there are several robotic customized devices for interacting with teaching material. For the cognitively impaired population, the teaching material must be adapted properly.

Here the software enabler mentioned above, for example, will be of use.

Interfaces for ubiquitous computing, in which portable wireless devices infuse virtual resources as we move through the real world. The early stages of "augmented reality" interfaces are characterized by research on the role of "smart objects" and "intelligent contexts" in learning and doing [16].

The art of this research is as the important issue ineffectiveness for learning is not the sophistication of the technologies, but the ways, in which their capabilities aid and motivate students, we analyze the latest conditions in ubiquitous learning system solutions in the Industrial 4.0 era, we can find both in the cities and villages, almost all adolescent learn to use smartphone devices with various brands and types, due to make an idea about this research—the relationship between humans and smartphones, such as bodies with clothes today. Therefore we connect human interaction with Smartphone in terms of filling up material that has been digitized with a variety of fun learning features, the contents of this material can be reached out in the form of interesting games, web-based applications which are containing tips and trick questions, logic questioner machines, or word-for-word devices for the purpose of understanding the meaning of words, and understanding mathematics with computed verbal and other types of learning models whose found in the conventional classrooms and many more, which by this study we present the emergence of future learning methods. The strength of this study is the idea of the emerging evolution of software engineering in the way of learning models, the most important media today is a smartphone, changing the way of thinking and shaping students' habits from conventional learning to digital learning, Then all the contents of the subject is converted into digital contents which is deployed in apps such as interesting, artistic and easily understood by age learning, and find that roles other than learners have not received much attention in the literature. Finally, we propose supporting different needs identified for four user roles by adding meta-level functionality to ubiquitous learning systems [18].

In this paper, we discuss the advent of u-work and u-learn service platform in the CSCW environment with ubiquitous computing technology [42]. Also, we will discuss prospects and

perspectives of ubiquitous work and ubiquitous learning with ubiquitous technology as emerging information and communication technology for education and training systems.

II. Methodologies of Learning Technology

A. The concepts of computer-supported cooperative work and ubiquitous work

Computer-supported cooperative work (CSCW) holds great promise for the organizations through the infusion of teamwork, effective networking, and creating multilateral work environments [4], [17]. People who work together in cross-functional or even cross-organizational teams can establish quick work plan, divide up tasks, and determine means of coordination and self-regulation. Often team members work asynchronously, but their work can be coordinated effectively through computer-supported cooperative work.

CSCW systems are often categorized according to the time/location matrix using the distinction between same time (synchronous) and different times (asynchronous) and between the same place (face-to-face) and different places (distributed). Table 1 shows the types of cooperation generated by CSCW.

Table 1. The types of cooperation generated by CSCW

Types of cooperation	***Computer-supported cooperative work***	***Authors***
Focused partnerships	Users who need each other to complete task e.g. joint authors of a report, a team of programmers working on software, journalists and editor working on a magazines or newspaper.	Chris Dede, Diana Walczak [1], Park Man Gon [3-4],
Online teaching or training	Person shares information with people at remote sites such as questions may be asked, and he/ she can keep a history and be able to replay it.	Ruzena Bajcsy, Chris Dede, Randy Pausch, R. Stanley Williams, Michael Zyda and Douglas H. Bennett [1]
Conference	Group participation distributed in space, which could be at the same time through chat, video conference, u-dashboard apps, electronic whiteboard, voice-over-net. This can also spread out over time e.g. email, discussion board, WhatsApp's, telegram and other smartphone apps regarding to social media features.	Park Man Gon [4], Milton Chen, Stephen D. Arnold, Chris Dede [1]
Structured work process	Under this type a set of people with distinct roles conduct a large task e.g. a company hiring committee accepts applications, reviews the application, invites top applicants for interviews, chooses the best, informs everyone	Milton Chen, Stephen D. Arnold, Chris Dede, Randy Pausch [1]
Tele-democracy	Under this type of CSCW, people need to collaborate locally and needs tools to record debate, register votes securely and ubiquitous voting (u-voting)	Chris Dede, Gerald A. Higgins, Ulrich Neumann and Chris Kyriakakis [1]

Achieving higher levels of productivity within a group is important to note that CSCW systems are not just useful for collaborative work. Their capabilities are equally important for collaborative learning and knowledge construction. That is why many organizations are utilizing CSCW technologies in their education and training systems. Now CSCW is transforming from the telework to ubiquitous work with new information and communication technologies such as BcN (Broadband convergence Network), WSN (Wireless Sensor Network)/USN (Ubiquitous Sensor Network), which support people working cooperatively. This means that CSCW is demanding an optimized working

environment that any worker conveniently and efficiently can do his task anytime, anywhere [3-4], [18].

The concept of u-Work that makes it possible to work anywhere anytime has transformed the conventional concept of time and space in which household work was possible only by the hands of people [19]. The u-Work environment refers to a new mode of work circumstances under which workers, taking advantage of sophisticated wired and wireless information communication technologies, can conduct their routine business works at any time and any place with mobility, as illustrated in Fig. 1.

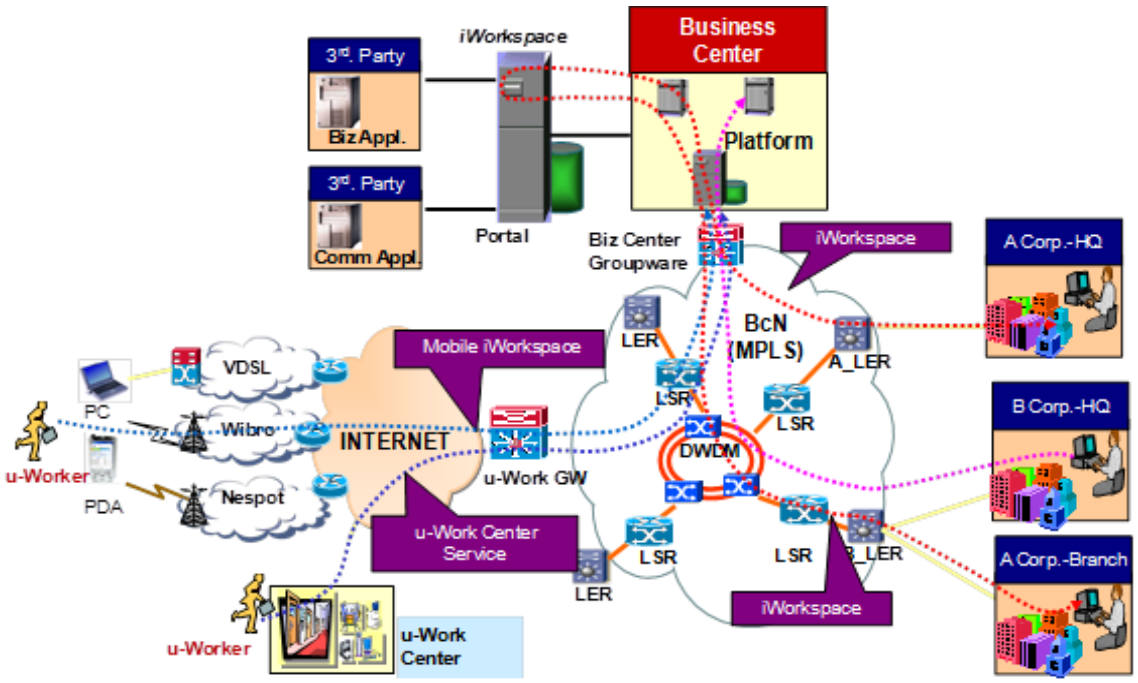

Fig. 1 U-Work Service Network Configuration

B. The platform of u-learning service

Fig. 2 illustrates the generic platform for u-work services. The u-work service platform is a middleware that enables the integration of diverse services by using business process management. U-workers in the place such as car, home, street or hot spot area can collect, store, manage, and analyze data through PC, PDA, or iPhone among various u-work services which are the major components of the platform. It serves as the hub to integrate techniques and functions that are associated with u-work services and provides an environment to develop and run the u-work services [20]. Besides, the platform provides service process templates, steps of a process, and work data structures, which allow service developers to easily create new u-work services based on the process template, and by considering specific concerns of the target user group and the environment. This makes the platform evolvable and adaptable to new situations. Figure 3 illustrates the architecture of the platform that shows the major components and the connections to the surrounding elements in the u-work service framework.

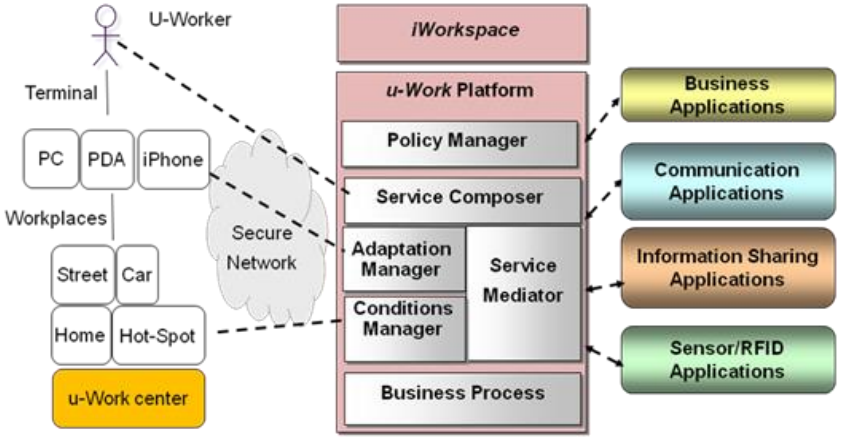

Fig. 2 U-Work Service Platform

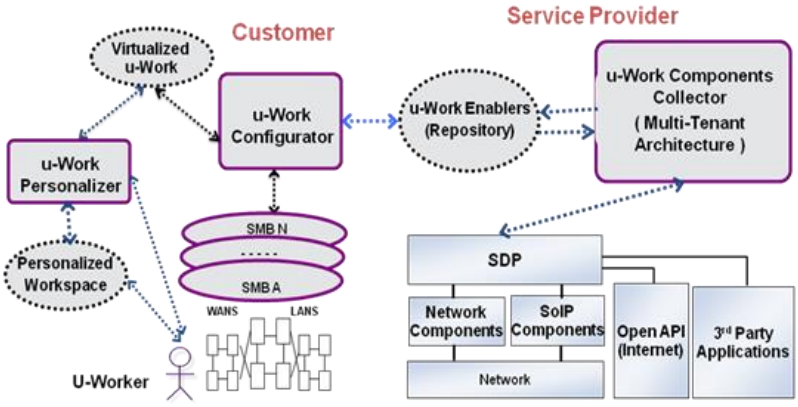

Fig. 3 Interaction role between u-Working Service Framework and u-Worker and Service Provider

III. Emerging of ubiquitous computing

Emerging of ubiquitous computing to work in the computer-supported cooperative works could be distracted as below.

A. Shifts from e-learning and m-learning to u-learning

The applications of information and communication technologies (ICT) in education and training systems have been used extensively in the classrooms, offices, and homes with mobility [21]. A key benefit of e-learning for teachers and learners is the increased flexibility in the approaches by which teachers teach, and learners learn under the web-based information systems with networks and computers. However, most e-learning experiences are based on the access of teachers and learners to the information resources such as database, accessing drivers, browsing tools, and so on through terminals, which is generally restricted either by location, time, or both.

Recently e-learning is shifting to m-learning with mobile devices such as PDAs, mobile phones (iPhone) and portable laptop computers with mobile technology for teaching and learning in small and manageable platforms that teachers and learners can undertake at their own convenience and efficiency[23]. M-learning is a natural extension to conventional e-learning practice, which allows high accessibility to teach and learning resources [24].

Technology now allows us to carry vast resources in our pockets and access these wherever we find convenient and interact with our peers instantaneously and work together remotely in ways never before possible. M-learning offers the possibility to arrange learning settings flexibly and spontaneously, helps organizational skills, encourages a sense of responsibility, helps both independent and collaborative learning, and can be used to help track and assess the progress of achievement for learners.

The integration of ubiquitous technology in education and training marks another significant step forward, with the advent of u-learning through the concept of ubiquitous computing. It is reported to be both pervasive and persistent, allowing teachers and learners to access education and training systems flexibly, calmly, and seamlessly [21]. U-learning has the potential to revolutionize education and training systems and to remove many of the physical constraints of traditional teaching and learning systems. Furthermore, the integration of adaptive learning and collaborative learning through u-learning may offer great innovation allowing for personalization and customization to the needs of teachers and learners. Progressive evolution from e-learning through m-learning to u-learning via distributing system through the collaborating system to integrating system is depicted in Fig 4.

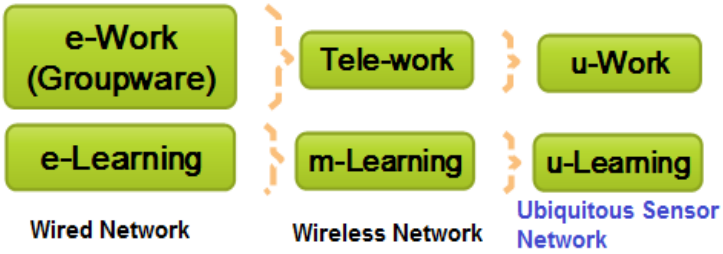

Fig.4 Progressive Evolution of computer-based teaching and learning systems and computer-supported cooperative work

Any of the three trends of computer-based teaching and learning systems can provide the possibility of augmenting text with graphics, animation, image, video, voice, and any other interactions. Even with limited connectivity beyond an institution, one can determine a teaching and learning path, arrange onboard to teach and learn new technology and knowledge, and provide a systematic teaching and learning experience [28]. With connectivity on-demand or always-on, one can have a fine-grained and rich learning environment when and where it is convenient.

This situation suggests that the design of teaching and learning needs to consider added dimensions: flexible content display, and the possibilities of delivering teaching and learning in random contexts [29], but also potentially right at the exact context.

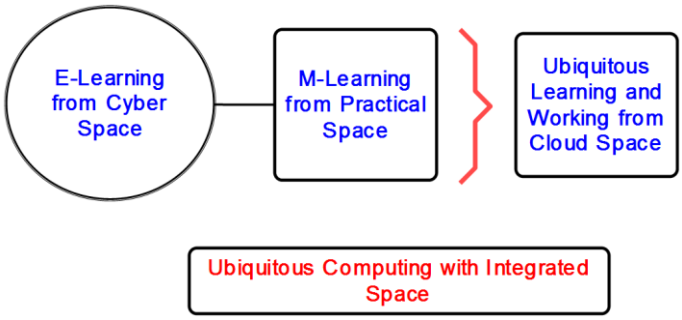

Fig. 5 Relationship among e-Learning, m-Learning, and u-Learning

It is difficult to find an accurate distinction between m-learning and u-learning [20] because it has a big pedagogical common area. However, we can classify u-learning as the intersection area of e-learning and m-learning as integrated space, as shown in Fig. 5.

B. Impact of ubiquitous technology in education and training

The rapid and accelerating move toward the adoption and use of mobile technologies has provided teachers and learners with the ability to study away from the classroom and on the move [30]. Wireless mobile technologies influence the evolution of current e-learning use and press forward the development of a new model of education, enabling anytime, anywhere, and anyhow learning. U-learning provides even greater freedom than the current learning environments, which have limited

access to content. Moreover, its applications will provide them with facilities for creating personalized learning environments. The applications of this technology will not only transcend the barriers of space and time but will also satisfy the changing educational needs [27]. Handheld computers can empower students to take responsibility for their own learning. While using handheld computers, students are more engaged in learning, and often find their own ways to use handheld computers to support their learning, both in and out of class. U-learning utilizes interactive tools such as simulations, learning games, threaded discussions, and video presentations, which add an extra dimension to coursework. Since multimedia resources offer text, audio, and video, one can learn through different modes, making the entire process more learner-centered. Under ubiquitous computing, handheld devices are always networked, thereby allowing easy input through pens and/or speech or even a virtual keyboard when necessary [28]. These devices also can let the learner see high-resolution images and hear the quality sound.

Fig. 6 represents the u-learning environment applying ubiquitous computing based on the wireless network system on the campus. U-learning is utilizing mainly three types of facilities: u-classroom, u-lecture, and u-experience. RFID server verifies and recognizes students' IDs using sensors network and displays students' information to u-boards [25]. This server is connected through the LAN, consisting of the data server, library server, and central server, thereby enabling the management to access information about the students.

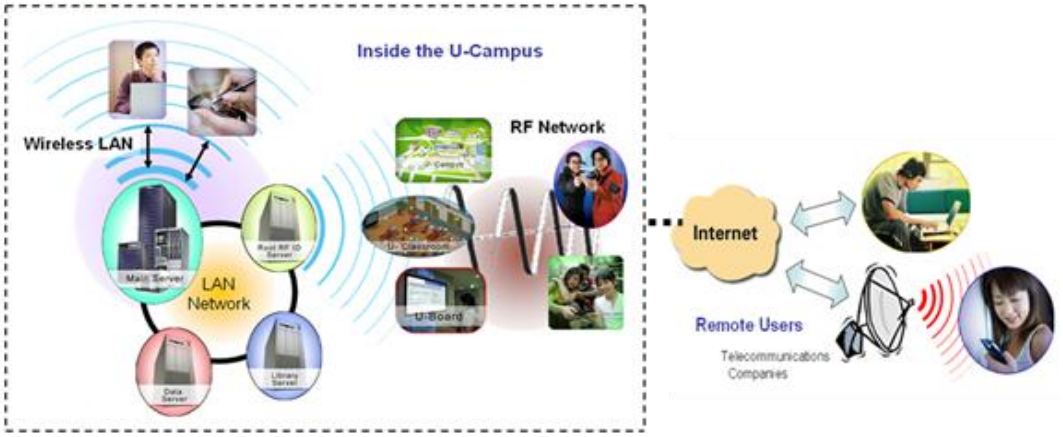

Fig. 6 Application of ubiquitous computing in education and training system

IV. Futuring Ubiquitous Learning System

Developing the ability to learn has become the primary goal of future education and training [21]. It is necessary to universalize access to education, including higher education and technical and vocational education and training. Recently the relationship between working and learning has been fundamentally changed by the rapid expansion of knowledge and information. In the concept of work-based learning, the work environment is becoming the primary source of learning. Knowledge workers must integrate information and knowledge and learn for their works under CIMS and CSCW environment with coworkers' groups to find solutions for new problems they encounter in their daily work [29]. By the advent of ubiquitous technology, knowledge workers have become ubiquitous workers and must learn for their works by service of u-work with u-learning systems implementation.

A. Ubiquitous lifelong learning and u-work scenario

Exceedingly flexible ubiquitous technology at anywhere and anytime can be used ubiquitous lifelong [3-4] learning for u-workers in the future [12]. A step by step demonstration of the u-work with personalized learning by taking an example is presented below:

Step 1: Registration to a Multimedia Contents Development course by Smartphone

Miss Airin registers for an advanced multimedia contents development course. She is having a problem in her response time and needs to learn more about web designing for her work. Based on her learning requirements and the course objectives, personalized academic material is downloaded into Airin's choice of form factors (one for the car, one for reading on her tablet, one for her graphical

user interface environment) [44]. Her wallet receives the transaction receipts, and her expense reports automatically report to her company, and the bill is paid instantly.

Step 2: Applying for Teleconferencing session on the plane

An animation creation session on campus is available via teleconference, and although Airin is on her way to the airport at that time, the session is recorded and sent to her through Smartphone, which she will interact with on the plane. As she reviews and interacts with the material, she watches information automatically displays onto her assessment monitor that she filled out with information on why she's taking this course.

Step 3: Identification of contents for projects/subjects

She identifies the contents which are useful to her, examines the autogenerated goal maps, and aligns the information with her current projects for her company. An email is automatically generated for her to send to her coworkers and customers to update them on new ideas.

Step 4: Interaction with her supervisor/mentor

A notification from her supervisor arrives on her Smartphone with a reminder of the first online project she wants to discuss. Along with it come to a research project outline, suggested contacts, and an analysis of her project. The supervisor reviews her task list and makes a few suggestions on how to work best with her collaborative u-workers team.

Step 5: Interaction with her supervisor by email by using Smartphone

A couple of days later, Airin returns from Yogyakarta city and emails her supervisor with some suggestions for a decrease in resources for their project. She has figured out a better way to solve one of their problems as a result of the first ubiquitous lifelong learning course interaction and evaluation of workflow for the project. She sees results already; she decides to take a Question and Answer exercise to see how to best move through the rest of the instructional material. She decides to work together with a couple of colleagues, who always share information on the topic she is reviewing for. She returns home and spends the weekend with the family then.

Step 6: Simulated work experience via shared applications from a real-world 3D environment

Two weeks later, she discovered that she did so well on the timed exam that the assessment tool, as well as the supervisor and her colleagues, suggest to her that she should probably move on to another interaction level. Airin is quickly able to advance to a simulated work experience via shared applications from a real-world 3D toolset accessible from her laptop. It is very easy to work on something anyone can see; she thinks to herself. She starts to take apart the virtual circuit board she has been working on, and the 3D environment explains what functionality has been eliminated. She inserts a new chipset that she programmed from working on her project, and the circuit board reflects much faster response time.

Step 7: Completion of her ubiquitous lifelong learning course based on a personalized level

In only the first week of her ubiquitous lifelong learning system, Airin has already demonstrated a level of skill to advance her to reach her career potential through a fully customized learning experience accessible at her convenience and choice of device, personalized level of learning, and length of time to complete. She plans she will register for other courses for her next works.

B. Ubiquitous Classroom

Fig. 8 represents an example of a ubiquitous classroom equipped with the following components through the access point and sensor nodes in education and training institutions.

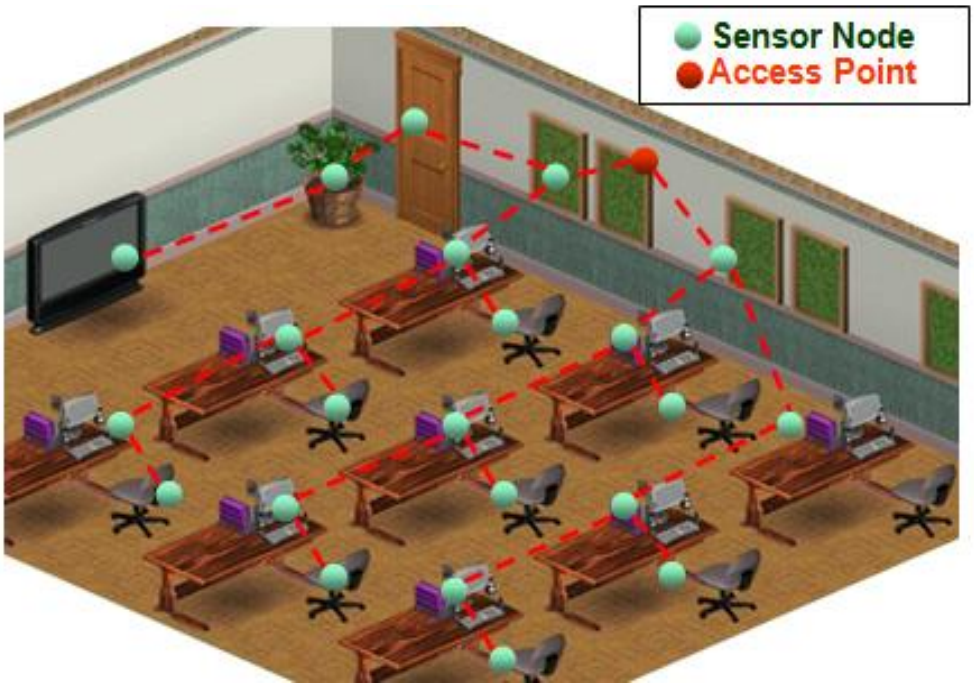

Fig. 8 an Example of Ubiquitous Classroom

1) Doors: The doors contain sensors that recognize and verify people with RFID tags, identify their attendances and monitoring every person coming and going out;
2) Lamping and Light System: The lamping and lighting system automatically adjusts to the illumination requirements of the ubiquitous classroom and the attendance of the people - switches off when it is dark and switches on when it is bright;
3) Windows: The windows automatically close and open according to the degree of sunlight entering the classroom, air circulation, and raining;
4) Classroom Computing System: This is a monitoring and controlling system that identifies users, sets the environment in connection with school servers, and keeps track of the results of all teaching-learning processes, such as attendance, evaluation, achievement, and so on;
5) Flowerpot: The flowerpot identifies its management status such as water, soil and light contents;
6) Classroom Chairs: With the students' RFIDs, the chairs can recognize the assigned students and determine their attendance, health status and will link the server for health care;
7) Multi-Vision: The multi-vision helps classes in connection with the school server and provides full class information such as student affairs, admission, and others [44-45].

V. Conclusion

Ubiquitous technology is producing intelligent and integrated space from electronic space and physical space through the ubiquitous sensor networks improving communication and computing capability embedded in various objects such as classroom, university, office, airport, home appliances, roads, tunnels, animals and plants. The transition toward the ubiquitous sensor network will accelerate the convergence not only in the technology area but also in the industry neither education area. This convergence trend will eventually create new kinds of industries and markets in cross space created by integrated space from electronic space and physical space toward cloud space.

Recently the relationship between working and learning has been fundamentally changed by the rapid expansion of knowledge base and information. In the concept of work-based learning, the work environment is becoming the primary source of learning. Knowledge workers must integrate information and knowledge and learn more for their works under a CSCW environment with

coworkers' group to find solutions for new problems they encounter in their daily work. By advent of ubiquitous technology, knowledge workers have become ubiquitous workers and must learn for their works by service of u-work with u-learning systems.

As Bill Gates commented upon the type of work, workplace, and workforce, we have got the platform of the Internet with wireless and low-cost connectivity, Internet of things (IoT), the thing that is driving the most change is the improvement of the software that sits on top of that platform. His opinion is that the knowledge workforce is becoming available, which is willing to use new ICT. More collaboration among coworkers, availability of information for 24 hours, and collaboration among several organizations are some of the recent trends at the workplace. With this emerging technological environment changes ubiquitous technology as a new ICT, types of work, workplace, and workforce. The learning systems are transforming from e-learning through m-learning to u-learning by use of the mobile device and wireless sensor network in education and training. The adoption and adjustment of these ubiquitous technologies would radically revolutionize the whole gamut of the education and training system for the work. There will be a shift from fixed traditional to flexible, innovative teaching and learning methodology and tools, multidimensional control and monitoring processes by identification systems, and self-paced learning. In a way, the learning environment becomes borderless with adaptive and collaborative learning in the ubiquitous world.

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