JKAU: Comp. IT. Sci., **Vol**. **9** No. 1, pp: 65 – 81 (1441 A.H. / 2020 A.D.)
Doi: 10.4197/Comp. 9-1.5

Smart- adaptive Learning Systems: Systematic Survey on the Ubiquitous Computing Environment

Muhmmad L. Hidayat, Fawaz Alsolami and **Muhammad S. Ramzan**

Faculty of Computing and Information Technology, King Abdulaziz University
Jeddah, Saudi Arabia

isaac.sayid@gmail.com

Abstract. Smart-adaptive learning is a model of technology-based learning that aware of the students' individual learning needs and style, situation, context, also the state of their learning process and acts according to them dynamically. This system can be applied to various fields such as education and training. One of the benefits of Smart-adaptive Learning is the ability of the system to realize and collect context-based information from students or students to then adapt to the student's learning characteristics and needs. Moreover, another essential feature of Ubicomp Smart-adaptive is its ability to provide access to learning resources that are digitally flexible, anytime, anywhere, and multi-wares. Most academic communities think that this scenario is still rare. Therefore, this article proposes to investigate the smart-adaptive ubicomp environment and its potential application in higher education. This study aims to examine the smart-adaptive ubicomp environments and to introduce these systems in the literature of the educational services and the recent research in this topic through a systematic survey study.

Keywords: Smart learning, Ubiquitous computing environments, Adaptive learning, Systematic survey

1. Introduction

Smart learning can be defined as a model of technology-based learning that aware of the students' individual learning needs and style, situation, context, also the state of their learning process and act according to them dynamically[1]. Meanwhile, adaptive learning is the smart-tutoring technology that is responsible for predicting student knowledge and providing personalized instruction to students based on their learning ability level [2].

In the context of education, Ubiquitous Computing Environments (UCE) are created technology-rich classrooms that combine a virtual and real learning environment by improving the quality of the teaching-learning process, making it more flexible and able to adapt to students' individual learning needs [3]. UCE also aims to support both instructors and students in the teaching-learning process.

In this scenario, UCE including some communication technology tools and computer modeling to provide educational content and information tailored to the context of students' conditions and needs without being limited to place or time [4].

In recent times, the development of UCE in the context of smart and adapting is time-consuming and requires a process that is not

easy. The challenge is to develop the u-learning application that must adapt to changing settings (smart) that are constant and flexible (adaptive) according to the needs in the current Educational field

To answer this challenge, and to provide precise information in the development of Smart-adaptive Learning, a systematic study is needed to find out the latest research frameworks and trends in this field.

Hence, the objectives of this article are to identify relevant research or literature regarding Smart-adaptive UCE its potential application in higher education through a systematic survey. And this study aims to investigate the state of the art on these topics. We have hope that this study can contribute to the development of Smart-adaptive Learning in the context of Ubiquitous Computing environments by providing an assortment of information that could facilitate improved research in this field.

This article is systematized as follows: Segment II describes the basic theory of Smart-adaptive Learning. Segment III describes the methodology used for systematic surveys; the results are obtained and produce in the analysis. Segment IV presents the final consideration and bibliographic references.

2. Smart-Adaptive Learning

Weiser [4] in 1991 proposed the three main properties for UbiCom System with two additional ones follow:

(a) computer interaction with humans needs to be more hidden because much HCI is overly intrusive, (b) computers need to be aware of the environmental context to optimize their operation in their physical & human environment, (c) computers can operate autonomously, without human intervention, be self-governed, and (d) computers can handle a multiplicity of dynamic actions and interactions, governed by intelligent decision-making, and (e) intelligent organizational communication [5].

Three methods to analyze and design UbiCom Systems to form a holistic framework for ubiquitous computing are proposed called the smart DEI. The Smart DEI framework based upon (a) Design architectures to apply Ubicom systems. Three main types of architecture design for Ubicom systems are smart device, smart environment, and smart interaction, (b) An internal model of the Ubicom system properties, and (c) A model of Ubicom system's interaction with its external environments [5]. From several definitions about Ubicom, Poslad (2016) gives synonymous summarized as follows, "The Ubiquitous Computing is the systems that are pervasive, ambient, available anywhere, anytime, and to anyone, where and when needed.

In the field of education, Ubicom also influences the way of learning, so it is called Ubicom learning (u-learning). After the introduction of mobile technology, mobile learning (m-leaning) has initiated the freedom to access content anywhere and anytime to the learners. However, the materials are still designed for all learners. These learning systems are still not able to adapt their responses appropriately to the need and the performance of each learner. Once the ubiquitous learning (u-learning) has been introduced, unconscious learning has gained much interest in using the contexts of each learner [9].

Since online students come from different backgrounds, have different activities, life, and learning experiences, they come and work in different places, so they need personalized support that is typically non-existent in existing online learning-personalization [6]. This technology may have

different goals and types. Still, the primary purpose is to help students learn according to their situation, context, personal learning style needs, and the state of their learning process [7], [8].

The terms of "Smart," on Ubicom analysis, consist of three dimensions: Smart devices, Smart environment, and Smart interaction. Smart devices tend to be more autonomous and focus most on interaction within a virtual computer world. The smart environment consists of devices, like sensors, controllers, and computers that are embedded in or operate in, the physical environment. Meanwhile, Smart interaction focuses on more complex models of interaction of distributed software services and hardware resources [9].

Besides Smart, now, digital learning has become more adaptive. In the e-learning system, the term adaptive proposed as a system that produces the most appropriate behavior to interact with each other learner. This system intends to improve the individual learning process [10]. Subsequently, when personality and emotions become more important among human characteristics, it is necessary to be considered in designing more adaptable learning systems. Numerous adaptive e-learning systems have been developed to consider human characteristics; however, most of those systems only considering learning styles, motivations, emotions, mood, or personality separately [11]–[13]. Therefore, it is now important to design an e-learning environment based on a learner's personality and emotion, that smart and also adaptive.

Smart-Adaptive Learning (SAL) is a general term that has the meaning of an experience that is based on intelligent technology to help students and teachers in the learning process, especially with the context of environments [14]. For that concern, the state of knowledge of ubiquitous computing suitable to this new educational model, and it is characterized as a computing model that can integrate various technologies for users and their environment, as well as assist them in completing tasks [15].

3. Systematic Literature Survey (SLS)

A Literature Systematic Survey was conducted in this work to search relevant research to this domain. An SLS is a scientific method that objective is to conduct literature research, looking for to sort evidence in the literature of a related field, allowing the discovery of appropriate works and prevailing gaps in the area in question, with a view to future trend systematic reviews and identification of areas for the main studies [16].

A. Planning

This systematic literature survey (SLS) has research questions (RQs) that must be answered through a literature review procedure with an appropriate protocol so that it can classify the evidence from the primary literature study related to the Research Question. Evidence obtained to answer the RQ was then identified and produced for further analysis [4]. The SLS implementation adopts a generally accepted approach by taking guidelines recognized by the academic community for conducting systematic reviews and surveys. The SLS plan consists of three main stages: planning, implementation, and summarizing the results [16].

These three steps aim to determine the main features of the survey so that the evidence obtained is more valid. Thus, more substantial evidence can further strengthen the purpose of this study. The start of the SLS protocol begins with the determination of research objectives and the formulation of RQs that represent these goals.

B. Objectives

The primary objective of this work is to conduct a careful survey of criteria regarding smart-adaptive learning in the context of ubiquitous computing, with particular attention to education services in tertiary institutions.

C. Research Questions

The survey's purpose is to find concise evidence that can answer the following research questions: RQ-1: What is the Smart-Adaptive Learning part in UCE is focused on the works? RQ-2: What research contribution or advantages of literature proposed to the development of smart-adaptive learning in the UCE? RQ-3: What is the works' open issues, limitations, or suggestions for future research?

D. Definition of Keywords

Establish keywords (K) based on consideration: the subject should be part of the research scope; it is important to search the selected database. The right database will determine the right foundation for the accuracy of the search string. In this way, the next group of keywords is as follows: K1: *smart learning environment*, K2: *ubiquitous learning environment*, and K3: *adaptive learning systems*.

E. Search

Search string for the SLS implemented the following search strings: (smart learning environment) OR (ubiquitous learning environment) OR (adaptive learning systems).

F. Execution

After careful consideration of determining the search database, four indexing engines were obtained as the primary sources of publications in the domain: ACM Digital Library (E1), Link Springer (E2), IEEE Xplore (E3), and Taylor and Francis Online (E4). Table 1 depicts the results achieved for each indexing engine.

G. Selection of Studies

After searching and obtaining a number of results, then the choice of works is arranged. This selection process helps in classifying which literature is most relevant for this proposal. In order to make the relevance of the election even better, an "inclusion and exclusion criteria" mechanism was carried out for the search results literature. The criteria are defined as follows, (1) Inclusion Criteria include (IC-1) articles must be published in English, (IC-2) the article has been published since 2015 (due to the recent development of Smart Learning and Unicom computational research) until 2020, (IC-3) articles have a complete systematic article publication (full study), (IC-4) Research/studies available for download with low access restrictions, and (IC-5) Works that describe Smart-adaptive learning systems and the type of Ubicom environment; (2) Exclusion Criteria: (EC-1) Publications with the nature of advertisements (shows/events or magazines), ppt slides, or lecture notes, (EC-2) Multiple publications, and (EC-3) Publications/studies that are not directly related to this research proposal.

Table 1. Search results.

	K1	K2	K3	Sub
E1	15	4	19	38
E2	39	12	22	73
E3	7	12	7	26
E4	2	6	2	10
Sub	63	34	50	**147**

Screening is made through three cycles using previously defined inclusion and exclusion criteria. In the first round, the primary selection of studies was carried out; this selection identified articles that met the inclusion criteria (IC-1, IC-2) and exclusion (EC-1 and EC-2). Furthermore, in the second round, the following criteria were applied, namely IC-3 and IC-4. In this round, a concise detection of the works designated in the first round is carried out. Articles are surveyed in terms of title, abstract, and keywords. Finally,

the third round of selection is carried out using the IC-5 and EC-3 criteria, followed by more in-depth reading of the resulting study to classify the indications of relevance. Table 2 presents a comparison of the final results of the primary, secondary, and tertiary elections held by the search engine.

Table 2. Prime, second, and tertiary selection results.

Engine	Prime Selection	Second Selection	Tertiary Selection
E1	21	13	9
E2	26	18	14
E3	16	11	6
E4	4	2	2
TOTAL	**67**	**44**	**31**

The outcome is described in Table 3, by the keyword group, publications title, engine indexer, and publication year. Subsequently, all the 31 selected studies were examined, trying to answer to the SLS RQs.

Table 3. Final results of the survey.

ID	Keyword group, Topic, Engine, Year	Ref
01	(k1) Learning analytics in a seamless learning environment (ACM, 2017)	[17]
02	(k1) Smart adaptive learning based on moodle platform (ACM, 2017)	[18]
03	(k1) The Improvement of collaborative learning in higher education through smart LMS (ACM, 2018)	[19]
04	(k1) Design of affectively evocative smart ambient media for learning (ACM, 2018)	[20]
05	(k1) The FIT-EBOt, a smart chatbot for administrative and learning support assistant (ACM, 2018)	[21]
06	(k2) Self-Regulated Learning and learning analytics in online learning environments: A review of empirical research (ACM, 2020)	[16]
07	(k3) Using Learning Styles MBTI Model to Adapt Learning • Applied Computing ~ Distance Learning (ACM, 2017)	[11]
08	(k3) Predicting the learner' s personality from educational data using supervised learning (ACM, 2018)	[22]
09	(k3) Adaptive learning practice for online learning and assessment (ACM, 2018)	[23]
10	(k1) Big data integration for the transition from e-learning to smart learning framework (IEEE, 2016)	[24]
11	(k2) The Context-aware ubiquitous of the vocabularies learning system in Arabic Language (U-Arabic) (IEEE, 2018)	[25]
12	(k2) Investigating learners' technology engagement - A perspective from ubiquitous game-based learning in smart campus (IEEE, 2018)	[26]
13	(k2) Towards an Adaptive and Ubiquitous Learning Architecture (IEEE, 2017)	[27]
14	(k2) Towards a New Ubiquitous Learning Environment Based on Blockchain Technology (IEEE, 2017)	[28]
15	(k2) Context-Aware ubiquitous learning on the cloud-based open learning environment: Towards Indonesia Open Educational Resources (I-OER) (IEEE, 2016)	[29]
16	(k3) An Adaptive E-Learning Environment Centred On Learner' s Emotional Behaviour (IEEE, 2017)	[12]
17	(k3) Adaptive Learning Model and Implementation Based on Big Data (IEEE, 2019)	[30]
18	(k1) A framework of learning activity design for flow experience in the smart learning environment (Springer, 2018)	[31]
19	(k1) An adaptive learning system in smart environments: user-centered design (Springer, 2018)	[32]
20	(k1) A conceptual framework for designing smart learning environments (Springer, 2018)	[33]
21	(k1) Personalized adaptive learning: an emerging pedagogical approach enabled by a smart learning environment (Springer, 2019)	[34]
22	(k1) Smart pedagogy for smart learning	[35]
23	(k2) Ubiquitous personal learning environment model (uPLEMO) (Springer, 2016)	[36]
24	(k2) Open student modeling for academic performance visualization in ubiquitous learning environments (Springer, 2017)	[37]
25	(k2) The comparison of students' satisfaction between ubiquitous and web-based learning environments (Springer, 2017)	[38]
26	(k2) Learning management System CATS (Springer, 2019)	[39]
27	(k2) Reviewing and exploring innovative, ubiquitous learning tools in higher education (Springer, 2020)	[40]
28	(k3) An experimental study on an adaptive e-learning environment based on learner' s personality and emotion	[10]

	(Springer, 2019)	
29	(k3) Adaptive Learning Management System in an adaptive form (Springer, 2020)	[41]
30	(k1) Ambient intelligence-based smart classroom model (Tandfonline, 2019)	[13]
31	(k2) A teacher training model in a ubiquitous learning environment: context-adaptive learning	[42]

H. Analysing the Studies

The studies went to analyze the objective after this SLS' final selection. The analysis of the research conducted aims to identify the most relevant information about the domain, mainly to answer RQ (research questions). Some related work has been synthesized to provide a broad view of the service and its application accordingly. As an answer to Q-1: Which Smart-Adaptive Learning part in UCE is focused on the works? Q-2: What research contribution or advantages of literature to the development of smart-adaptive learning in the UCE? Q-3: What is the works' open issues, limitations, or suggestions for future research?

All studies present a Smart-adaptive learning environment in the Unicomp environment, offering a variety of applications in specific domains. However, due to the number of articles selected and page limitations, not all publication chosen articles will be presented in the following analysis.

This analysis is grouped into four categories, LMS topic, Pervasive Intelligent topic, Context-aware topic, and Smart Pedagogy topic.

1. LMS Topic

A study (ID-01) by Mouri et al. proposes an analytic method called VASCORLL, which is an abbreviation for the Visualization and Analysis System for Connecting Relationships of Learning Logs, which works in cyber-physical settings. VASCORLL functions to visualize and analyze learning logs collected by a seamless learning system. Visualization and analysis methods using SCORLL are based on graph theory, social network analysis, and graph drawing algorithms to find essential words in a seamless learning environment.

SCORLL with EPUB e-book format allows students to learn through two different types of learning activities: e-book based learning activities and authentic learning activities. By using SCORLL, students can learn new knowledge through their multimedia experiences to enable the detection of student learning habits and recommend learning objects (LO) that are more suitable for them. For suggestions, future work should include applying VASCORLL to other application domains such as physics, mathematics, science education, and long-term evaluations with sufficient numbers of participants.

The study of (ID-02) proposed the development of SALCM (Smart Adaptive Learning Control Module), a learning module plug-in for empowering Moodle Learning Management System (LMS) to be more environmentally aware. Using SALCM, Moodle, that lack of customization mechanisms to control the learning process, can provide teachers with an integrated system that allows them to control the learning process of learners to the course content suited to their levels (personalized content according to their level). Study (ID-03) give more contribution to make LMS smarter with improving student's (learners) collaboration practices using an intelligent-LMS agent called SCCLMS (Smart-Cloud Collaborative LMS).

Smart LMS integrates a Multi-Agent System (MAS) to track the level of collaboration and productivity of each student and their study groups in the educational sphere. This system can provide information to teachers about the level of collaboration and

productivity of each student in the group so that teachers can exploit the data provided to encourage collaborative learning, minimize student isolation, and invite them to use collaboration tools.

The SCCLMS can overcome the limitations of LMS. LMS, which has basic functions as a communication platform and manage courses, are upgraded to platforms that allow collaboration, so students could collaborate with the best methods for gaining knowledge with other collaborators (see Fig. 1). The MAS was designed according to a multi-agent approach. This multi-agent consists of seven artificial agents, namely: a). *Student_Agent*, b). *Tutor_Agent*, c) *Teacher_Agent,* d). *Pedagogical_Agent* e). *Assessment_Agent* and f). *Tools_Agent.*

Each agents functions described as follows (Table 4):

Table 4. Multi-Agents System.

Agents	Functions
Student agent	monitoring students in the execution of their assignments and collect tracks of online student activities, their learning activities, and collaborative tools that are manipulated.
Tutor agent	ensuring tutor tasks, assisting students, adapting for students' needs in a learning scenario, encourages collaborative work, motivating, and helps struggling students.
Teacher agent	ensuring teacher's tasks to design and produce courses contents, knowledge transfer, and assessment
Pedagogical agent	consisting of presenting to student's educational content improved to their profiles.
Assessment agent	Assessing students" knowledge level using a set of tests utensils and exercises
Tools agent	ensuring the tracking of all student actions during a learning session and collecting students" traces for being stored in the database.
Database Agent	managing data stored in the database.
Coordinator Agent	managing and coordinates interactions between agents deployed and the cloud-based database

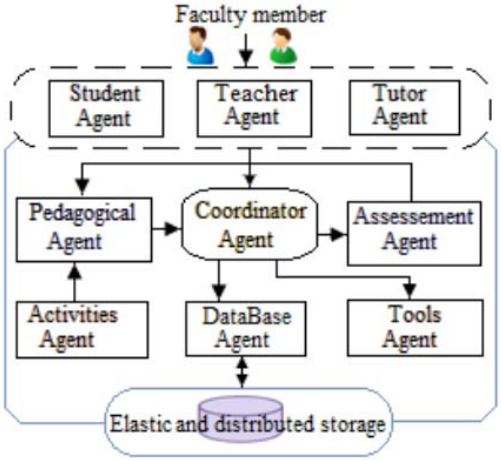

Fig. 1. Model of agents in smart-Cloud Collaborative LMS.

The contribution of the article (ID-03) in supporting collaborative learning in the context of higher education is to develop an information system for teachers/tutors to get information about student and group productivity in collaborative activities. Suggestions for this research that the collaborative learning educational system can be applied to many more varied subjects. It is given that each subject has its learning character (for example, practical work in a laboratory).

In terms of LMS development, research (ID-26) states that the Learning Management System (LMS) requires the expansion of several functions, including support for U-conferencing. The main contribution of this research is the development of a novel framework for activating U-Conferencing facilities at Moodle LMS. This result was achieved using a technology called *BigBlueButton*. The results of this study are additional features of the conference so that it can be modified and utilized in LMS in the context of broad and distance learning, for example, MOOC (Massive Open Online Conference) (see Fig. 2).

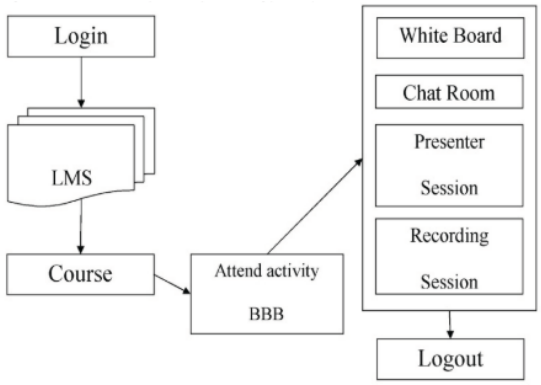

Fig. 2. Concept framework of U-conferencing facility.

Article (ID-29) proposed a more humanized approach to behavior; that is, they test students with a previous placement test. The results of the placement test or initial detection test will be used as a basis for the level of learning content in the LMS. All student classification procedures are carried out by real-time personalization based on Adaptive LMS (ALMS) and Personal Page Rank algorithm. After that, the Navies' Bayes classifier is used to classify students based on the results of skills tests. Students are sorted by their grades, grades 80 will be provided by advanced material, grades 40-79 will be given by medium-level material, and under 40 will get a basic level one.

This ALMS study has a significant contribution in the form of adaptability to the learning styles of each user or ways of learning that must be considered to achieve superior and better feedback. However, as a system, it has inevitable limitations. These limitations include the need for more graphical user interfaces, more security features so that the system does not lose reports on student grades that are very varied, and the need for the use of advanced expert systems in the future so that learning models can be fully automated.

2. Pervasive Intelligent Topic

In the study (ID-05), the authors propose an intelligent learning environment by presenting a chatbot agent called FIT-EBot. This chatbot automatically answers student questions related to any service provided by the education institution on behalf of the academic staff.

In general, the purpose of developing chatbots is to receive messages from users and generate answers comfortably actively. FIT-EBot is implemented by utilizing Artificial Intelligence techniques in analyzing user messages and making responses, such as the *Dialogflow* framework from Google.

The main contribution of this work to the development of the Ubiquitous Learning Environment is the existence of a smart system that can play the role of a friendly and solutive assistant. Smart and adaptive systems provide solutions for higher education institutions to innovatively improve their current services and reduce spending on labor costs.

Following is the architecture of this FIT-EBot, which has several main components; they are the analysis of user messages & Response generation, process specifications, and GUI development (see Fig. 3).

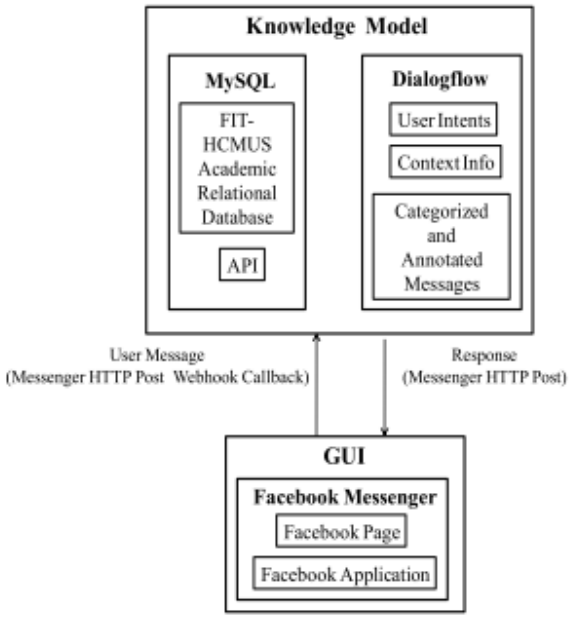

Fig. 3. The FIT-EBot Architecture.

However, this system has several weaknesses that need to be improved through further research and development. These weaknesses include 1) the need for the development of chatbots for other purposes (eg questions related to learning and study content). This improvement can be done through a process of analysis and training using AI algorithms from a database collection. 2) The need to improve the knowledge structure of an integrated semantic framework to analyze user input and to produce responses 3) the need for adjustment and standardization of knowledge models based on ontology technology.

Another improvement is the development of mobile, proactive, web-based semantic learning systems that use Bayesian classifiers and ontologies. This is to facilitate the introduction of different context information and the implementation of system reactions to changes in the system. Expected results, the system will proactively be able to produce a composition of learning services that are tailored to the actual needs, preferences, and context of students.

The study of (ID-21) and (ID-30) were focusing on developing a smart classroom that uses ambient technology (equipped with sensor networks). The ambient classroom concept is a working environment that aware of the presence of users. It enables the performance of various teaching resources, provides the elements needed for personalized learning, group learning, as well as deliver support with adaptive and student-centered learning. The (ID-30) paper proposed the development of an evocative and sensitive learning environment based on smart ambient media, called SAMAL (Smart AMbience for Affective Learning). Figures 4 & 5 describe the mecchanism.

The SAMAL system consists of a series of interactive learning scenarios with affectively evocative virtual reality activities designed. Its objectives are to (a) motivate and stimulate different ways of thinking through changing affect states, and (b) help students to acquire and apply general knowledge in specific materials.

The main contribution of those two works is they provide a unique ambient media environment or classroom to integrate cognitive and affective approaches to enhance learning. Future development of the model should investigate the effects of using other learning strategies (such as learning through tangible use or the flipped classroom model) and other criteria for choosing the proper strategy.

3. The Context-aware Topic

In this study (ID-11), the authors proposed a framework design for the Ubiquitous Context-Aware Arabic Vocabulary Learning System, which is referred to as "U-Arabic." This framework aims to help students master Arabic vocabulary in an exciting game-play environment and utilize the QR-Code anytime and anywhere.

This system uses a sensing technology system called CAULS (Context-aware ubiquitous learning system). This system consists of advanced sensing technology such as NFC, RFID, QR Codes, GPS in conducting learning activities.

This research produces an indicator that context-aware learning technology everywhere is a suitable technology that can benefit students in improving their Arabic vocabulary learning and motivating them to learn continuously without knowing the limitations of time and place.

Study (ID-19) proposed an approach in applying user-centered learning design to

develop ProTuS (Programming Tutoring System) further. ProTus has an additional component in the form of visualized interactive learning analysis, which is projected to provide intelligent and interactive content, personalization options, adaptive features, and analytic learning as support for users involved in learning complex cognitive skills.

In the study (ID-23), the author has proposed a learning scenario that supports Ubiquitous Learning with a Personal Learning Environment (PLE) approach, called uPLEMO (the ubiquitous PLE model). This model aims to improve the educational process through computational and pervasive learning approaches.

This study aims to provide a ubiquitous PLE model that can be continued to the reflection stage of a personal learning environment and can have a high potential for application in ubiquitous learning. The advantage is that the uPLEMO scenario model can be applied in many fields of knowledge, be it for tutors, students, teachers, institutions, even companies that plan ICT-based education processes.

This research has a contribution that emphasizes the benefits obtained in learning, not only for personal (PL) but also the benefits for the educational environment (LE/Learning Environment), which also wants to know the development or attainment of learning from students involved. As for input, future studies are needed that can improve multi-device implementation scenario based on ubiquitous computing or/and ubiquitous ICT resources, so that uPLEMO increasingly has high validity in the implementation in real learning widely.

4. Smart Pedagogy Topic

Smart Learning is a subordinate of technology-enhanced learning that provides support for control functions of resource use and information transfer, as well as proactively providing necessary study guidance, support tools, and support behaviors at the right opportunity, the right level, and in the proper form. In research (ID-18), the authors present the steps and framework of learning activities in the Smart Learning Environment (SLE) in the way of learning experience scenario. The limitation of this study is the need for more evidence for the significance of the theory. Moreover, this research is more directed at the theoretical approach of a learning model instead of practical research based on this framework.

The study (ID-25) proposed a development process of environment and the pedagogical suitability in the digitalized learning in higher education. The aim of this study was to compare the students' satisfaction between a ubiquitous learning environment based (on 360o–technology) and a traditional web-based online learning environment.

The results of this work described there is an equal satisfaction of students between the ubiquitous and traditional web-based environments. Based on this work, for further development, it is necessary to optimize: (a) the design of development and implementation of ULE, (b) detailed instructions, (c) instant feedback, and (e) one-line support system. It also needs to clarify the structure and components of the learning environment and learning materials. Furthermore, all learning materials will be updated and requires more addition in terms of interactivity and technical reliability of the environment.

In the study (ID-31), the authors presented their views on the teacher training model of prospective teachers in context-adaptive learning of ubiquitous environments (u-learning). According to the authors, there are differences in the context for prospective teachers/teachers between the level of teaching

training and the practical level of teaching. This research aims to address real problems in conventional teacher training, including differences between training content and actual practice, and a kind of personalization of specific subjects in the material and application.

This study shows that the teachers of the research subjects gave a positive attitude to the adaptive model and were encouraged to carry out learning better in the classroom. As a research suggestion, the authors hope that the application of this adaptive learning model can be applied on a larger scale or applied to other fields based on experience.

Based on a review study of 31 previously selected articles, we then made tabulations to answer questions from this systematic review literature study. To answer the three Research Questions, we make a table that explains the answer components as below (Table 5).

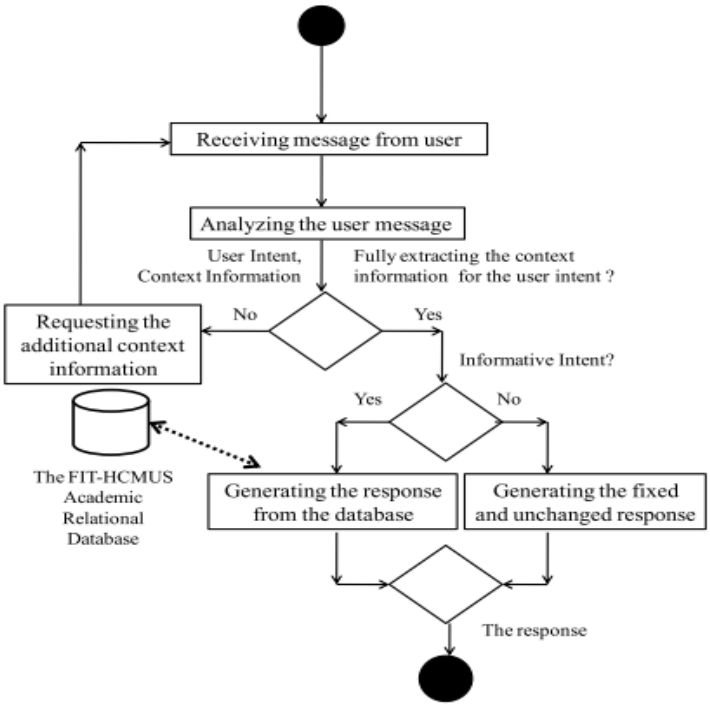

Fig. 4. The FIT-EBot intelligent process.

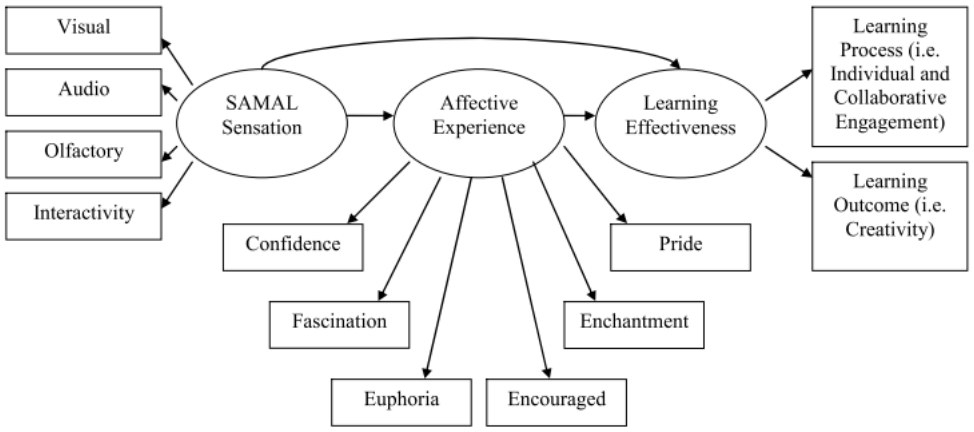

Fig. 5. Research Model: Smart Ambience Learning for Information Management.

Table 5. Literature survey results.

(ID)	Research Questions		
	RQ: What Smart-Adaptive Learning part in UCE-properties is focused on the works?	RQ2: What research contributions or advantages of literature proposed to the development of smart-adaptive learning in the UCE?	RQ3: What is the works' open issues, limitations, or suggestions for future research?
01	Context-Aware, adaptive, operate autonomously	An analytic method that is called VASCORLL to detect students learning habits and recommends appropriate learning objects for them.	The challenge is how to apply the VASCORLL model into other subjects of education, namely maths, physics, science education, with a higher number of participants.
02	Context-Aware, adaptive, personalized	development of SALCM, a learning module plug-in for empowering Moodle Learning Management System. It provides teachers with an integrated system that allows them to control the learning process of students to the course content suited to their levels (personalized content according to the student's cognitive level).	Need to be more autonomous in the future
03	Handle multiply actions and interactions, context-aware	develop LMS to be smarter with improving student's (learners) collaboration practices and productivity levels using smart-LMS agents called SCCLMS (Smart-Cloud Collaborative Learning Management System).	Apply this intelligent to a more specific subject in the future study
05	Handle multiply actions and interactions, context-aware, and intelligent organizational communication	a smart learning environment by presenting a chatbot called the FIT-EBot, that able to gives a reply automatically to students' questions related to any services from the education system. This bot system is smart because it can improve its current services innovatively and reducing employment expenses.	it is expected that the system will proactively be able to produce more composition of learning services that are tailored to the actual needs, preferences, and context of students.
11	Handle multiply actions and interactions, context-aware, adaptive	The U-Arabic, it is a framework that aims to help students master Arabic vocabulary in an exciting game-play environment and	Need more autonomous

		utilize the QR-Code anytime and anywhere. The system uses a sensing technology system named the CAULS (Context-aware ubiquitous learning system).	
18	Smart pedagogy	presented the steps and framework of learning activity in the smart learning environment (SLE) for flow experience.	further follow-up is needed to find more evidence to prove the significance because it is only a theoretical, not a practice based on this framework
19	Adaptive, personalized, smart pedagogy	Presented a Learning Programming System using additional analytic learning in the form of interactive visualization. This system is projected to provide intelligent and interactive content, options that support personalization, adaptive features, and learning analytics as support for students active in learning complex cognitive skills	Need more sustenance for users involved in learning multifaceted or more complex cognitive skills
21	Context-aware, adaptive, personalized, smart pedagogy.	developing an intelligent classroom that uses ambient technology (equipped with sensor networks) to enhance learning	Future development of the model should investigate the effects of using other learning strategies
23	Context-aware, adaptive, smart pedagogy, handle a multiplicity of dynamic actions and interaction	propose a learning scenario that supports Ubiquitous learning with Personal Learning Environment (PLE) approach. This research has a contribution that emphasizes the benefits obtained in learning, not only for personal (PL) but also the benefits for the educational environment (LE/Learning Environment), which also wants to know the development or attainment of learning from students involved.	To apply this result in many areas of knowledge, either for tutors, learners, teachers, institutions, even corporations planning educational courses with ICT-based.
25	Smart pedagogy	The aim and contribution of this study were to compare the students' satisfaction between a ubiquitous learning environment based (on 360o–technology) and a traditional web-based online learning environment.	Based on this work, for further development, it is necessary to optimize: (a) the design of development and implementation of ULE, (b) detailed instructions, (c) instant feedback, and (e) one-line support system.
26	intelligent organizational communication	proposes an additional facility for LMS to support U-conferencing, in order to enrich the LMS become more naturally ubiquitous	this work may be better if extended with further functionalities of learners' behavior analysis.
29	Adaptive, personalized	Proposed the ALMS; a real-time personalization based Adaptive LMS and Personalized Page Rank algorithm to test each learner skill-levels in a particular school subject	In future developments, this application will need several expansions such as a more diverse graphical user interface, students' mark data security features. However, it is used on different devices and the need for a more autonomous expert system.
30	Context-aware, adaptive, personalized, smart pedagogy	developing a smart classroom that uses ambient technology (equipped with sensor networks) to integrate cognitive and affective approaches	using other learning strategies such as learning through tangible use or the flipped classroom model) and other criteria for choosing the appropriate learning strategy.
31	Adaptive pedagogy	Developed a model of context-adaptive teacher training in a ubiquitous learning (u-learning) environment for teachers.	the researchers should apply the model in broader-scale course participants or different areas based

			on the experience, in future research

4. Final Conclusions

This literature survey study aims to review systematically in order to understand the state of the art of Smart-adaptive learning in the ubiquitous environment. The literature review study is divided into four main topics, namely LMS topic, Pervasive Intelligent topic, Context-aware topic, and Smart Pedagogy topic.

From the LMS topic, several recommendations are obtained, which can be used as material for further study or a starting point for research development: 1) the development of LMS features to be more adaptive to the user's personal needs (cognitive level and learning style) in this case are students, 2). Features of student collaboration and tracking of student access during the learning process, 3) U-conferencing features that allow learning with the MOOC system, 4). LMS systems are autonomous and adaptive to the needs of students to obtain academic information using AI-based agent assistants, 5). Rich in user interface features that are easy and accessible, 6) has a reliable security system, both to maintain the database as well as the security of the user's data (students, tutors, teachers, or staff).

The topics of Pervasive intelligent and context-aware, both as part of the hardware, have several recommendations in the form of an infrastructure system that has the ability of ambient technology (equipped with sensor networks). This infrastructure is useful for enhancing pervasive learning that applies calm computing, which is responsive to changes in the environment or changes in learning content. In addition to services, several devices, and sensor technologies are needed by the environments to recognize and collect information from the student's context during the learning process, such as mobile smartphones, RFID, QR-code, NFC, bar code readers, GPS, PDAs, etc.

As for the smart-pedagogy topic, which is part of educational science, which is the spirit of educational activities, there are some recommendations, including the education of the readiness of teachers or teachers to adapt to smart-adaptive learning systems. This preparation starts by modifying the learning curriculum of each subject (because each subject has its characteristics). After that, training for prospective teachers and teachers is needed so that they are trained in learning systems based on ubiquitous technology (trained in using equipment/gadgets, trained in using high-tech classrooms, computerized assessment scenarios, appropriate learning models that are adaptive, and adaptive to the psychological condition of students in the system enhanced learning).

In light of contributing to the development of this part of the study, by presenting an intelligent part of the system, research contributions, and limitations or research problems, it is hoped that this Literature Review Survey can be used as an investigative material to assist in the development of a new Ubicomp learning environment based on recommendations obtained and summarized from some related published articles. The results of this review can be an information base to influence the process of achieving requirements and characterize application scenarios for the area in question.

References

[1] **Molina-Carmona, R.** and **Villagrá-Arnedo, C.** "Smart learning," *ACM Int. Conf. Proceeding Ser.*, pp. 645–647, 2018, doi: 10.1145/3284179.3284288.

[2] **Chaplot, D. S.,** "*Personalized Adaptive Learning using Neural Networks*," pp. 165–168, 2016.

[3] **Ferreira, H., De Oliveira, G. P., Araújo, R., Dorça, F.** and **Cattelan, R.,** "Technology-enhanced assessment visualization for smart learning environments," 2019.

[4] **Lopes, A. R., De Oliveira, D. C., De Sousa Aguiar, R. C.** and **Braga, R. T. V.,** "Context-Aware ubiquitous learning: Literature systematic mapping on ubiquitous learning environments," *2017 Int. Symp. Comput. Educ. SIIE 2017*, vol. 2018-Janua, pp. 1–6, 2017, doi: 10.1109/SIIE.2017.8259662.

[5] **Poslad, S.,** *Ubiquitous computing : smart device, environment, and interactions*. 2016.

[6] **Molina-Carmona**, **R.** and **Villagrá-Arnedo**, **C.,** "Advances in Smart Learning," *ACM Int. Conf. Proceeding Ser.*, pp. 649–652, 2019, doi: 10.1145/3362789.3362951.

[7] **Price, J. K.**, "Transforming learning for the smart learning environment : lessons learned from the Intel education initiatives," *Smart Learn. Environ.*, 2015, doi: 10.1186/s40561-015-0022-y.

[8] **Zhu, Z., Yu, M.** and **Riezebos, P.**, "A research framework of smart education," *Smart Learn. Environ.*, 2016, doi: 10.1186/s40561-016-0026-2.

[9] **Poslad, S.,** *Ubiquitous Computing: Smart Devices, Environments and Interactions*. West Sussex: John Wiley & Sons, Ltd., 2009.

[10] **Fatahi, S.**, "An experimental study on an adaptive e-learning environment based on learner' s personality and emotion," *Educ. Inf. Technol.*, vol. 24, pp. 2225–2241, 2019.

[11] **Talhi, S., Behaz, A.** and **Model, L.**, "Using Learning Styles MBTI Model to Adapt Learning • Applied Computing ~ Distance Learning," in *ACM ICCES conference*, 2017, pp. 22–25.

[12] **Kanimozhi. A.,** "An Adaptive E-Learning Environment Centred On Learner' s Emotional Behaviour," in *International Conference on Algorithms, Methodology, Models and Applications in Emerging Technologies (ICAMMAET)*, 2017.

[13] **Radosavljevic, V., Radosavljevic, S.** and **Jelic, G.,** "Ambient intelligence-based smart classroom model," *Interact. Learn. Environ.*, vol. 0, no. 0, pp. 1–15, 2019, doi: 10.1080/10494820.2019.1652836.

[14] "*Roadmap for Adaptive and Personalized Learning in Ubiquitous Environments*," pp. 1–13, doi: 10.1007/978-3-662-44659-1.

[15] **Saha D.** and **Mukherjee, A.,** "Pervasive computing: A paradigm for the 21st century," *Computer (Long. Beach. Calif).*, vol. 36, no. 3, pp. 25-31+4, 2003, doi: 10.1109/MC.2003.1185214.

[16] **Viberg, O., Khalil, M.** and **Baars**, **M.,** "Self-Regulated learning and learning analytics in online learning environments : A review of empirical research," *Assoc. Comput. Mach.*, pp. 524–533, 2020.

[17] **Mouri, K., Ogata, H.** and **Uosaki, N.**, "Learning analytics in a seamless learning environment," *ACM Int. Conf. Proceeding Ser.*, pp. 348–357, 2017, doi: 10.1145/3027385.3027408.

[18] **Louhab, F. E., Bahnasse, A.** and **Talea, M.** "Smart adaptive learning based on moodle platform," *ACM Int. Conf. Proceeding Ser.*, pp. 1–5, 2017, doi: 10.1145/3175628.3175635.

[19] **El Mhouti, A.** and **Erradi, M.,** "Towards a smart learning management system (smart-LMS) to improve collaborative learning in higher education," *ACM Int. Conf. Proceeding Ser.*, 2018, doi: 10.1145/3286606.3286784.

[20] **Kwok, C., Ip, H.** and **Kong, S.**, "Design of affectively evocative smart ambient media for learning," pp. 65–75, 2009.

[21] **Hien, H. T., Cuong, P. N., Nam, L. N. H., Nhung, H. L. T. K.** and **Thang, L. D.,** "Intelligent assistants in higher-education environments: The FIT-EBOt, a chatbot for administrative and learning support," *ACM Int. Conf. Proceeding Ser.*, pp. 69–76, 2018, doi: 10.1145/3287921.3287937.

[22] **Idrissi, M. K.,** "Predicting the learner' s personality from educational data using supervised learning," in *SITA 2018*, 2018, pp. 1–7, doi: 10.1145/3289402.3289519.

[23] **Cai, R.,** "Adaptive Learning Practice for Online Learning and Assessment," in *ICDEL 2018*, 2018, pp. 103–108.

[24] **Udupi, P. K., Malali, P.** and **Noronha, H.,** "Big data integration for transition from e-learning to smart learning framework," in *3rd MEC International Conference on Big Data and Smart City*, 2016, pp. 1–4.

[25] **Alobaydi, E. K. R., Alkhayat. Y., Arshad,, M. R. M.** and **Ahmed, E. R.,** "Context-aware ubiquitous Arabic vocabularies learning system (U-Arabic): A framework design and implementation," *Proc. - 7th IEEE Int. Conf. Control Syst. Comput. Eng. ICCSCE 2017*, vol. 2017-Novem, no. November, pp. 23–28, 2018, doi: 10.1109/ICCSCE.2017.8284373.

[26] **Zhai, X., Dong, Y.** and **Yuan, J.,** "Investigating Learners' Technology Engagement - A Perspective from Ubiquitous Game-Based Learning in Smart Campus," *IEEE Access*, vol. 6, no. c, pp. 10279–10287, 2018, doi: 10.1109/ACCESS.2018.2805758.

[27] **Araujo, R. D. Cattelan, R. G.** and **Dorca, F. A.** "Towards an Adaptive and Ubiquitous Learning Architecture," *Proc. - IEEE 17th Int. Conf. Adv. Learn. Technol. ICALT 2017*, pp. 539–541, 2017, doi: 10.1109/ICALT.2017.63.

[28] **Bdiwi, R., De Runz, C., Faiz, S.** and **Cherif, A. A.,** "Towards a New Ubiquitous Learning Environment Based on Blockchain Technology," *Proc. - IEEE 17th Int. Conf. Adv. Learn. Technol. ICALT 2017*, pp. 101–102, 2017, doi: 10.1109/ICALT.2017.37.

[29] **Selviandro, N.** and **Septiana, G.,** "Context-Aware ubiquitous learning on the cloud-based open learning environment: Towards Indonesia Open Educational Resources (I-OER)," *2016 4th Int. Conf. Inf. Commun. Technol. ICoICT 2016*, vol. 4, no. c, 2016, doi: 10.1109/ICoICT.2016.7571966.

[30] **Liang, Q,** "Adaptive Learning Model and Implementation Based on Big Data," *2019 2nd Int. Conf. Artif. Intell. Big Data*, pp. 183–186, 2019.

[31] **Gao, B. Wan, Q. Chang, T.** and **Huang, R.,** *A Framework of Learning Activity Design for Flow Experience in Smart Learning Environment*. Springer Singapore, 2018.

[32] **Vesin, B. Mangaroska, K.** and **Giannakos, M.**, "*Learning in smart environments : user-centered design and analytics of an adaptive learning system*," 2018.

[33] **Freigang, S., Schlenker, L.** and **Köhler, T.,** "A conceptual framework for designing smart learning environments," *Smart Learn. Environ.*, vol. 5, no. 1, 2018, doi: 10.1186/s40561-018-0076-8.

[34] **Peng, H., Ma, S.** and **Spector, J. M.,** *Personalized Adaptive Learning : An Emerging Pedagogical Approach Enabled by a Smart Learning Environment Analysis : Comparing the two pillars of personalized adaptive learning*. Springer Singapore, 2019.

[35] **Lorenzo, N.** and **Gallon, R.**, "*Smart Pedagogy for Smart Learning*," pp. 41–69, 2019.

[36] **López, G. A. M. Builes, J. A. J.** and **Puche, W. S.,** "Ubiquitous Personal Learning Environment model (uPLEMO)," *Proc. 2016 Technol. Appl. to Electron. Teaching, TAEE 2016*, 2016, doi: 10.1109/TAEE.2016.7528383.

[37] **Ferreira, H. N. M., Araújo, R. D., Dorça, F. A.** and **Cattelan, R. G.**, "Open student modeling for academic performance visualization in ubiquitous learning environments," *2017 IEEE Int. Conf. Syst. Man, Cybern. SMC 2017*, vol. 2017-Janua, pp. 641–646, 2017, doi: 10.1109/SMC.2017.8122679.

[38] **Virtanen, M. A., Kääriäinen, M., Liikanen, E.** and **Haavisto, E.,** "The comparison of students' satisfaction between ubiquitous and web-basedlearning environments," *Educ. Inf. Technol.*, vol. 22, no. 5, pp. 2565–2581, 2017, doi: 10.1007/s10639-016-9561-2.

[39] **Popova, Y. B.,** "Learning Management System CATS," *Sci. Tech.*, vol. 18, no. 4, pp. 339–349, 2019, doi: 10.21122/2227-1031-2019-18-4-339-349.

[40] **Aljawarneh, S. A.,** "Reviewing and exploring innovative ubiquitous learning tools in higher education," *J. Comput. High. Educ.*, vol. 32, no. 1, pp. 57–73, 2020, doi: 10.1007/s12528-019-09207-0.

[41] **Jagadeesan, S.** and **Subbiah, J.,** "Real - time personalization and recommendation in Adaptive Learning Management System," *J. Ambient Intell. Humaniz. Comput.*, 2020, doi: 10.1007/s12652-020-01729-1.

[42] **Chen, M. Chiang, F. K. Jiang, Y. N.** and **Yu, S. Q.,** "A context-adaptive teacher training model in a ubiquitous learning environment," *J. Inf.*, vol. 4820, no. March, 2016, doi: 10.1080/10494820.2016.114384].

أنظمة التعلم الذكية المتكيفة: مسح منهجي لبيئة الحوسبة في كل مكان

محمد لطفي هدايت، و **فواز السلمي**، و **محمد شير رمضان**

كلية الحاسبات والمعلومات، جامعة الملك عبد العزيز، جدة، المملكة العربية السعودية

isaac.sayid@gmail.com

المستخلص. التعلم التكيفي الذكي هو نموذج للتعلم القائم على التكنولوجيا الذي يدرك احتياجات التعلم الفردية للطلاب وأسلوبهم، ووضعهم، وسياقهم، وكذلك حالة عملية التعلم الخاصة بهم ويعمل وفقًا لهم ديناميكيًا. يمكن تطبيق هذا النظام في مجالات مختلفة مثل التعليم والتدريب. تتمثل إحدى مزايا التعلم الذكي التكيفي في قدرة النظام على إدراك وجمع المعلومات المستندة إلى السياق من الطلاب أو الطلاب للتكيف بعد ذلك مع الخصائص والاحتياجات التعليمية للطالب. علاوة على ذلك، هناك ميزة أساسية أخرى لـ Ubicomp Smart-adaptive وهي قدرتها على توفير الوصول إلى موارد التعلم التي تتسم بالمرونة رقميًا، في أي وقت وفي أي مكان وبأدوات متعددة. تعتقد معظم المجتمعات الأكاديمية أن هذا السيناريو لا يزال نادرًا. لذلك، تقترح هذه المقالة التحقيق في بيئة ubicomp التكيفية الذكية وتطبيقها المحتمل في التعليم العالي. تهدف هذه الدراسة إلى فحص بيئات ubicomp الذكية المتكيفة وإدخال هذه الأنظمة في أدبيات الخدمات التعليمية والأبحاث الحديثة في هذا الموضوع من خلال دراسة استقصائية منهجية.

الكلمات المفتاحية: التعلم الذكي، بيئات الحوسبة في كل مكان، التعلم التكيفي، المسح المنهجي.