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The Role of the Smart Learning Environment in Advancing the Smart Learning Process: Review

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A,2,3bstract

Currently, the educational organizations and institutions are very interested and engrossed by the change in how human's perspectives are changing and run. Education is always at the front line of all those aspects that humans are striving to achieve. Smart technologies are being used to change the methodologies of the conventional educational aiming at enhancing the performance and the ability of learners to be familiar with the ever-changing world. A new pedagogical approach that considers collaborative learning is being used under designing a smart learning environment (SLE) where information and communication technologies (ICT) and radio frequency identification (RFID)-based indoor positioning system were used to examine students' perceptions and the involvement of groups into smart classroom. This cannot be achieved without merging the interactive multimedia system, ubiquitous computing, and several handheld devices. The teacher role is no longer carrying the same picture in the eyes of learners and amazingly, the position of the teacher was found to increase the engagement and motivation of the students. In smart learning, teaching and learning have to deconstruct as a condition for relevancy. It is hoped that smart learning could result in enhancing the effectiveness and efficiency of learners while keeping education flexible and comfortable. Internet, digital resources, classes online, and wireless networks are just possible foundations of smart learning. Constructing a framework for smart learning should take new concepts such as instruction via class-based differentiated, collaborating using group-based, personalizing via individual-based, and mass-based generative learning. It is worth to say that smart learning is a very complicated process which carried out with so many challenges and obstacles such are learners' perception, cultural differences, and the basic preparation and training of teachers.

Keywords: Smart learning, pedagogy, smart technology, smart workplace, challenges

1. Introduction

Learning is a very old experience that has been practiced by people throughout various methods depending on the available tools and purpose. Textbooks were instructed to students for many decades all over the world. Lectures were offered traditionally in special places which, later on, named schools where students receiving knowledge. The developments of learning focus on consolidating different topics under curricula to emphasize the capabilities of students (Noor-Ul-Amin, 2013) or, as recently advocated by Miller (2019) under the concept of holistic curriculum.

It is important to explain the meaning and the difference between teaching and learning as these two terms will be used and mentioned frequently in this paper and to remove any possible confusion. Teaching means to "show" or to "point out" which often refers to classrooms, lessons, and adopting specified textbooks. In teaching, teachers are focusing on communication through which transferring knowledge accompanied by emotions and/or skills transfer to learners or students (Brookfield, 2020). Teaching is carried out via two methods: formal and informal. The formal, as

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in schools or universities, governed by the systematic educational system and licensed professionals while the informal (tutorial) does not require regulations, classrooms, and professionals. The other term, learning, means to “get knowledge” or to “think about”. All people learn via new concepts or new knowledge acquiring insights from thinking about something. In other words, learning is the acquisition of new information (Mohd, Shahbodin, Rashid, Jano, & Al-Shami, 2019). or the modification of existing knowledge, preferences, expertise, and other aspects of behavior (Merriam & Baumgartner, 2020). Table 1 summarizes the basic differences between teaching and learning (Prozesky, 2000).

Table 1. Comparisons between teaching and learning (Prozesky, 2000)

Teaching	Learning
Imparting knowledge	Recipient role
Higher authority	Lower authority
Better skills	Lesser with know-how
Requires presence of learners	Less dependent on teacher presence
Arouses curiosity and motivation	Improved throughout cognitive stimulation
Gives feedback	Understands and applies feedback
Can be mandated	Cannot be mandated
Teachers less than learners	Learners more than teachers
More autonomy	Less autonomy
Continues life and death	Only life experience

The concept of smart learning has evolved as an important shift from traditional or conventional education. There are two steps that characterized this shift: the importance of using technology to improve learning and the emergence of adaptation and personalization (Pal et al., 2019; Gros, 2016). Designing the latest technology in education is to improve smart behavior to collaborate for collective use (Höjer & Wangel, 2015). Smart learning has evolved with different themes such as seamless learning and ubiquitous learning (Al-shami, Shahbodin, Rashid, Jano, & Ku, 2019). Seamless learning suggests a continuous learning experience independently from space-time, social background, and technologies (Ritella et al., 2020; Sharples et al., 2016). On the other side, ubiquitous learning refers to distributing learning experience across time and space by consolidating the differences between the two opposite features across a line such as work and play or public and private (Muñoz-Cristóbal et al., 2018; Burbules, 2012). Smart learning is not technology-enhanced learning, but it, rather, shows collective experiences aim at improving learning experiences throughout integrating various technologies, environments, and content. Meanwhile, another term was emerged named learning analytics which has been used to focus on optimizing measuring, collecting, analyzing, and reporting contextual learner data to achieve the highest level possible of learning environments (Nistor et al., 2018; Siemens, 2012). Since the year of 2016, learning analytics has been adopted to support certain processes and characteristics of smart learning (Giannakos et al., 2016). Later on, learning analytics was modified to discover and analyze student behavior to align suitability of learning environments, and to gather information to distinguish learning evidence that leads to facilitate instructional support (Kumar & Vivekanandan, 2018).

2. Smart Learning Environment (SLE)

2.1 Definition of SLE

The focus of this article is about learning; however, teaching and learning can interconnect with each other on many occasions. Teaching and learning require a certain environment. In this article, the focus is on the leaning process, hence, a smart learning environment (SLE) will be used as a focal point to study the smart learning throughout the experience that various nations and/or organizations have been adopted (Gao et al., 2019).

Firstly, SLE should be defined to make approaches, analyses, and conclusions plausible with lest conflict, if any, because SLE has been defined differently by scholars (Merriam & Baumgartner, 2020). One possible reason for this confusion was due to the fact that SLE is still being integrated into the environment of Technology-enhanced learning (TEL). However, the International Association for Smart Learning Environments defines SLE as "an environment that features the use of innovative technologies and elements that allow greater flexibility, effectiveness, adaptation, engagement, motivation, and feedback for the learner" (Dorn, 2018).

In another circumstance, smart learning has been defined as an important tool for enhancing lifelong learning by empowering learners to efficiently solve those problems using personal contexts and abilities (Zhu et al., 2016; Merriam & Baumgartner, 2020). The implementation of smart learning relies on introducing smart devices and intelligent technologies (Gros, 2016). The smart devices are those devices that are characterized by computers, smartphones, iPads, and other similar tools. The intelligence technologies such as artificial intelligence (AI), internet of things (IoT), and clouds are being used to run the smart devices (Chen et al., 2016). It is important to remark that the two elements mentioned above were integrated leading to the emergence of an environment known as ‘smart’ learning. Generally, SLE refers to more than the name-based education, but it is a new way of stimulating creativity and thinking by encouraging all individuals regardless their differences and aiming at changing the traditional teaching using smart technology and well-trained teachers (Hoel and Mason, 2018). SLE could be defined in terms of a rich physical environment with digital adaptive devices aiming at promoting better and faster learning by accessing these devices and receiving the necessary learning guidance, suggestions or supportive tools to them in the right form, at the right time and in the right place (Hwang, 2014).

SLE is considered as a new learner-initiated supported by the collaboration of smart technology and teachers (Noh et al. 2011; Merriam & Baumgartner, 2020). In another definition of SLE, Spector (2014) suggested that SLE is a mixture of innovative alternatives and supports planning and mainly is characterized by effectiveness, efficiency, engagement, flexibility, adaptivity, and reflectiveness. Literature has agreed on some features of SLE which can be summarized as learner-centric, adaptive learning service, interactive and collaborative tools, context-aware, and ubiquitous computerized access (Montebello, 2019).

Smart learning is a complete platform of a new leaning methodology that relies primarily on smart devices and intelligent technologies (Al-Shami, Sedik, Rashid, & Hussin, 2018b); however, these two elements have no meaning without being carried by teachers to create a smart environment (Zhiting Zhu et al., 2016). Figure 1 shows one of the possible educational platforms which includes the following three mutual interactive elements of learner, teacher, and technology which, collectively, produce smart learning.

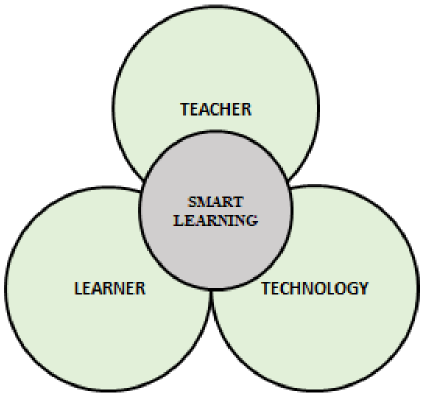

Figure 1. Smart Education Framework (Adopted from Zhu & Sun, 2016)

2.2 Historical Developments

The historical developments of the SLEs were closely related to the development of artificial intelligence. However, there is a time gap of about 10 years between developments in educational technology and the developments in computer science (Spector & Anderson, 2000; Spector & You-Qun, 2015). Historically, the field of artificial intelligence emerged in the 1950s with a proposal for the Dartmouth Summer Research Project on Artificial Intelligence which includes automating complex activities, natural language processing, artificial neural networks, machine learning, and abstracting concepts from data (Spector, 2016). The essential reason for this 10-year gap is the huge challenges that were facing the implementation of such an advance technology (Bilal et al., 2016). By the mid-1960s, AI researchers were able to develop expert systems to solve complex problems and/or aid the inexperienced persons in solving complex problems such as identifying a compound based on data from a spectrometer (Spector, 2016). More advanced developments took place in the early 1970s such as creating an expert system called MYCIN to identify bacteria and recommend antibiotics by Stanford University (Shortliffe & Buchanan, 1975). In a recent review paper, Belciug et al. (2020) explained the beginning of the intelligent decision was a support system without artificial intelligence; however. It was followed by introducing the metamorphosis into intelligent tools. At that time, there was no idea what could this system bring to the field of educational system. Developments continued and by the 1980s, many expert systems were being used in a variety of domains such as accounting for tax analysis and, more importantly, in developing a larger field of AI (Schalkoff, 2011). Following these expert systems where a simple form of AI is needed, the creation of commercial expert systems was soon followed and introduced in the domain of educational technology (Merrill, 1998). Since then, a number of other systems, including Guided Approach to Instructional Design Advising (GAIDA) and Experimental Advanced Instructional Design Advisor (XAIDA) (Spector et al., 1993). The guidance for GAIDA was primarily based on Gagné, & Gagné (1985) nine events of instruction, and Robert Gagné was an in-house advisor on the project after his retirement from Florida State University. The transformation to the domain of educational technology depends on three activities of activity, process, and things (characterizing functions). By using these three activities, XAIDA could generate an appropriate lesson automatically in a matter of minutes as pointed out by Kučera et al. (2020) and appeared in so many fields such as control systems, refining IP prefixes, traffic patterns controller, and, most importantly, reducing data-plane communication overheads by up to two orders of magnitude with respect to state-of-the-art solutions.

The historical developments of SLE were crowned by developing the components of a conceptual framework as an advanced step towards an intelligent tutoring system (ITS) that provides one-on-one instruction to students in a computer-based environment. In the ITS system, a rule-based production was created to find and apply an appropriate rule to generate new instruction or feedback based on what data the gathered information in the subject domain model. In the 1980s and 1990s, ITSs received a great deal of interest and support, but the achieved successes were largely limited to subject domains that involved very well-defined subject matter and problem-solving procedures (Spector, 2016). In another view, SLE is an educational system that is enriched with digital techniques and established to be context-aware and adaptive devices aiming at promoting better and faster learning (Koper, 2014).

In 2010, SLE was initiated to be service-based learning by utilizing the semantic web and ubiquitous computing. In the beginning, SLE was composed of collaborative learning space through which the traditional learning system is transferred into a new form that is independent of space and time (Scott & benlamri, 2010). In the last two decades, many countries were experimenting and implementing elements of smart education. In Malaysia, adoption of the vision which requires a developing workforce to be ready to carry the requirements of the 21st century which include introducing modern technologies in the context of education. Singapore has also enhanced the role of technology in schools by introducing modern technologies such as promoting interactive learning in education to meet the needs of diverse learners. Singapore has been focusing on the learners by implementing the technology-based environment at all environments of educational levels to achieve the entire educational system based on the lifelong learning principle (Kadhim & Othman, 2012; Kadhim, 2018). Another Asian country, Korea implemented a very special form of smart education project by promoting self-directed instruction along with an enjoyable atmosphere for using resources and technology. In the Gulf region, United Arab Emirates (UAE) has started a smart learning program as an initiative by Mohammed Bin Rashid in 2012 to implement smart learning in elementary and high schools to align with many countries in this important field (Zhu et al., 2016).

SLE is considered a huge educational project because of a huge number of attendants who gathered without discriminating of race, origin, gender, and others hoping to achieve the noble goal of being self-learners and self-motivated, and able to access the personalized learning content according to their personal difference (Kim et al. 2012). Currently, Khlaif & Farid (2018) have raised the issue of identifying the variation in one country in the Middle East when Palestinians implemented smart learning project in the Palestinian public schools. The findings have suggested that there was a clear change in teachers' roles as a result of smart learning implementation due to the influence of the smart earning environment in these schools.

2.3 Components of SLE

Recently, mobile technology has increasingly become one of the major foundations of SLE worldwide. Mobile technology has altered education or learning from a localized position to a mobile position (Merriam & Baumgartner, 2020). Moreover, new developments in technology have moved mobile learning toward much wider learning called ubiquitous learning which entirely independent of location and time restriction (Hwang et al. 2008). The transition towards smart learning was assisted by several intelligent technologies such as cloud computing (CC), Internet of things (IoT), learning analytics, big data, wearable technology, and many others. Out of these technologies, CC, learning analytics, and big data focus on the ways of capturing learning data and how to analyze this data (Mayer-Schönberger and Cukier, 2013; Picciano, 2012). The individual learner at any location and anytime could react with the classes and instructions (Johnsen et al., 2016). In this part, SLE will be studied and analyzed.

2.3.1 General Concept

The absence of a clear and precise definition of SLE results in a confusion between the available smart technology and the physical preparation to conduct smart learning because of the advancement of technology compared to the possible application. However, regardless of this time-gap, researchers and educational professionals continued discussing the SLE concept (Hwang, 2014; Scott & Benlamri, 2010). In 2010, the concept of SLE was proposed to achieve the following three goals: (1) focus on earners, (2) to enhance the performance and the effectiveness of smart tools, (3) utilizing smart tools cautionary without undermining the smart learning process (Gwak, 2010), and later to achieve the fourth goal which compromises the concept of learner-centric and service-oriented educational paradigm (Kim et al., 2012).

Since its implementation about four decades ago, smart learning was mainly the responsibility of the government or, to a lesser extent, private organizations (Merriam & Baumgartner, 2020). This shows the importance of learning as a prominent initiative by offering the best digital developments to their citizens. Simply speaking, smart learning initiatives were made by countries towards the implementation of smart learning. In Australia, implementation of the smart educational system focuses on students as the principal pillar due to their potential for multidisciplinary (Dong et el., 2020). Australian system was built on adapting learning programs to satisfy the needs of learners, providing portfolios for student learning, stimulating collaboration, providing digital resources for teachers and students, automating computerized administrative work(s), monitoring and reporting activities om online learning. In New York, smart school proposal considers adopting online learning, increasing smart learning scope, implementing transformational procedures, enhancing network system by linking to high-speed internet, opening inside and outside the classroom channels of communication (Zhu & Yu, 2016), providing high-quality training and professional development, and adopting relevant skills aligned with the development in the 21st century (Hobgood, & Ormsby, 2010).

Regarding the components of smart learning, the following six pillars were widely considered amongst researchers: learning resources, intelligent tools, learning communities, learning resources, learning methodologies, and teaching communities (Huang et al., 2013) as illustrated in Figure 2.

The four interconnecting components of learning resources, intelligent tools, learning communities, and teaching communities are called working place. Besides, the other two components of learning methodology and teaching methodology are called the first and the second interacting with the working place of the four elements. In the working place, the focal point of SLE includes learning resources and intelligent tools (Gargiulo & Bouck, 2019). These two components interact with the learning community and teaching community while these two communities are interacting with others. Learners and teachers are located on the left side and right side of Figure 2.

Learners' part includes learning community and learning resources inside the working place fortified by learning methodology. Teachers, on the other side, include teaching community and intelligent tools fortified by teaching methodology. As such, SLE with the six components represents the general foundations of the new form of education.

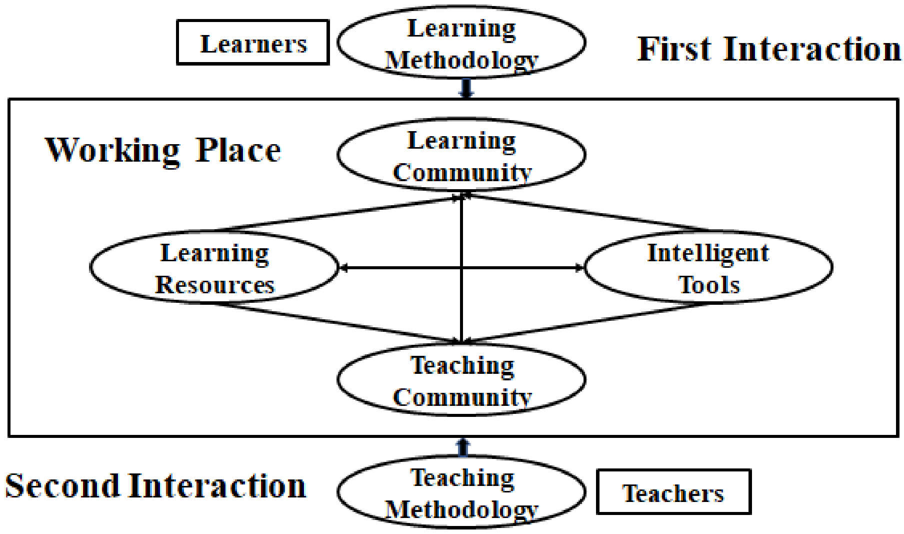

Figure 2. The components of smart learning environment (Huang et al., 2013)

2.3.2 Intelligent Tools

Since the implementation of smart learning, learning resources have been tightly connected to new wireless and ubiquitous and mobile technology as shown previously in Figure 2. This technology carries out new terminology such as mobile learning (m-learning) and ubiquitous learning (u-learning) to facilitate the learning outcome achievement and to reduce location and time constraints (Lai, 2020; Laru et al., 2014). The difference between m-learning and u-learning is that m-learning implies wireless devices while u-learning is based on ubiquitous computing technology (Bdiwi et al., 2019). The smart technology of sensors and devices was considered as a support to the smart learning environment (SLE) (Chin & Chen, 2013). The purpose of implementing smart technology in smart classroom culture is to determine the capability of this technology and to encourage strong interactions between students (Omae et al., 2017). Therefore, learners, see Figure 2, aim at learning and working together to discuss problems presented by teachers and to seek a suitable solution in terms of the collaborative learning process (Tesavrita, et al., 2017). Other difficulties arose from the unparalleled rapidity of expanding information and communication technologies (ICT) and the progress of technology-based learning (Makahinda, 2018). The role of the web digital collaborative exchange and subsequent software systems is very vital to advancing the universities which appear in merging ubiquitous technology and the overall learning system (Moyne et al., 2018). The new idea of dependency of knowledge-based economy on the new pedagogy could create a combination of creativity that promotes the suitability of digital technology in educational information (Cope & Kalantzis, 2013). The location-based educational service includes several software techniques that are important and significant to a good sector of learners (Guo et al., 2015). Even though smart technology is available; the importance of the teacher cannot be ignored because teachers still constitute the front line in the learning process. After all, the influence of the teacher in SLE on the achievement of the students as described in Figure 2. The students' performance is the key element in the SLE approach which is connected to developing ubiquitous computer technology to benefit organizations, schools, and universities. Integrating smart technology in SLE represents the highest task of all educational institutions. The field of integrating smart technology is known as interactive multimedia learning where a model for students' performance is needed the most.

2.3.3 Designing Smart Learning Environment

The implementation of smart technology for SLE is shown in Figure 3. The design is normally called SLE architecture which is consisted of several software modules and embedded gateway (Yang et al., 2017). The system is based on information and communication technology (ICT) which provides a full range of asynchronous and synchronous communication tools (Al-Shami, Sedik, Rashid, & Hussin, 2018a). On the left side of Figure 3, a combination of sensors, smart devices, software, applications, and real-time services to improve the collaborative learning experience which, in turn, enhances the delivery of high-quality data to students. To achieve this purpose, the following four systems were implemented: videoconferencing system, video on demand (VoD) streaming server, cloud management information system (CMIS), and a gateway. Out of these four systems, gateway represents the bridge between the connected devices with the software platform with numerous available technologies (Bdiwi et al., 2019).

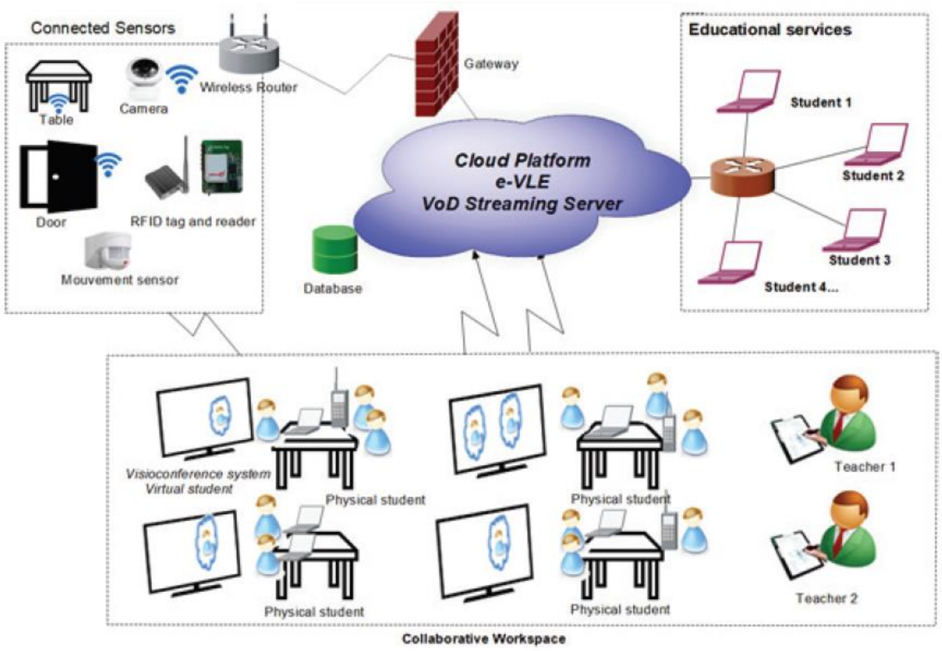

Figure 3. Smart learning environment (Bdiwi et al., 2019)

2.3.4 Gateway's architecture

The gateway was named because it represents the "gate" between two networks such as a router, server, or any similar device through which information can flow in and out the network throughout a hardware device (Hakiri et al., 2015). Gateway, a name of a computer company, is an anode that is located at the "edge" of the network to protect other nodes. The gateway may be used to translate and format the incoming data to be recognizable by the internal network. A famous example is the home network called router which allows computers to send and receive data over the Internet within the local network. A more advanced gateway system called firewall which filters inbound and outbound traffic flow and, at the same time, disallowing incoming suspicious or unauthorized sources. The most advanced gateway system is called proxy where a combination of hardware and software to filter traffic between two networks (Zachariah et al., 2015).

The role of gateway hardware in SLE is to improve interactive communication between various groups and the teacher (Bdiwi et al., 2019). For completeness and perfectness, the access permission has been regulated by permission and authentication to allow the management of both teachers and students. For teachers, the system provides a complete remotely supervising amongst learners. The Video on demand is another server that enables the management of the collaborative classroom as shown in Figure 3. The virtual meeting may facilitate a new methodology of communication using the services of a videoconferencing system within the collaborative environment (Bdiwi & Bargaoui, 2015). In SLE architecture, there are four layers: (1) the application to manage all services in the SLE, (2) the classroom manager to provide an exchange of the context data by allowing connection of the management devices, (3) the device manager for awareness, and (4) the access technologies to manage protocols of communication among different devices.

2.3.5 Smart Classroom Execution

The old fashion classroom is still in the memory of most people; it is a simple room with desks and blackboard. Prior to that, learners used to sit quietly on the floor while teachers sitting on a chair and, in most cases, on the floor, too. The principal activity by the students was a combination of listening and memorization to whatever teachers said. Tests were normally oral and given by the end of course (Rumble, 2019). Generally speaking, traditional education was associated with coercion where severe punishments could be applied to correct behavior or conducting error by students. In traditional education, boys and girls have received education separately and were taught some subjects according to their gender (Gay, 2018). Regarding curriculum, old fashion learning system usually pays attention to high-level attention and time-honored knowledge. This educational system was experienced mostly in America and the majority of Europe until the end of the 19th century. The development of the classroom depends on the available illustrating materials. Later, the old fashion classrooms were developed to include maps that were normally hanged on the wall or other illustrative materials suitable for the class materials (Rumble, 2019). In this section, we give an overview of our new SLE based on an indoor positioning system of the teacher. Then, we describe some challenges that we faced in the technical implementation process (Beck, 1956).

The evaluation of the pedagogical term in a smart learning classroom has been conducted using the students' performance using an indoor positioning system (Bdiwi et al., 2019). Teachers' performance was also evaluated by measuring the collaboration between students and teachers. The teacher's location inside the workspace is very important because this position reflects the engagement of students and expectations for a successful learning experience (Schmoker, 2018). The teacher's location is monitored by RFID. The size of the classroom in SLE is within 5 m × 5 m equipped with RFID components and several other sensors. In the smart classroom, the detection of several tags in the action zone can be done simultaneously. The gateway is the management of SLE via a software platform that allows data processing from tags and anchors and is executed in the gateway. The architecture of the collaborative workspace shown in Figure 3 combines ubiquitous computing, multimedia interactive system, real-time location system, and several software tools to collectively share educational information and to determine the teacher's position. The classroom observation system evaluates how students' attention is increased and provides all possible means that shows the enhancement caused by teachers who are in close proximity within the groups. The smart learning classroom has been completely implemented; however, enhancement is possible in the near future as smart technology is progressing. The location-based services could extremely regulate and manage the behavior of collaborative groups in terms of promoting the effectiveness of the assessment process and feedback (Bdiwi et al., 2019).

2.3.6 Tracking Smart Systems

Smart workspace is defined as an advanced paradigm through which a different delivery of smart pedagogical practices was used to offer educational content differently (Norton, 2018). Examples are the connection of a great number of wireless sensors along with mobile devices, available software systems, and various intelligent equipment. These tools (devices or equipment) are to provide effective communication to learners anywhere and anytime. Based on this approach, smart technologies are the most significant methodology to incorporate the technological strategies aiming at ensuring the enhancement of learners via transferring higher-order knowledge (Zhu et al., 2016). The availability of smart technology has no effective result unless connecting these devices with the appropriate mechanism (Khan & Salah, 2018). In this regard, radio frequency identification (RFID) technology is the pioneer in the success of SLE by using electromagnetic fields in order to transmit data (Gharat et al., 2017). RFID requires various hardware and software systems to make and to provide suitable interaction with smart devices, learners, and teachers. RFID provides also a system that enables deploying and tracking infrastructure (Gharat et al., 2017). The process of implementing smart tools meant to change the field of education by facilitating the learning process combined with critical thinking (Elhoseny et al. 2017). In addition to RFID, a real-time locating system (RTLS) has been increasingly implemented in remote education to resolve indoor tracking problems with the aid of a global positioning system (GPS) as an outdoor technique (Dong et al., 2018). RTLS and GPS were used for the non-educational approach as they were adopted to keep tracking learners inside and outside the classroom. As smart devices are progressing and getting more complex, teaching methods have to researched, investigated and evaluated continuously (Bdiwi et al., 2019).

The tracking systems face challenges such as the inaccuracy of the exact positioning of learners; hence, developing local-base devices is another challenge. Finding a suitable solution was performed by several researchers such as Bobescu & Alexandru (2015) who used Android mobile devices by implementing an algorithm of Wi-Fi trilateration through which the indoor signal propagation is collected to recover reliable location. Dari et al. (2018) have criticized the mobile technique as nothing but a new version of GPS. Another technique called received signal strength (RSS) was used in connection with the access point by developing fingerprint techniques to assist RSS via a mobile device application called iBeacon (Bdiwi et al., 2019). This technique was then developed by collaborating iOS and Android through the service of Bluetooth low energy (BLE) (Fard et al., 2015). The main objective of developing such devices was to enhance learners' attendance and, then, to evaluate interaction among teachers and students. It seems that evaluating effective teaching in an intelligent environment is more difficult than traditional classroom.

2.4 Summary of Historical Developments

Table 2 summarizes the historical developments that either constitute the foundations of smart learning or expressing the developments that have become a part of smart learning. All developments such as creating expert systems from the 1950s until the 1980s represent building up the blocks that result in developing smart learning. Since the early 1980s, smart technologies such as AI, ITS, ICT, XAIDA, GAIDA, ANN, decision tree, random tree, display information, theoretical smart learning, and learning analytics.

Table 2. Historical Developments of Smart Learning Environments

Year	Application	Aim	Reference
1950s	Academic Enterprise	• Implementing Artificial Intelligent	Specter (2016)
Mid 1960s	Dummy Expert System	• Solving complex problems	Lindsay et al. (1980)
Early 1970s	Expert System	• Analysis	Shortliffe et al. (1975)
1970s	Information and Communication Technology	• Computers	
1980s	Advanced Expert System	• Analysis and accounting	Schalkoff (2011)
Late 1980s	Artificial Intelligent (ID Expert)	• Commercial and educational	Merrill (1987)
Early 1990s	XAIDA and GAIDA	• Designing and viewing lessons to improve human productivity and training	Spector et al., (1993)
1990s	Intelligent tutoring systems (ITSs)	• Expert system to provide one-on-one instruction to students in a computer-based environment • simplifying learning and raining • managing students' engagement in the learning environment • pedagogical model for instruction and presentation • facilitating tutoring process	Shute, & Psotka (1994)
1992	Information and Communication Technology	• e-mail, audio conferencing, television lessons, radio broadcasts, interactive radio counselling, interactive voice response system, audiocassettes and CD ROMs • World Wide Web (WWW)	Pelgrum, & Law (2003) 7 Sharma (2003)

1992	Technology-Learning link	• Developing link between schools, learning and computer technology	Mevarech, & Light (1992)
1996	Artificial Neural Network (ANN)	• Image processing • Forecasting • Classifying students • Simulation	Lau et al. (2019)
Early 2000s	Decision tree	• Internet of Things (IoT): machine learning, data mining, statistics	Mahmood et al. (2019)
2003	Random tree	• Modelling	Uzelac et al. (2018)
2008	Random forest	• Machine learning	Elhoseny et al. (2017); Bahnsen (2015)
2008	K-means Clustering	• Machine learning • classify students' learning activities using e-learning • participation of students in the classroom, submit assignment, view assignment	Latipa Sari et al. (2017); Miyazaki, & Kurashige (2010)
2009	Display of information	• Communication between devices • Students' location • Implementation of AR and VR in education	Wang and Yeh (2018); El Mrabet, & Moussa (2019); Srivastava, & Yammiyavar 92016)
2010	Theoretical Smart Education	• Students' performance prediction	Muthukrishnan et al. (2018)
2015	Naïve Bayes	• Simulation • Machine learning • Classifier • Data mining	Saritas, & Yasar (2019); Zhou et al. (2020)
2016	Learning analytics	• Optimizing learning and learning environments	Siemens (2012)

2.5 Discussion and Conclusion

Smart education has been born to show a new paradigm in universal education aiming at improving life-long learning and to provide simple techniques to transmit knowledge. The general characterization of smart education includes being contextual, personalized, and enhancing problem-solving ability in smart environments. The first foundation of smart education is to minimize the cognitive load of learners and, simultaneously, enable them to focus and to facilitate ontology construction. Smart education is flexible; however, it works collaboratively with the intelligence of learners.

A smart city, including education, is an example of how technology has changed the lives of people (Hollands 2008). Just imagine when all faculties in smart cities collaborated mutually, smart education has integrated ideas, technology, theories, and experience of others to serve only one purpose represented by smart education.

Adaptation to smart learning analytics is measured by the ability of such a system to sense, infer, and anticipate self-learning based on the suggestion by Uskov et al. (2017). In this system, self-regulation should facilitate as many learning activities as possible besides visualizing and offering learners' feedback. Currently, smart learning environments are indispensable due to the wide range of implementing smart technology to ensure to make sure that smart learning is available regardless of time and location. It is widely believed that smart learning has enough technology to achieve such a purpose despite the fact that learners have different acceptance and agendas (Boulanger et al., 2015).

Smart learning environments have to achieve the basic assumption of all humans are intermittently rational. The variations amongst people should be taken seriously and adequately. This not applied only to various communities, but it should be applied even to a small class where a very limited number of learners exist due to the variation of learners to technology and suitable training that they acquired. In this regard, people can create their own internal representations or mental models and those people have various tendencies to engage or discourse based on personal ability (McManus, 2006). Understanding and realizing these two capabilities are the criteria that decide the success of the learners. The first step is always the most difficult step in any process. In smart learning, the first step is acceptance followed by engagement (Pirnay-Dummer et al., 2010).

Developing technologies that are familiar to modern society, smart education has reached tremendous success; however, challenges exist. Formalization of pedagogical theory, leadership for educational institutions, preparing and training competent teachers, establishing the structure for education, and creating ideology for this education are some of these challenges. Integrating various scenarios to build data-centric smart education is another challenge. As smart education is progressing, searching for interconnected and interoperable learning services between the smart education system and other systems could be a future challenge. Other challenges arose from various points such as system and policy shifts, continuous change to educational environments, and the reaction of different cultures. It is a very big task to shift the conventional educational system to a new system where teachers, students, parents, stakeholders have to come to a consensus agreement. In addition, other challenges are related to policies, ethics, and social aspects.

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