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New Development and Evaluation Model for Self-Regulated Smart Learning Environment in Higher Education

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Abstract—The smart learning environment is a technology-supported learning environment that is enriched with digital resources, context-aware and adaptive devices, and can provide appropriate support to meet the learning style and abilities of diverse students to promote better and enhances learning process in higher education. It is a student-centered learning environment that has the capacity to engage students and offers an effective learning process. It is characterized by the ability to provide interactions between students and facilitators, and personalized and inclusive learning experiences to anyone, anytime and anywhere using smart mobile devices. However, despite the increasing use of smart learning environment in higher education, there is no well-defined model with a set of educational requirements for developing and evaluating self-regulated smart learning environment which considers both instructional and evaluation design. Therefore, this article explores instructional design and learning evaluation process to propose a new set of educational requirements referred to as smart learning environment pedagogical and educational requirements model (SLE-PERM) for developing and evaluating self-regulated smart learning environment. Next, the article presents the application of the educational requirements on three common learning management system (LMS) namely: Moodle, Blackboard and Schoology which can be used to evaluate the suitability of LMS to guide stakeholders on the critical issues that require pedagogical and educational requirements for developing a self-regulated smart learning environment in higher education.

Index Terms—Smart learning environment, development and evaluation model, self-regulated learning, learning management system, higher education

I. INTRODUCTION

The educational process involves interactions among students and the teacher, and in most cases, a teacher provides the learning contents, while the technical issues such as learning support, pedagogical theories, and accessibility are provided and supported by the educational provider. Today, the development of technology has changed the way educational processes are conducted around the world. The recent developments in smart and intelligent technologies such mobile computing, Internet of Thing (IoT), artificial intelligence etc., have changed the educational paradigm of a teacher from content and knowledge provider to knowledge facilitator [1, 2]. These technologies are transforming educational institutions into a smart education environment that can stimulate and support students to learn at their own pace with little support.

A. Background

The developments in smart technologies are transforming an online learning process into the smart education system, a new and emerging educational process that represents an integration of smart objects and systems, smart technologies, smart environments, smart pedagogy, and learning analytic to make learning effective and provide an opportunity to develop domain-independent meta-skills for a long-life learning process. It creates innovative approaches to teaching and learning strategies, innovative smart classrooms with easy local/remote student-to-faculty interaction and local/remote student-to-student collaboration. This new learning environment is enriched with digital, adaptive and context-aware resources that can provide personalized and inclusive learning experiences to enhance teaching and learning in an online learning paradigm [3-5]. The students can use a smart learning environment and digital learning devices to support their learning strategies in order to enhance their learning experiences in an online learning environment, and one such strategy is self-regulated learning (SRL), which is defined as self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal learning goals in a subject [6]. It is well established that students' ability to self-regulate their learning process can enhance skill and performance [7, 8].

The self-regulated smart learning environment can provide a platform for student to set their learning goals, plan, monitor and reflect on their achievements in order to provide personalized and inclusive learning experiences to develop skills for the lifelong learning process. However, despite the increasing research in a smart learning environment, there is a lack of models which outline educational requirements for developing and evaluating the self-regulated smart learning environment. The main question addressed in this article is what are the educational requirements for developing and evaluating a self-regulated smart learning environment in higher education.
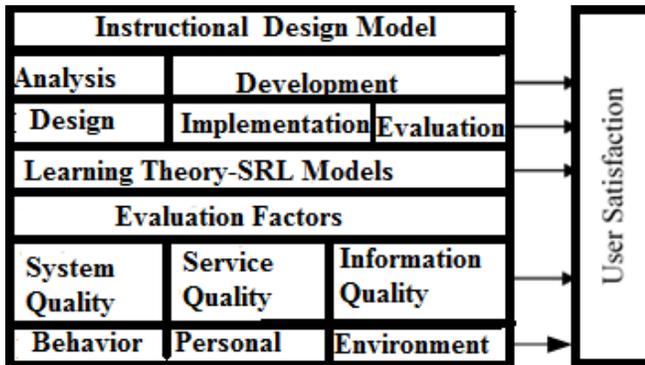
Fig. 1 Smart Learning Environment Pedagogical and Educational Requirements Model (SLE-PERM).

B. Our Contributions

In this article, we identified the most relevant educational requirements for developing and evaluating self-regulated smart learning environment which can motivate learners, instructors, and decision-makers in developing and adopting smart education system, in general, to meet the aspirations of the current learners and prepare them for future lifelong learning process. Contributions of this article are summarised as:

- Development of a model referred to as smart learning environment pedagogical and educational requirements model (SLE-PERM) for developing and evaluating self-regulated smart learning environment.
- Application of the model to three common learning management systems: Moodle, Blackboard and Schoology, and findings shows that there are relationships between the educational requirements and users' satisfaction.

The remainder of this article will proceed as follows. Section 2 explores the educational requirements and proposes the requirements model. In section 3, we provide the application of the proposed model. Conclusions are drawn in section 4.

II. EDUCATIONAL REQUIREMENTS

In order to identify existing research results on educational requirements for self-regulated smart learning environment, a systematic literature review method by [9] has been used in ACM, IEEE, Science Direct, Springer Link databases, and Google Scholar from the years 2011-2018. The search yielded 4 articles on the search terms Educational Requirements OR Development OR Evaluation AND Self-regulated Smart learning Environment AND Higher Education. After applying the systematic review methodology, removing duplicate, and those articles that are abstracts only, we found only two articles that deal with educational requirements in an online environment that are related to this work. In [10], the authors developed the model of instructional design based on the self-regulated learning using Modular Object-Oriented Dynamic Learning Environment (MOODLE) aimed at investigating how an instructional model can develop students' self-regulated learning and the effectiveness of the instructional design model

to increase students' study competency moderated by their self-regulated learning. The findings show that the model promotes a higher learning autonomy than the instructional design model, and effectively increases students' learning competency moderated by their self-regulated learning better than instructional design model. In a similar way, the authors in [12] integrated ADDIE (Analysis, Design, Development, Implementation, and Evaluation) framework as an instructional model, information success model [11] as mobile learning design evaluation factors, and learning theories. We found [12] related to our work, however, it lacks SRL models to evaluate SRL environment. Therefore, we introduce SRL models as learning theories, social cognitive theory and information system success model [11] as evaluating factors, and ADDIE model as an instructional model to develop a new educational requirement for self-regulated smart learning environment called the SLE-PERM. This new model is shown in Fig. 1.

A. Instructional Design Model

Instructional design is an approach to designing, developing and delivering, implementing and evaluating instructional environment using techniques and strategies derived from different learning theories to address instruction design problems [12]. Application of learning theories to SRL environment deals with the analysis of SRL environment needs and developments of the delivery of a self-regulated smart learning environment to meet the learning goals. While there are many instructional design models, this article adopted ADDIE model which is more a generic process, traditionally used by instructional designers and training developers to provide a dynamic, and flexible guideline for building an effective training and performance support tools [12, 13]. In other words, it is an approach to develop better instruction and learning through the integration of pedagogy and technology [12]. Authors in both [14] and [15] argued that the act of analysis, development, and evaluation in the ADDIE model supports the construction of meaning in order to enable the transition from theory to practice. This instructional model consists of five phases can be seen in Fig. 1 and are discussed as follows:

1) Analysis: The main purpose of this phase is to explore the characteristics, readiness, needs of the potential user, and resources needed for implementing the educational intervention. In other words, this involves exploring learners background, skills, and resources towards self-regulated smart learning environment, and constraints that might limit the scope and delivery of the system [12].

2) Design: This explores learning objectives, assessments, contents organization, and subject matter analysis after the analysis phase based on educational problems identified in the literature. This phase should be systematic and logically arranged to guide development and evaluation strategies to attain sets goals. The design phase can be a design document, framework, model or concepts with a detailed methodology to aid development [16].

3) Development: This is to create and assemble the contents described in the design phase. In this article, various smart and intelligent technologies will be studied to develop a self-regulated smart learning environment. This phase also involves testing, debugging and provide a procedure for using the system and the need for feedback.

4) Implementation: This phase provides a method of delivery, learning outcomes, students registration, workshop, and training. According to [17], there is a need to study concepts as tools to be understood through use rather than delivered through instruction.

5) Evaluation: This phase can be a formative or summative evaluation. While the earlier is conducted at each stage of the development process, the latter is conducted at the end of instructional programmes. The essence of the evaluation is to determine the effectiveness and efficiency of the self-regulated smart learning environment. At this phase, specific impacts of the new environment on learners' learning outcomes, interfaces, and satisfaction are evaluated. This will provide insights into evaluation decision before the full implementation, decision on how and when to collect data relating to the overall effectiveness, relevance of self-regulated smart learning environment, objectives and course content, correctness of learning materials, analysis of the feedback collected from learners, measurement of learning content validity and reliability, and the assessment of learners' reaction to the instructional learning quality [12].

B. Learning Theory

In this article, we adopted self-regulated learning (SRL) models as the learning theories. One reason that explains the interest in the SRL lies in the fact that we live in a society where lifelong learning process is increasingly important and informal learning environments require self-regulation skills. Moreover, SRL can support students self-awareness and self-regulation level so as to enhance their cognitive, metacognitive, motivation and engagement in an online learning environment [18, 19]. The three phases of SRL, namely: forethought phase (goal setting and planning), performance phase (task strategy, help-seeking and intrinsic interest), and the last phase, self-reflection (self-evaluation and self-monitoring); and their sub-processes are derived from commonly used models such as the Zimmerman, Pintrich, Boekaert, Corno and Mandinach, and Winne and Hadwin models. In the forethought phase, learner set goals and strategically plan how to achieve their goals; the performance phase is the actual process of learning and involves the strategies aimed at fostering the quality and quantity of learning performance through self-instruction, self-control and self-observation; and in self-reflection phase, the learner reflects and evaluates their reactions to performance goals compared to the outcomes. Moreover, Zimmerman and Pintrich's models emphasized a clearer distinction among the involved phases and sub-processes that, while Boekaert's, Winne and Hadwin's, and Corno and Mandinach's models are more explicit, making SRL an open process that has recursive phases [17, 20, 21].

C. Evaluating Factors

The evaluating factors integrate the components of social cognitive model and information system success model, and these are discussed as follows:

1) Social Cognitive Model: The social cognitive theory provides a model for learning that considers the social environment, the personal factors such as effect and cognition of the learner, and the behavior [22-24]. The author further asserts that students' motivation is influenced by their cognitive processes and their social environment. Students' personal factors such as their self-efficacy beliefs, can be a consequence of their own learning behavior such as their use of learning strategy, and their surrounding environment. Similarly, students' learning environment such as peers (environmental factor) may affect their self-efficacy beliefs and their learning behavior, and may lead to changes in their learning environment [22-24]. The author in [25] affirms that how individuals interpret the results of their performance attainments informs and alters their environments about their self-efficacy beliefs, and that in turn inform and alter their subsequent performances. The author in [26] stated that when students were able to control their personal, behavioral, and environmental factors, they are self-regulating their learning behavior. Both the theory of SRL and the theory of reciprocal interaction of learning are related and adopted in this new model [18, 24]. These three factors are considered as learning interactions.

2) Information System Success Model: The information system success model DeLone and McLean [11] considered the variables of information quality (information display, system accuracy, relevance, and completeness), system quality (system performance, response time, ease of use, user interface, reliability, security, availability), and service quality (quick response time, processing time, helpdesk) as determinants of the success of the system information. We considered these variables as learning technology qualities which can impact students' learning process.

III. APPLICATION OF THE NEW EDUCATIONAL REQUIREMENTS MODEL

This section considers the application of the set of educational requirements of the proposed model to analyze the pedagogical and educational requirements of the common and widely used LMS (Moodle, Blackboard, and Schoology) as the case study in order to demonstrate the applicability of the model and feasibility of the approach for self-regulated smart learning environment development and adoption in higher education. The proposed model Fig. 1 has four educational requirements namely: instructional design model, learning theory, learning interactions (behaviour, personal environment), and learning technology qualities(information quality, system quality and service quality). We adopted the weighting scale from 1 to 5, where 1 indicates that the requirements are considered as less important, 3 is neutral while 5 is considered as the most important requirements [12]. These three common learning management systems are: Moodle is a cloud-based

TABLE I Educational requirement for the common learning management systems

LMS	SLE-PERM Requirements	Scale	Comments
Moodle	Instructional Design Model	5	This is based on self-motivated cloud-based mobile learning with the following instructional design process: Identifying the general self-regulated smart learning environment objectives, carrying out the instructional analysis, executing the characteristics and previous knowledge analysis, formulating the specific instructional objectives, developing online assessment tools to find out the core competency, developing teaching and learning strategy, designing the learning materials in a form of learning object materials, designing and executing online formative evaluation, carrying out program revision and designing and executing summative evaluation [10], [12], [27].
	Learning Theory	5	Based on a social constructionist learning theory which facilitates construction of new knowledge [12], [27].
	Learning Interactions	5	It provides learning interactions among instructors and learners through a forum, feedback, collaborative, administrative panel, peer interaction, chats and dialogue to support the learning process [27].
	Learning technology Qualities	3	The learning materials uploaded have to be read on a screen of a mobile device, and sometimes difficult for some learners. Furthermore, the Moodle spaces for uploading materials and communication created confusion for the learners [12]. A well-structured course that included putting all course materials, the process of planning and designing can improve the quality of the course, more so, the cloud-based version of the Moodle enables less processing power from mobile devices and increase battery lifespan [30].
Blackboard	Instructional Design Model	4	Based on different instruction design tips to help the development of online materials and transition between different learning components, student participation, methods for assessment and follow proven instructional design techniques [12], [28].
	Learning Theory	5	Blackboard uses constructive, instructions, communicative, collaborative and social learning for designing learning materials. The rich educational content of blackboard builds on these learning theories empowers instructors with tools to engage learners [12], [27].
	Learning Interactions	5	Developed using different platforms (Android, iOS, BlackBerry, and webOS) to support learning contents delivery [12]. It provides different instructional design tips to help in the overall development such as the organization of online materials, the transition between different learning components, student participation, methods for assessment and follow proven instructional design techniques. It has a resource center for all learners and instructions needed support and has different learning resources such as text, images, graphs, audio, video etc. to facilitate content learning across users [12], [28].
	Learning technology Qualities	4	The content alignment is based on standards, objectives, and goals to facilitate more effective instruction that enables instructors to share and find quality learning content [31] and to facilitates a complete learning content solution that provides personal, course, institutional, and global content management capabilities for all types of learning content [12], [28].
Schoology	Instructional Design Model	3	Based on the ADDIE instructional design model [12], [29], [31] to provide a solid design of online course contents.
	Learning Theory	5	It uses learner-centered, community-centered, knowledge-centered and assessment-centered approach to enhance the learning experience by using learning theories that include constructive, cognitive, transactional distance theory and situated learning etc. [12], [29].
	Learning Interactions	3	It supports learners by providing links, video and internet resources in their forum articles, texts, websites, online quizzes, discussion boards, flipped lessons and review materials to their learners in an organized manner [12]. It also creates the resources that the instructors and their peers have inserted, and allowed learners to self-assess their works and peers-assess by posting and commenting on each other works [12], [29], [32].
	Learning technology Qualities	3	It also creates dynamic contents, uses third-party contents, and embed multimedia into lesson and assessments. It can easily be shared with faculty with different instructions based on interactive formative assessments [12], [33].

web mobile learning open source free learning management which is available as iOS and Android platforms. It allows learners and instructors to interacts and work anywhere at any time using mobile devices [27]; Blackboard comes as a web or mobile application that provides an interactive learning platform. It can be installed on mobile devices and permit learning anywhere at any time [28]; Schoology is a learning management system available as a free native mobile application that is provided to extend the learning process beyond the classroom. Schoology is offered on many platforms. Schoology redefined the LMS to provide online education as a collective effort and to increase the impact of all students and teachers involved in the education activities [12, 29].

Table 1 above provides a summary of the application of the new set of educational requirements on the common learning management systems. The result of scoring shows that learning theories scored the highest across the three platforms. This was also observed to be less in the instructional design model, and there are few discrepancies across other requirements. However, Moodle scored highest requirements compared to the Blackboard and Schoology. Furthermore, Schoology on the other hand, scored average and low in some requirements, which makes it the least compared to the other two. In terms of the SRL environment, it is clear that these three-platforms lack the SRL model to develop and evaluate a self-regulated smart learning environment. These requirements provide the needs to design, develop and implement a self-regulated smart learning environment to support learners towards lifelong learning process.

CONCLUSIONS

This article explored literature, experience, and technical reports to propose novel educational requirements for self-regulated smart learning environment addressed from the

dimension of instructional design (ADDIE), learning theory (SRL models), and evaluation factors (learning interactions and learning technology qualities). The proposed set of educational requirements has been applied to three common LMS to analyze the user satisfaction. It has been concluded that the proposed model has a positive impact on the LMS indicates that there is a relationship between users' satisfaction and educational requirements. The proposed model can be used to evaluate the suitability of learning management system. Furthermore, it can guide stakeholder on the critical issues that require pedagogical and educational requirements for developing smart learning environment content for supporting the design and evaluation of the self-regulated smart learning environment across the three phases of self-regulated learning process in higher education. We recommend that future works should consider other technology and organizational factors on evaluation design and direct towards evaluating the feasibility and cost effectiveness of self-regulated smart learning environment in higher education.

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