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Work-in-Progress: Model of Self-Regulated Smart Learning Environment

***Abstract*— The use of smart and mobile technologies provides a smart learning environment that can support diverse learning needs. The self-regulated learning process has been identified as one of the strategies that can support students in the online learning environment. Metacognitive skills such as goal setting, task strategy, self-reaction, help-seeking, time management can be developed in a smart learning environment to support the learning process. However, despite the increasing research in the smart learning environment, there is a scarcity of well-documented work on how the metacognitive components in a smart learning environment could be modeled to support the development of a self-regulated smart learning environment. This paper explored the metacognitive components in the smart learning environment to propose the hybrid model, referred to as MSLEM: Metacognitive Smart Learning Environment Model which can be beneficial to researchers for providing a personalized learning environment for supporting the online learning process**

Keywords— Smart learning environment, self-regulated learning, metacognitive skills, learning model

I. INTRODUCTION

The increasing development in smart and mobile technologies are transforming the learning environment into a smart learning environment, which can support smart pedagogy to meet diverse learning needs [1]. However, student in online learning needs more support than those in-class in order to be motivated and succeed. Furthermore, with the current disruption of teaching and learning due to the Covid-19 pandemic around the world, and potential situations in the future, there is an urgent need to bring innovations that can support the online learning process for the continuity of education. Several smart learning environments have been developed to support students in the learning process to motivate and increase interaction; however, self-regulated learning (SRL) has been identified as one of the strategies that can support students to develop metacognitive skills to enhance learning experiences for supporting online learning process [2-5]. Despite the increasing research in the smart learning environment, there is the scarcity of a well-documented work on how the metacognitive components in a smart learning environment could be modeled and integrated with the SRL process to support the development of a self-regulated smart learning environment to provide personalized learning and skills development [1, 3, 6]. This paper model the metacognitive components in smart learning environment to support competency and skills development for success in online learning environment.

II. BACKGROUND

A. Self-Regulated Learning

The SRL is defined as a planned thought, action developed, and cyclical phase adopted to achieve a personal learning goal [7]. It has become a key concept in educational literature and an overarching construct composing of many variables that underpin the learning process over the years [8-12]. One reason for the interest in SRL is that that lifelong learning is increasingly critical in both formal and informal learning processes and can support metacognitive skills development [4, 7]. The SRL has three phases which includes: Forethought, performance, and self-reflection; and comprising of cognitive, metacognitive, motivational components [7-12]. The metacognitive dimension is regarded as a super-ordinate ability to control cognitive, and motivational processes to achieve a set learning goal [7-9].

B. Self-Regulated Learnining Model

The SRL has different models which includes: Zimmerman, Pintrich, Boekaert, Hadwin, Efklides, and Winne and Hadwin [8-11]. These models are developed from different learning theories; however, all agreed on stages and phases of the SRL process as supported by a piece of evidence from their usage [7-8]. Furthermore, despite the differences in the theoretical constructs, theories and empirical pieces of evidence agreed on a dynamic process from cyclical phases and components influencing learner, context, and task [7-8]. This paper adopted Zimmerman model as one of the earlier models of the SRL process, which is widely used in literature and useful for measuring cognitive and metacognitive component [7]. The Zimmerman's model was developed from socio-cognitive theory, stressed that people gain information by studying others and social contact. It has a distinct process and sub-process and integrates a "regulation of cognition/metacognitive strategies," that plays a central role in the self-regulatory learning process [7]. It is the most cited model for the study of the SRL method with simple three distinct processes, and centered on how metacognitive and motivating mechanisms and values communicate in consecutive cyclical stages [7, 8].

C. Metacognitive Regulation

Metacognition is becoming aware of one's awareness; metacognitive aspects of learning include one's focuses capabilities, such as aptitude and how to modify cognitive learning strategies [6-8,]. Metacognition regulation tends to enhance metacognitive abilities and coordinates cognitive learning strategies [6]. Students' ability to control their learning is an essential concept in learning success, which provides them with an opportunity to coordinate and complete cognitive tasks and strategically make use of learning strategies to control their learning progress [6, 8]. The desire to realize how students' study individually can be accomplished through the components of the metacognitive regulation [6].

D. Smart Learning Environment and Metacognitive Components

A smart learning environment is a student-centered learning environment that focused on personalized learning experiences that shift the role of a teacher from instructor to the facilitator [4, 13, 14]. It has a number of metacognitive components that can support learning process. For example, Hwang [15] identified five main components which are segmented into five modules which are: Student state detection module, student performance evaluation module, adaptive learning task module, adaptive learning content module, and personal learning support module as well as an inference engine. The metacognitive abilities are an essential factor in a learning process and can support learning personalization, which may differ among learners with the same cognitive ability that can result in dissimilar cognitive development [13,14]. Thus, based on these components and concepts, Sumadyo et al. [6] categorized the metacognitive components of a smart learning environment into five modules. These five modules are discussed as follows:

- Cognitive detection module: This component captures goals setting and personal information. The goal can be a set of achievements reached at the end of the course. These attributes form a learning portfolio and benchmark for students' cognitive ability profile.
- Learning content management Module: This component provides learning resources or task strategies outlined based on the content. A student is free to use the desired learning contents that suit their learning styles. This module also provides an opportunity for help-seeking or interaction with colleagues or facilitator during the learning process.
- Inference engine Module: This module is the intelligent part of the model that contains an algorithm for smart decision-making regarding students' cognitive level and determine students' metacognitive status so that student can select an action for planning their metacognitive improvement.
- Adaptive assessment Module: This component, with the assistance of the inference engine plans and provides a learning assessment to students. The outcomes of this assessment concerning prior knowledge and goal selected will provide insight into students' learning competency and skills needed.
- Metacognitive Module: This component contains direction for improving metacognitive abilities. This can be action-related, content-related, learner-related, or social-related, which students can use to enhance their metacognitive skills.

These components can provide a foundation for developing a model of smart learning environment for supporting the metacognitive skills and learning for online learning success. However, the components along are insufficient to provide a dynamic model for supporting metacognitive development in a smart learning environment. There is a need to extend and model with other related components.

III. MODEL OF SMART LEARNING ENVIRONMENT

To develop a model of the self-regulated smart learning environment to support skills development, the metacognitive components in the smart learning environment [6] are extended with the inclusion of the intervention engine module to provides a platform for a facilitator to support individual or a cluster of the student in the self-regulated smart learning environment [16] and SRL process as the learning theory to provide the learning process [8]. Based on the methodological approach of Canter [5], these components are integrated into a model called Metacognitive Smart Learning Environment Model (MSLEM). Fig I show the interaction of the metacognitive components in the smart learning environment, and the entire model has six modules, i.e., cognitive detection, learning content management, metacognitive technique, assessment, adaptive, and intervention engine. From Fig I, it can be seen that cognitive detection module offer a process to select a pre-defined goal, which can be a set of achievements or competency that students are expected to achieve at the end of a course. The learning content management module manages digital learning resources and provide task strategies into different formats to support the learning styles and need of learners and provides opportunities for help-seeking. Whenever students feel confident about their learning process, they can assess their learning level by taking assessment in the assessment module based on the selected learning goal generated by the adaptive assignment module. The inference engine module provides the intelligent part of the model that contains an algorithm for smart decision-making regarding students' cognitive level and determines students' metacognitive status to choose for planning the development of their metacognitive skills.

The metacognitive module provides a real-time data about the student competency and skills direction, available to both student and facilitator. However, when the student fails in improving their abilities to solve a problem, the intervention engine module allows the facilitator to provide intervention support to help the student to succeed. Thus, in the SRL process, the cognitive detection module works at the forethought phase, the learning contents management module work at the performance phase, and lastly, the adaptive assessment module and inference engine work at the self-evaluation subprocess of self-reflection and intervention engine and metacognitive module work at the self-reaction sub-process of self-reflection phase.

Table I shows the mapping of the MSELM across the three phases of Zimmerman's model of SRL process in Table I. The measurable sub-processes components of Zimmerman's model: Goal setting, task strategies, time management, help-seeking, and self-evaluation, are mapped to the MSLEM in Fig I., and are the metacognitive skills that students' need to have and improve to succeed in the online learning environment [4-6].

From Table I, the self-regulated smart learning environment can be development by the advancement in smart and wireless technologies. For example, the features of mobile devices, RFID (radio frequency identification), IoT (Internet of Things) devices can meet the action and learning process in self-regulated smart learning environment needs with the support of wireless and sensing technologies [12, 15, 16]. Distance learning students or individual students from different locations can study the same subject with intelligent mobile devices. For example, a mobile device interface can capture the cognitive detection module and other basic personal information. Computer vision technology can capture the face and emotion of students while answering problems, GPS or IoT devices can capture environmental situations and conditions, and all these data will create students' profiles. They can be used for providing personalized support. The learning content management module can be hosted on a cloud-based database or cloud-based learning management system to provide digital learning resources and task strategies concerning the subject matter. This allows students to learn concepts, seek help, interacts with colleagues while learning. When the students feel confident about their learning process and desire to learning assessment to gauge their capabilities, the adaptive assessment module provides questions to a student based on the selected learning goal.

The inference engine will provide an intelligent decision and recommendation based on the cognitive detection module, task strategies used, competency performance during an assessment, time spent while learning, and the kind of task strategy used. The level of recommendation which triggers self-reaction varies; some can be basic techniques and formulae for solving problems, while other resources recommendation and others could be the entire subject. The learning analytics, big data, and neural network can help make intelligent decisions and assist in the adaptive assessment. The recommendation from the inference engine and the cognitive module is managed by the metacognitive module, which can be view by both the student and facilitator. The information in the metacognitive module can motivate the student to improve competency and skills development for a subsequent task. The intervention engine provides an interface for the facilitator to provide personal help for a student or group of students when they are struggling in the learning process. Other technologies can that support the development of self-regulated smart learning environment is Augmented Reality technology, which integrated learning problem into a digital world like in the real world to help students learn at their own pace [10, 13, 14].

IV. CONCLUSION AND FUTURE WORK

This theoretical paper bridged the gap in knowledge by exploring literature and identified and extended the metacognitive components in the smart learning environment to propose a model called MSELM for supporting metacognitive skills development for the online learning process. The metacognitive in the model (MSLEM) provided insights into developing a self-regulated smart learning environment to support online learning experiences.

In future, the work will focus on validating the model and then developing it into an application as a proof of concept.

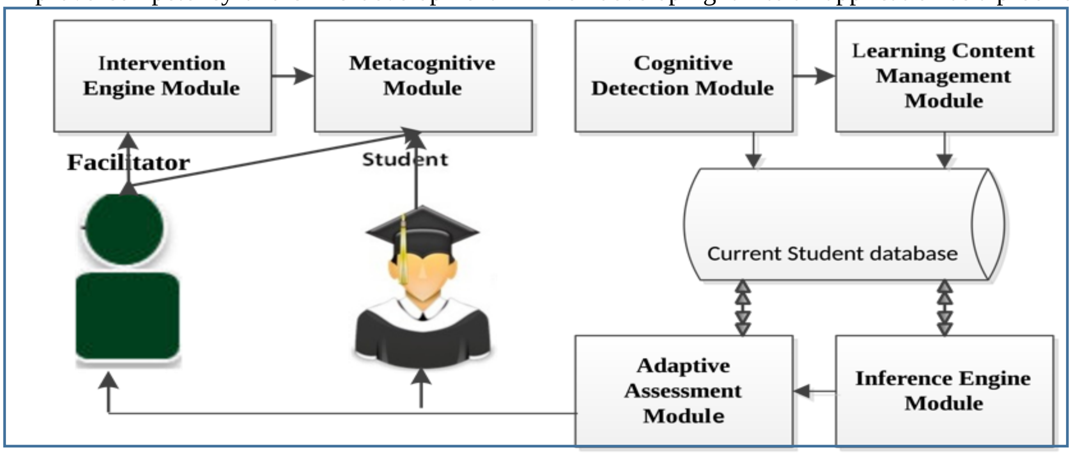

Fig I. The Metacognitive Smart Learning Environment Model (MSLEM)

Table I: Mapping of the MSLEM to Zimmerman's SRL Model

SRL Phases	Metacognitive Skills (MS)	Actions	MSLEM Component	Tools
Forethought	Goal setting (GS)	Select performance level and assessment criteria	Cognitive Detection Model	Features of smart mobile devices
Performance	Task strategy (TS)	Use of specific tactics or resources related to the task & take exercises & Assessment	Learning Contents Management Module & Adaptive Assessment Module	Cloud-based database, cloud-based learning management, i.e., google cloud system, Neural Network, learning analytics
	Help-Seeking (HS)	Ask questions when need through chat with peers and facilitator	Learning Contents Management Module	Cloud-based database, cloud-based learning management, i.e., google cloud system

	Time-Management (TM)	Plan on using the time during the task and monitor time spent on each lesson or task	Learning Contents Management Module	Features of smart mobile devices
Self-Reflection	Self-Evaluation (SE)	Assessment of performance concerning assessment criteria modulated by the performance level of the goal, View performance, and recommendations	Inference engine Module & Adaptive Assessment Module	Learning Analytics & Neural Network
	Self-Reaction (SR)	Plan to improve skills based on the contents of the learning performances	Metacognitive Module	Learning Analytics & Neural Network

The first stage is to model a learning agent using the five metacognitive skills as inputs and associated learning style model as outputs using an artificial neural network. The second stage is to generate a dataset for training and testing the model. The dataset for the five metacognitive skills, i.e., goal setting, task strategy, help-seeking, time management, and self-evaluation, will be simulated with the corresponding learner's learning style model. The model will take a simulated generated dataset to train and test the learning agent applicability. The model is validated if the learning agent can correctly predict the learner's learning style based on combining the five metacognitive skills with a higher degree of accuracy. The third stage is integrating the inference engine module with other modules using smart and mobile to develop the model into a self-regulated smart learning environment to provide learning personalization for supporting online learning experiences.

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