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EVALUATING STUDENTS' EMOTIONAL RESPONSE IN AUGMENTED REALITY-BASED LEARNING USING KANSEI ENGINEERING

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ABSTRACT

Augmented reality (AR) is believed to be the next wave of online learning. New user experiences become possible to afford AR capabilities with the advent of powerful smartphones. Mostly, studies related to the use of augmented reality in education focus on cognition with little consideration is given to emotions which is important in learning. Therefore, this research aims to identify salient connections between emotions and design elements of augmented reality-based online learning material by applying Kansei Engineering (KE) approach. In this research, mobile augmented reality application related to the human heart was prepared to be used as a case for the study. Seven specimens of the mobile augmented reality application were evaluated with 55 emotions of Kansei Words (KW). 28 students from one of the public universities performed the evaluation experiment. The gathered data were then analyzed using Factor Analysis, Principal Component Analysis and Partial Least Squares analysis. The results revealed the important pillars of emotions or *kansei* semantic space emotions for augmented reality-based online learning materials. Based on Factor Analysis, it revealed four main pillars; *professional-motivated, confused, wandering-thrilled* and one additional pillar; *trustable*. Besides that, this research described design elements of augmented reality-based online learning material that might evoke specific emotions based on five identified pillars. Ultimately, this research is an attempt to guide the design with affective formula during preparation of augmented reality online learning materials in the future.

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LIST OF ABBREVIATIONS

LMS	Learning Management System
HEIs	Higher Education Institutions
MOHE	Ministry of Higher Education
AR	Augmented Reality
VR	Virtual Reality
FA	Factor Analysis
PCA	Principal Component Analysis
PLS	Partial Least Squares

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Technology has proven to be a useful for education and can help to achieve goals in teaching and learning by providing platform such as Learning Management System (LMS), Content Management System (CMS) and Massive Online Open Course (MOOC) in which facilitates online learning. Currently, Internet penetration in Malaysia stands at 67%, thus it is reliable to harness the power of online learning to widen access to good quality content, enhance the quality of teaching and learning, lower the cost of delivery and bring Malaysian expertise to the global community. (MOE, 2015). In response with demand, most universities in Malaysia have their own LMS. The deployment of LMS enables self-pace online learning and the world of e-learning continues to evolve within the use of emerging technology. Moreover, the global LMS market is expected to grow at 24% from 2016 to 2020 (Docebo, 2016).

Online learning (e-learning) is confined with the concept that uses the internet to deliver content of wide range of study programs at anytime and anywhere which facilitate interactions between teachers and students (Lister, 2014; Sandanayake et al., 2011). In e-learning system, there are three components known as content (learning material), connectivity (delivery of the content) and community in which content is identified as the most important thing for an e-learning system (Lim & Lee, 2013). In addition, e-learning basically has played the role of one-way learning method to the user which has resulted in boredom because the learners passively absorb the delivered knowledge. This is supported by Krithika and Priya (2016), in which there is a necessity to analyse emotions as instructional aides become ineffective in an interactive learning technologies, particularly e-learning.

Based on previous research, emotions of a student during course engagement play a vital role in any learning environment including e-learning (Barker & Gossman, 2013). Positive emotions such as enjoyment and satisfaction are known factors that can

improve academic achievement (Pekrun, 2006). In contrast, negative emotions can sometimes be a catalyst for improving academic achievement (Hascher, 2010). Evaluating the emotion of an online learners can progressively help in enhancing learning experience and update the learning contents (Krithika & Priya, 2016). Recent study by Adnan and Redzuan (2016) revealed design for video-based online learning material with emotional consideration. In online learning, instead of learning material, content acts as an instructor. Therefore, ensuring the delivery of the right contents to the learners with a good design results in an effective learning (Krishnan & Vanitha, 2016).

According to Satpute et al. (2015), augmented reality can be utilized in online learning as learning material and shows positive response of students which in turn facilitate the learning process, thus provide effective learning. AR is an emerging technology with a combination of computer graphics, vision and multimedia, which enhance the user's perception of the real world through the aid of virtual information (R. Azuma et al., 2001). With the aids of multimedia elements and interaction in the design, AR can facilitates learning (Solak & Cakir, 2015). Despite above study, research in emotion towards online learning is still lacking (Krithika & Priya, 2016). Therefore, this study is an attempt to design and engineer emotional experience of students to achieve effective formula during preparation of online learning materials, particularly augmented reality based online learning materials. Practically, the right student's state of emotion and a good sensation are said to be able to contribute to the effective use of online learning thus makes students' engagement in online learning material more effectively.

1.2 Research Background

Higher Education Institutions (HEIs) needs to keep evolving and to stay abreast with global trends (MOE, 2015). Augmented Reality (AR) is among technology pillar in Industry 4.0 (MITI, 2017). Current trend for AR applications is the rapid development and adoption of mobile computing devices such as smartphones and tablets (Huang et al., 2013; Nincarean et al., 2014). Recently, researchers are progressively exploring on augmented reality technology especially in educational

fields. AR is a proven technology that effectively engages learners in numerous learning activities including abstract concept subjects (Radu et al., 2010; Yen et al., 2013). In Malaysia, research on augmented reality is still in their infancy and mostly focusing on the effectiveness of implementing these technology with primary school students Majid & Husain, 2014) and secondary school students (Ng et al., 2016) in learning science subjects.

Significantly, augmented reality is the future of online learning (EXULT, 2017; Ira & Berge, 2009). A comprehensive survey by Satpute et al. (2015), indicates that the effectiveness of AR technology can be a leverage for online learning. With Mobile Augmented Reality, the scope and prospective functionality of AR are extended (Kourouthanassis et al., 2013). The collaboration of AR and mobile devices can improve learning experience thus enhancing the process of obtaining information (Cadavieco et al., 2012). A study by Jamali et al. (2015) had utilized Mobile-Augmented Reality for learning human anatomy which focuses on usability. Similarly, Kiourexidou et al. (2015) studied online education of anatomy course using AR to enhanced learning. Although AR has performance related issues, but it is continuously used as it is effective in learning and this hidden value is not fully addressed (Radu et al., 2010).

As technology continues to transform the educational landscape, improving learning experience is vital to attract and sustain learner interest. Researchers revealed that emotions in computer-supported learning can also affect learners' performance and achievement (Lemke, 2013). Pekrun and Stephens (2010), agreed upon that emotions have immediate effect on learning and achievement which mediated by attention, self-regulation and motivation. Mostly, learning process occur when learners are in a positive state of emotion. This aligned with three recent studies, in video-based online learning (Adnan & Redzuan, 2016), web-based online learning (Redzuan et al., 2014) and mobile learning (Taharim et al., 2013), have investigated how design elements could connect to a specific emotion. Similar with above studies, (Chuah et al., 2011) incorporated emotions in instructional design of a desktop Virtual Reality based learning environment which in turn can affect learning. A preliminary study was conducted on 32 medic students from a local public university and revealed the relevancy of issues in online learning including students are less satisfied with current online learning material (53.1%) and they are having difficulty to visualize abstract

concept in learning human anatomy course (71.9 %).

Capturing emotion in online learning are quite challenging and there is still little empirical research on learner's emotion (Krithika & Priya, 2016; Linnenbrink-garcia & Pekrun, 2011). Indeed, design based on emotion can deeply affect overall user experience (Brown & Voltz, 2005; Triberti et al., 2017). The implications of emotion for online learning help to maintain interest as well as motivation or else nothing will stick (Adnan & Redzuan, 2016). Emotion muster student's persistence in leaning, thus ensure optimal learning outcome (Quinn, 2006). Capturing student's emotion in online learning with AR technology is rarely emphasized and not fully addressed in higher education setting, thus stimulates this study to evaluate students' emotional response in higher education institutions while using augmented reality-based online learning materials. As formulated by (Nagamachi, 1995), Kansei Engineering (KE) is an ergonomic consumer-oriented technology which has been successfully used to incorporate the emotional appeal in product design. In product design, designers widely used KE to decide on high satisfaction of product parameters, features or elements such as color, layout and size (Chuah et al., 2011). Due to this fact, the apparent need to investigate emotional factors of AR-based online learning by incorporating KE methods. The identified emotion is important in order to find connection between these emotions with specific design elements. This research demonstrates KE method in evaluation process of such learning environments with the support of empirical findings.

1.3 Problem Statement

The Ministry of Higher Education (MOHE) aspires to globalize online learning and key initiatives include making online learning an integral component of higher education and lifelong learning (MOE, 2015). As discovered by Embi (2014), online learning environment available in most universities was not optimized to create meaningful experience for the learners. This is proven by Bawa (2016), although online course enrolment has risen rapidly, online courses continue to display serious issues of low retention rates. Among the factors that contribute to dropout in online course are educational level (Park & Choi, 2009) and failure in understanding the content (learning

material) (Bawa, 2016; Willging & Johnson, 2004). Researchers have also highlighted the psychological attributes such as student's satisfaction and student's motivation which is closely related to the emotion are associated with student's persistence in an online learning (Bawa, 2016; Hart, 2012; Park & Choi, 2009; Willging & Johnson, 2004).

Based on the preliminary study, students having difficulty to learn complex course with abstract concept and they perceived assist form online learning with simple and interactive design. As revealed by Yen et al. (2013), Augmented Reality (AR) is promising technology for interactive learning especially for abstract concept in nature such as science education. Moreover AR can enhance student's engagement and motivation in learning (Radu et al., 2010). However, until now AR applications oriented to education have not been so deeply explored (Saidin et al., 2015). As reported in (Docebo, 2016) AR is an emerging technology that is believed to become the next wave of online learning. This is supported by Satpute et al. (2015), as AR technology can be used with online learning. Mostly, researchers have studied the use of AR in education towards usability and the effectiveness in learning (Duenser, Grasset, & Billinghurst, 2008). Not many are looking at the affective value of AR (Radu et al., 2010). Researchers believed the important of emotions in learning (Sandanayake et al., 2011; You, 2016). The exact content (learning material) is crucial in online learning (Lim & Lee, 2013). Moreover, capturing student's emotion in online learning is still lacking (Krithika & Priya, 2016).

Eventually, it is difficult to engage students in online learning and the design missing non-cognitive elements which is emotions (Quinn, 2006; Redzuan et al., 2014). Significantly, the understanding of learner's emotion is important in order to design the learning material, the issues on how to affective design online learning materials in respect with student's engagement in online learning need to be addressed. According to Scherer (2005), emotion can drives one's action tendencies. As the content is strongly affected by student's orientation, unsatisfied student are more likely to respond negatively. Consequently, it can give a negative impact on student's persistence in online learning. Eventually, it can threat Malaysian aspiration to globalize online learning. Therefore, it is imperative to identify emotions experienced by students towards online learning materials, particularly augmented reality learning material. In

order to come out with affective solution, an emotional approach using technology can be used to incorporate emotions into design. This research intended to formulate design elements for augmented reality online learning materials based on desired emotions in order to engage students in the online learning.

1.4 Research Questions

1. What are the emotions of students in the experience with augmented reality-based online learning materials?
2. How specific emotions associate with the design elements of augmented reality based online learning materials?

1.5 Research Objectives

1. To identify the emotions experienced by students while using augmented reality-based online learning materials.
2. To classify the design elements of augmented reality-based online learning materials for specific emotions

1.6 Research Scope

Based on the preliminary study, the heart is the selected case of study in which is among difficult topic to study by students. The Android platform dominates Malaysia's smartphone devices (EY, 2016). Therefore, this research used mobile augmented reality application particularly vision-based related to case of study which taken from Google Play Store. Moreover, this mobile augmented reality applications act as an online learning materials or specimens in this research.

Based on observation from current market (Google Play Store), there is a lack of augmented reality application related to the case of study, while the contents mostly in English. For the evaluation experiments, it is necessary to collect as many samples as possible to be used as specimens (Nagamachi & Lokman, 2011). Therefore, the Human Heart Mobile Augmented Reality application (HeMAR) is developed in the

Android platform as additional specimens which covers the human heart topics and is fully in English. HeMAR is a mobile augmented reality application using camera-based tracking method in visualization through marker.

Moreover, medic students from Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh are called upon to participate in evaluation experiment and psychological measurement (Kansei Form) is used for these students. The tertiary students are among those who are actively uses Internet (34.3%) (MCMC, 2016). In addition, participants must have the capability to express their emotions accordingly and have experience in an online learning.

1.7 Research Limitation

This research has several limitations which should be acknowledged and due to the feasibility of the research, only certain aspects will be discussed in this research. The participants of the study involved undergraduate students only, particularly first year students. They have no experience with augmented reality technology and Kansei Engineering (novice users).

Moreover, only seven specimens were used in evaluation experiments which are in Android platform and vision-based. There are four specimens which were taken from existing mobile augmented reality application that are related to the case of study in Google Play Store, while three specimens were generated through HeMAR. Besides that, the design dimension of this research only focused on interface of augmented reality-based online learning materials (specimens).

1.8 Research Significance

1) Educational designer

   As a guideline to inform the design of emotionally-sound augmented reality-based learning material in which the designer can optimize the positive features and minimize the negative ones when developing this type of learning material.

2) Higher education institution

To provide an insight for higher education institutions in improving online learning material in which the emotional experience can be designed and engineered to achieve an effective formula during preparation of augmented reality-based online learning materials in the future.

3) Student

To give a new sensation for students in online learning, thus assist to globalise online learning. Students' emotions are taken into account while designing learning material which can affect students' persistence in online learning.

1.9 Research Design

Table 1.1 The Research Design Summary

No	Research Questions	Research Objectives	Method	Outcomes/Deliverables
1	What are the emotions of students in experience with augmented reality-based online learning materials?	To identify the emotions exerienced by students while using augmented reality-based online learning materials.	**Literature Review:** Emphasize on Student's emotions Augmented reality-based online learning material design and Kansei Engineering. Tools: Books, Journals, Articles, Proceeding and Thesis. **Preliminary Study:** Emphasize on content and issue of online learning material. Tools: Online Close-ended Questionnaire **Observation:** Review and selection of augmented reality-based online learning material from apps store. **Expert Review:** Review educational content for augmented reality-based online learning material. **Data Collection:** Tools: Online Close-ended Questionnaire. Technique: Prepare 7 specimens for online learning material, prepare questionnaire, select participants and run experiment in control environment for evaluation	The emotions exerienced by students while using augmented reality-based online learning materials that can embed when design augemented reality-based online learning materials.

No	Research Questions	Research Objectives	Method	Outcomes/Deliverables
			and perform statistical analysis to analyze result.	
2	How specific emotions associate with the design elements of augmented reality based online learning materials?	To classify the design elements of augmented reality-based online learning materials for specific emotions.	**Literature Review:** Emphasize on Student's emotions Augmented reality-based online learning material design and Kansei Engineering. Tools: Books, Journals, Articles, Proceeding and Thesis. **Preliminary Study:** Emphasize on content and issue of online learning material. Tools: Online Close-ended Questionnaire **Observation:** Review and selection of augmented reality-based online learning material from apps store. **Expert Review:** Review educational content for augmented reality-based online learning material. **Data Collection:** Tools: Online Close-ended Questionnaire. Technique: Prepare 7 specimens for online learning material, prepare questionnaire, select participants and run experiment in control environment for evaluation and perform statistical analysis to analyze result.	The design elements of augmented reality-based online learning materials for specific emotions according to student's preferences in order to motivate students using online learning effectively.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

As stated in chapter before, this research deals with the evaluation of student's emotional response in augmented reality-based learning. In order to understand student's emotional response in augmented reality-based learning, and to develop measurements for them, multidisciplinary literatures including psychology, sciences, technology and Human Computer Interaction (HCI) are analyzed in this chapter thus led to the essential elements for this research.

Student's emotion, augmented reality-based online learning, mobile augmented reality and the characteristics of augmented reality-based online learning are explained in section 2.2, 2.3, 2.4 and 2.5 respectively. Meanwhile, the relationship between augmented reality-based learning and students' emotions is explained in section 2.6. This research involves in identifying emotions, theory and model related to emotion also classification of emotion measurement are necessary to determine the appropriate method and has been covered in section 2.7 and 2.8 respectively. Lastly, section 2.9 summarized all sections in this chapter.

2.2 Student's Emotion

Psychologists have offered a wide-range of definitions in emotion which are focusing on different manifestations or components of the emotion. At present the term emotion is introduced by Kleinginna and Kleinginna (1981), as a complex set of interactions among subjective and objective factors, which can give rise to affective states, generate cognitive processes, activate widespread psychological adjustments and lead to behaviour that is usually goal-driven and adaptive. This supported by Scherer (2001) that defined emotion as a process of changes in different components and agreed upon that the term emotion is used for event of affective order. In his extensive research, the three components involved are the experience or conscious feeling of emotion, the

processes that arise in the brain and nervous system, and the apparent expressive patterns of emotion (Scherer, 2005). With that, emotion can be summarized as inner feelings, desires and psychological responses that drives one's action tendencies which can be measured. Moreover, emotions are difficult to study because of the complexity and dynamic nature of emotions (Linnenbrink-garcia & Pekrun, 2011).

The study of emotion has been in the focus of the research agenda for many years. Recently, there has been a growing interest in the role of emotions in academic settings, especially in learning. However, so far how emotional experiences affect the performance in the virtual is still not fully addressed (Krithika & Priya, 2016). Generally, there are lack of adequate empirically proven strategies to address the presence of emotions in learning (Hascher, 2010; Mello, Taylor, Davidson, & Graesser, 2008). Despite that, researchers making great strides in understanding the central role of emotions for student's academic lives in various academic setting. Emotions such as enjoyment, hope, pride, anger, anxiety, shame, disappointment and boredom are associated with students' motivation and performance (Pekrun, et al., 2011). Mostly, positive activating emotions (enjoyment) can improve academic achievement (Pekrun, 2006). In contrast, negative activating (anxiety) and deactivating emotions (boredom) can impair motivation and interest (Pekrun & Stephens, 2010). However, Hascher (2010) claimed that there is no clear rules such as positive emotions foster learning and negative emotions are detrimental. For instance, curiosity can motivate students for enhance learning (Heylen et al., 2004).

Based on previous research, emotions play a vital role in online learning (Barker & Gossman, 2013). According to Broadbent and Poon (2015), students play a more demanding role in online learning and take more responsibility for their learning compared to face-to-face settings. In contrast, Paechter et al. (2010), argued that instructor's expertise and support formed a distinct and important factor in which emphasize on coherence of the learning material, the stimulation of learning motivation and the facilitation of collaborative learning. However, has highlighted that it is important to design emotionally engaging experiences in this kind of self-regulated learning (Cho et al., 2017). Previously, O'Regan (2003), has identified particular emotions that are significant for students in online learning such as frustration, fear, anxiety, shame, excitement and pride in which those emotions seemed to inhibit or

enhance the teaching and learning process. A study by You and Kang (2014), conveyed that experiencing enjoyment fostered self-regulated learning, while confusion, frustration and boredom often related with negative emotions in online learning (Graesser & D'Mello, 2012). However, the effect of negative emotions somehow can also lead to positive side of learning (Noteborn et al., 2012). Distinct research by Butz et al. (2015), analyzed program-related emotions and technology related emotions in online learning and found that students are devoid of emotion in online learning.

Eventually, there is no easy way for teacher to analyse student's behaviour and emotions in online learning environment (Raquel Faria et al., 2016). Hence, individual learners in traditional face-to-face learning or e-learning conditions show no emotions unless they are triggered by teachers, instructors, students or features from the environment or learning material (Rothkrantz et al., n.d.). A study by Butz and Harsell (2016), concluded that the emotions prepare the motivational and physiological energy, create the concentration, change the thoughts, and stimulate desires and purposes related to the activity.

2.3 Augmented Reality-Based Online Learning

Nowadays, online learning becomes a common practice in the educational systems, especially higher education. Many universities have been implementing e-learning systems to enable people to learn anytime and anywhere and also to deliver content, which provides methods that build new knowledge, skills relevant with individual learning goals in order to improve student performance (Charoenpit & Ohkura, 2013). According to Lim and Jung (2014), learners competence and motivation are more effective in enhancing learning performance notwithstanding the importance of learning contents or leaning material of a Learning Management System. The concept of teaching and learning without boarders applied in e-learning can enhance students learning experiences, but online learning environment available was not optimized to create meaningful experience for the learners (Embi, 2014). Moreover, it is very difficult to engage learners in the learning experience. Therefore, an effective solution is required to hook online student, thus e-learning designers must address the important components without supposing perfectly capable self-learners (Quinn, 2006).

Recently, there is an increasing interest in augmented reality (AR) technology especially in learning. Augmented Reality (AR) is a multidisciplinary field encompass computer graphics, computer vision and multimedia, which deals with the combination of real-world and computer-generated data (Azuma et al., 2001). The most popular definition for AR is given by Milgram and Kishino (1994) referring to the existence continuum of real-to-virtual environments in which AR is a specific area within the generic area of Mixed Reality as shown in Figure 2.1. By way of summary and to avoid limiting AR to specific technology such as head mounted devices, AR can be described as the real-time combination of digital and physical information through different technological devices (Azuma, 1997; Fernandez, 2017). In addition, Azuma (1997) explaining AR as a technology that have three main characteristics which are combines real and virtual worlds, real-time interactive and registered in 3D.

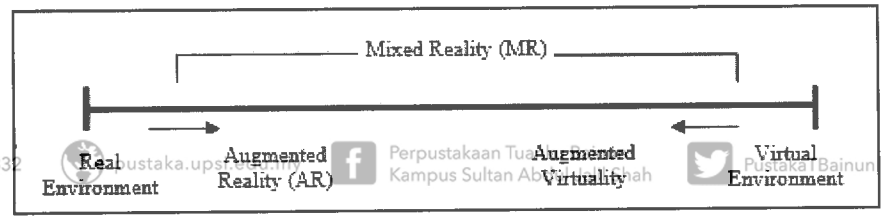

Figure 2.1 Milgram's Reality-Virtuality continuum
(Milgram & Kishino, 1994)

Researchers had stated the effectiveness of augmented reality in learning and most of the studies found that AR can enhance learning performance, promote learning motivation and increase learning engagement (Kiourexidou et al., 2015; Nincarean et al., 2014). Elsewhere, researchers have studied the effectiveness of AR technology in special education (Arvantis et al., 2009; Chen & Lee, 2016). In Malaysia, most study have indicated the importance of inclusion in technology enhanced learning approaches for science education in which rich of abstract concept in nature (Arvantis et al., 2009; Ng et al., 2016). As stated by Satpute et al. (2015), AR can be integrated with online learning and is believed to be the next wave of online learning. This support by a report that forecast technology for e-learning (Docebo, 2016).

Early implementation of Augmented Reality in desktop environment is the development of Multimedia AR Interface For ELearning (MARIE) by Liarokapis et al.

(2002), with superimposing Virtual Multimedia Content (VMC) information and using HMD for visualization. The MARIE system mixes together virtual reality techniques and human computer interactions techniques which enables educators in using more sophisticated techniques, thus helps students to learn engineering course more effectively through VMC which consists of 3D object, images, animation, text and sound. Significantly, the use of AR content is found to be able motivate and inspire interest in learning English (Lim & Lee, 2013).

This study proposed an immersive AR based e-learning system based on marker which enables learner to lead their learning activities by interacting with the content in which webcam is used to interact with system. A distinct study by Hamada (2016), used marker less AR to integrate practical activities for engineering education in e-learning system. As result, students can make repetitive learning by choosing elements in understanding different components and function, thus facilitate adaptive learning. Moreover, learners can actually see, listen to supplementary digital information and can intuitively manipulate the virtual information, allowing them to repeat a specific part of the augmentation as many times as they want which can benefit such learning (Liarokapis & Anderson, 2010). Despite these benefits, so far AR applications oriented to education have not been so deeply explored (Saidin et al., 2015).

2.4 Mobile Augmented Reality

Augmented reality (AR) offerings a particularly powerful user interface (UI) to context-aware computing environments. The first-generation of AR, the interaction occurs primarily through the desktop. In contrast, Mobile Augmented Reality (MAR) extends the scope and prospective functionality of AR, thus present a dynamic way for people to interact with computers and digital information (Kourcuthanassis et al., 2013). The concept of MAR is applying AR in mobile setting in which away from conditioned environments and confined spaces. MAR combines display, tracking and wireless to operate. As mobile devices are enhanced with more sensors, powerful embedded cameras, and increased processing power and features, new user experiences become possible to provide AR capabilities through wireless devices, such as smartphones and tablets (Sa & Churchill, 2012). As found by Coimbra et al. (2015) technology-enhanced