THE EFFECT OF COLLABORATIVE MOBILE AUGMENTED REALITY APPLICATION ON STUDENT'S LEARNING PERFORMANCE

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ABSTRACT

The objective of this study is to develop and test the effect of a mobile learning application, called Collaborative Mobile Augmented Reality Learning Application (CoMARLA), on student learning achievement and motivation in learning the Information Technology course. The development of CoMARLA is based on a framework guided by Moshman's constructivist learning principles and Keller's motivation principles. This study was based on a quantitative approach using a quasi-experimental method that employed a 2 by 2 factorial research design. The independent variable was the learning method and the dependant variables were students' learning achievement and motivation, with gender as the moderator variable. The sample of the study consisted of 120 social science undergraduates, with a mean age of 19.5 years, who were divided into an experimental and a control group. The experimental group received treatment with the use of CoMARLA on the mobile platform, while the control group received the same treatment with the use of similar application on the desktop platform. The research instruments used were a set of multiple-choice test and Intrinsic Motivation Inventory to measure students' learning achievements and motivation, respectively. A series of tests based on the independence t-test and Analysis of Covariance (ANCOVA) were performed on the data. The findings showed the students' learning achievements and motivation after treatment were significantly higher than they were before treatment. The same findings showed the experimental group's learning achievement and motivation after treatment were significantly higher than those of the control group. In addition, male participants' learning achievement was significantly higher than that of female participants. However, no significant difference in motivation between the two genders was observed. Overall, the findings suggest that such a novel mobile learning application can be used to help improve the learning achievement and motivation of social science undergraduates in learning Information Technology course.

KESAN PENGGUNAAN APLIKASI '*COLLABORATIVE MOBILE AUGMENTED REALITY*' TERHADAP PENCAPAIAN PEMBELAJARAN PELAJAR

Abstrak

Objektif kajian ini adalah untuk membina dan menguji kesan penggunaan satu aplikasi pembelajaran yang dinamakan sebagai "Collaborative Mobile Augmented Reality (CoMARLA)" dalam pembelajaran subjek Teknologi Maklumat. Rangka kerja pembangunan CoMARLA adalah berpandukan kepada prinsip-prinsip pembelajaran konstruktivis Moshman dan motivasi Keller. Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk faktorial 2x2 kuasi-eksperimental ujian pra dan pos. Pembolehubah kajian adalah terdiri daripada pembolehubah bebas iaitu dua mod pembelajaran, pembolehubah bersandar iaitu pencapaian pelajar dan motivasi, dan jantina sebagai pembolehubah moderator. Sampel kajian melibatkan 120 orang pelajar sains sosial dengan purata umur 19.5 tahun yang telah dibahagikan kepada kumpulan eksperimen dan kumpulan kawalan. Kumpulan eksperimen menerima rawatan dengan aplikasi CoMARLA manakala kumpulan kawalan menggunakan kaedah konvensional dalam mempelajari topik Unit Sistem Komputer. Instrumen yang digunakan dalam kajian ini adalah set ujian aneka pilihan dan Inventori Motivasi Intrinsik. Data kajian dianalisis dengan sampel bebas ujian t dan Analisis Kovarians. Dapatan kajian menunjukkan terdapat perbezaan yang signifikan bagi pencapaian dan motivasi bagi pelajar yang mengikuti rawatan dengan aplikasi CoMARLA. Dapatan kajian juga menunjukkan pelajar dalam kumpulan yang menerima rawatan dengan aplikasi CoMARLA adalah signifikan lebih baik berbanding dengan pelajar dalam kumpulan kawalan. Seterusnya, hasil kajian tidak menunjukkan perbezaan yang signifikan bagi aspek motivasi antara kumpulan rawatan dan kumpulan kawalan. Namun begitu, wujud perbezaan yang signifikan bagi aspek motivasi antara jantina bagi kumpulan pelajar yang mengikuti pembelajaran dengan CoMARLA. Implikasi kajian ini dapat dirumuskan bahawa aplikasi CoMARLA berpotensi untuk digunakan secara meluas dalam pembelajaran bidang Teknologi Maklumat.

CONTENT

LIST OF TABLES

LIST OF FIGURES

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LIST OF ABBREVIATIONS

3D	Three Dimensional
ANCOVA	Analysis of Covariance
AR	Augmented Reality
CoMARLA	Collaborative Mobile Augmented Learning Application
ICT	Information and communications technology
MANCOVA	Multiple Analysis of Covariance
MAR	Mobile Augmented Reality
MKO	More Knowledgeable Other
UPSI	Universiti Pendidikan Sultan Idris
UTAUT	User Acceptance and Use of Technology
ZPD	Zone of Proximal Development
GLM	General Linear Model
MSC	Multimedia Super Corridor
MOE	Ministry of Education
MP3	MPEG-1 Audio Layer-3

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 The Background of the Study

At the dawn of the new millennium, the world has been witnessing a myriad of transformations or changes, affecting every sphere of the human's life across the globe. Naturally, these changes have reshaped the educational, political, and social landscapes, exposing humans to new challenges. One thing is for sure, the human's life is now more dependent on Information and Communications Technology (ICT), especially computer technology, which helps nations to move forward with greater ease and efficiency. Undisputedly, the use of ICT has literally swamped the human's life – in fact, it has become totally indispensable (Thomas & Watters, 2015). For example, design engineers will rely on specialized equipment, notably ICT-based hardware and software, to analyse the mechanical properties and dynamics of components in their designs. Likewise, environmental scientists will use an array of ICT systems to gather and analyse a huge amount of environmental data before making precise predictions or forecasts. More importantly, those involved in teaching, such as lecturers, instructors, and teachers, have become more and more dependent on novel, innovative learning tools and materials (which are invariably based on digital technology) to improve their tasks (Zylka *et al*., 2015). Given the imperative to stay abreast with this kind of technologies, it is not surprising that many nations have begun putting in every resource available to improve the ICT *Competency* of their populace, as only through such competency can the nations move forward in this challenging time. In some nations, the efforts to educate the masses with an ICT start at the preschool level, such as Greece and China (Liu *et al*., 2014).

In recognition of the need to educate and equip its general masses with this technology, Malaysia has introduced and implemented a series of initiatives to make Malaysians ICT literates. Among those, the *Multimedia Super Corridor* (MSC) represents the pinnacle of Malaysia's efforts to help produce a vast pool of knowledge workers to spur its economic growth. More importantly, the MSC program was launched to catapult Malaysia to an industrialised nation by 2020, the year that will see Malaysia as a high-income nation. Undisputedly, Malaysia is hard-pressed to achieve this ambitious goal as the number of engineers, scientists, computer experts, and IT specialists will be extremely huge, thus entailing a concerted effort to produce such a workforce. As it stands now, Malaysia is still short of meeting the required number of ICT professionals as evidenced by the high recruitment of foreign ICT experts, programmers, and analysts, especially from India (Gopinathan & Raman, 2015).

Taking cognizance of such predicament, the Malaysian government, through its Ministry of Education (MOE), has revamped its educational policy by introducing important changes to its primary, secondary, and tertiary educational curricula and academic programs (Hanapi & Nordin, 2014). For example, all primary school pupils will now have to learned the basic of ICT, starting from Year Four to Year Six, totalling three years of learning the subject matter (Barghi *et al.*, 2017). For the secondary schools, the subject *ICT Literacy* serves an elective subject by which the secondary school students can learn at the lower secondary level, namely at the Form 2 and Form 3 levels involving 14-year-old and 15-year-old pupils, respectively. In addition, students can also learn *Programming* and *Multimedia Production* subjects at the middle, secondary level, namely at Form 4 and Form 5 consisting of 16-year-old and 17-year-old pupils, respectively (Kassim *et al*., 2014). At the tertiary level, many Malaysian public universities mandate their “non-technical” and “non-ICT” fresh undergraduates to take of the university compulsory course, notably *ICT Competency* (Arokiasamy *et al.*, 2014). Only when students are equipped with the knowledge and skills in ICT can they learn more efficaciously as today’s learning realm is characterized by the use of digital contents and delivery. Devoid of such ability can render students ineffective or demotivated in their pursuit of academic excellence, be it as the primary or tertiary levels (Hussein & Kabai, 2015).

In carrying out the above reforms, many problems have emerged besetting the smooth transitions from old teaching and learning practices to new ones. Such problems encompass a wide range of technical, logistical, managerial, and financial issues. Such issues have become a focal point in many studies in Malaysia of late. In terms of academic achievement, studies have shown that the secondary school pupils' learning performance in the *ICT Literacy* subject is just average, especially among those from sub-urban and rural communities compared to those living in big cities and affluent neighbourhood (Sua, 2012). Undeniably, the latter represents students who are economically disadvantaged, depriving them the necessary supports to help learn effectively (To, 2016).

Another problem seems to stem from the schools' policy with regard to the prioritization of subjects. Being an elective subject, *ICT Literacy* is deemed less important by many school administrators, which has resulted in less financial and logistical support. As a consequence, the subject matter is being taught in less favourable condition, as typified by poorly maintained computer laboratories and inadequate teaching and learning aids (Thomas & Watters, 2015). Without the necessary redress, the situation has made the teaching and learning process stale, lacking the vitality to make students motivated and engaged in learning the subject matter (Fini *et al.*, 2010). Ultimately, their learning efficacy suffers, with many of the students failing to attain high grades in their assessments. The importance of motivation in learning should never be downplayed as many studies have endow its positive impact on learning efficacy (Yilmaz, 2017). In general, students with high motivation tend to invest in more effort to achieve the learning goals, and they will be more persistent, and not easily defeated, when face challenging tasks (Bindewald & Atallah, 2017).

Another disturbing trend is that male students tend to outperform their female counterparts in learning the subject matter (Michalak *et al.*, 2017). These finding run parallel with other findings of research focussing on the learning achievements of technical and science-related subjects among secondary school pupils or middle-graders (Markovits & Benenson, 2010). The former's superiority may be attributed to their advanced computing experience, particularly in video games or computer games, thus giving them a comfortable lead (Kinsler, 2013; Tomai *et al.*, 2014). Consequently, boys will also develop a strong inclination to learn any subjects that require extensive use of computers. In all likelihood, male students will also develop strong motivation in learning this subject compared to female students (Hedges & Nowell, 1995).

Currently, in majority of the schools nationwide, the time allocated for the teaching of the subject matter is notoriously paltry. Thus, many teachers are compelled to rush to assure they could complete the school curriculum on time (Alhija, 2016). In such learning scenario, students will be short-changed of quality and meaningful learning experience. Obviously, this is not the fault of teachers, but rather the existing teaching constraints that preclude such learning opportunities (Rodríguez *et al.*, 2016). This type of situation also prevents students to work in the classroom, and they are forced to take home their assignments, but completing such tasks is quite impossible as many students do not have the right platform to collaborate (Nincarean *et al*., 2013; Ngang *et al*., 2014; Stanisavljević-Petrović *et al*., 2015).

A vast majority of schools in Malaysia is not equipped with the right teaching and learning platform to help students complete their assignments, tasks, or reports. Thus, a new and an affordable learning platform is entailed to provide students the learning space in which learning materials and communication tools can be used for their learning benefits (Ghani *et al.*, 2014). In fact, collaborative learning has become commonplace in many developed nations given its many learning benefits, such as enhanced reasoning, better social interaction, and increased motivation.

Fascination with technology has always been a driving force for people to improve their productivity. Especially in teaching, technology has always been at the forefront in many learning reforms or transformations. Its importance to facilitate and support the teaching and learning process has become more and more critical in today's learning realm as the focus of education nowadays to provide sufficient and meaningful learning opportunities to every student. In this regard, many new learning concepts, such a technology-enhanced learning, computer-mediated learning, web-based learning, e-learning, multimedia learning, and m-learning, among others, have been introduced with some degree of success (Blömeke *et al.*, 2012). In addition, teaching materials and contents take the form of digital multimedia elements (i.e., text, graphics, video, audio, and animation) to enrich the learning process (Johnson *et al.*, 2014).

Likewise, interactive and immersive learning environments using innovative technologies, such as virtual reality (VR) and augmented reality (AR), are being used to help students learn complex and abstract learning concepts with ease (Billinghurst *et al.*, 2001; Craig, 2013; Wang *et al.*, 2013). These technologies were once used almost exclusively in the military and research domains, but now they have been made in road in the educational realm. All these accomplishments owe to the continually improving desktop computing technology, engendering effective, and yet, affordable learning solutions to schools and colleges. Studies on the impact of learning applications based on VR and AR have found to be quite efficacious in various disciplines, notably engineering, science, and technology (Cheng & Tsai, 2012; Johnson *et al.*, 2010).

Of late, a variant of AR technology – mobile augmented reality (MAR) technology – is making its presence equally important for training and learning purposes. The appeal of MAR to educators lies in its mobility as learning applications can be accessed using the ubiquitous mobile devices, namely hand phones. Learners can now gain access to learning materials and contents anywhere, anytime on their "palms". Arguably, the mobility of this technology will transform the way in which learners learn in this new millennium. In developed nations, MAR learning applications are being used in many learning contexts (Chang *et al.*, 2010; Li, 2010;

Ma, 2008), which has improved students' learning performance and motivation (Radu, 2014; 2012).

Nonetheless, the use of this technology in Malaysia is almost non-existent. Even in the western countries, some scholars have cautioned their wholesale adoption in schools, and one of these concerns is that some of these applications were developed without any strong theoretical underpinnings (Kirner, 2012; Reis & Kirner, 2012). In light of this revelation, research on the use of such technology in the Malaysian educational context needs to be addressed to help improve the learning of ICT C*ompetency* among fresh non-IT undergraduates in universities. Unresolved, this predicament will propagate to higher level of learning (i.e., upper secondary and tertiary levels) as pupils of lower secondary schools will eventually pursue higher studies in universities and colleges.

1.2 Problem Statements

As discussed in the literature, the current state of affairs of Competency of ICT learning in the colleges and universities among non-technical undergraduates are not encouraging due to a host of factors or reasons. From the students' perspective, the subject matter is deemed less important compared to other courses given its status as one of the university courses, not the core courses, thus deserving less effort in learning. Such negative perception stems from students' lack of appreciation or knowledge on the importance of ICT in their academic pursuits and future careers.

Further compounding the problem, the current teaching and learning practice lacks innovation or novelty as lecturers and instructors only rely on prosaic or outdated technological tools to help them deliver the learning contents effectively and efficiently. The teaching and learning process is normally carried out based on limited time allocation, making lecturers and instructors to rush with their lectures. Hence, students are being deprived sufficient time to discuss with their peers and instructors to gain a greater understanding of what has been learned. Furthermore, the current learning practice is too focused on individual learning, not so much about collaborative learning. Thus, students have few or no opportunities to work in team in solving problems during the learning process.

Against the above prevailing constraints and problems, students' learning achievements in the subject matter have been relatively poor, despite the heavy investment and emphasis placed on learning this subject (Siddiq *et al.*, 2017). In addition, such learning environment has also exerted a negative impact on the students' morale as evident from their low motivation or lack of interest to learn (Pimmer *et al*., 2016). This poor motivation or low interest in learning is to be expected given the less conducive learning environment to nurture their thinking, cognition, or reasoning (Sun *et al*., 2016).

As part of the solution to address the above problems, several teaching and learning tools, systems, or applications have been introduced and used to help students learn more efficaciously (Overbaugh & Casiello, 2008). Nonetheless, the impact of such deployment has been minimal for a number of reasons (Neij *et al*., 2017). First, such learning applications have been implemented without proper considerations in the learning context. Second, the learning applications have been developed without proper considerations of the target users in terms of the users' technology skills, demographics, and background (Buabeng-Andoh, 2012). Third, some of the learning applications have been developed without strong theoretical foundations to elicit meaningful learning. In unison, the above factors will render the use of such learning applications ineffective at best or disruptive at worst (Swaggerty *et al*., 2017). Hence, more efforts are needed to produce learning applications that can help students learn with greater efficiency and keen interest. With improved learning applications, the knowledge construction during the learning process will become more intense and meaningful, resulting in better understanding of the subject matter being learned (Damşa & Ludvigsen, 2016). Therefore, this study concentrating on the learning application that put various students' background and develop an application that can assist to boost student motivation during the learning process that accredit to higher learning performances.

1.3 Purpose of Study

The discussion based on the review of the related literature highlights a range of issues confronting the teaching and learning of ICT *Competency* at University Level. Notably, students' learning performance or achievement and motivation in learning the subject matter have been found to be relatively poor (Chen, 2017). Several demographic factors have been found to contribute to the above problems, such as students' gender and academic achievement (Hajovsky *et al*., 2017). In addition, the current teaching practices have been found to be ineffective or inefficient, rendering students poorly motivated or disinterested (Alén *et al.*, 2015). Furthermore, the use of existing learning aids or tools is not being maximized due to tight teaching schedule (Lai *et al.*, 2016). Further compounding this problem, existing learning tools have been found to be less efficacious due to their poor designs that are devoid of sound theoretical foundations (García-García *et al.*, 2017). Thus, the present study aspiration to address these issues such that new insights can be revealed to help improve the current situation. Moreover, the motivation strategy has been discoursing to help improve students' motivation in teaching and learning environment (Karaman & Watson, 2017). Furthermore, the discussion on learning theory enable a framework that could help more researchers infer more about mobile augmented reality peculiarly in educational intentions (Akçayır & Akçayır, 2017).

1.4 Research Objectives

The main objectives of the present study are to design and develop a Collaborative Mobile Augmented Reality Learning Application (CoMARLA), and to test its impact on student learning of ICT *Competency* subject. In particular, the specific objectives of this study are as follows:

a) To design and develop a collaborative mobile augmented reality learning application based on the constructivist learning principles that can foster collaborative learning.

b) To examine the impact of the novel learning tool on students' learning performance in learning ICT *Competency* course.

c) To examine the impact of the novel learning tool on students' motivation in learning ICT *Competency* course

d) To examine the user acceptance of the collaborative mobile augmented reality learning application among the participants who used it in their learning of ICT *Competency* course.

1.5 Research Questions

Addressing the research objectives entailed the formulation of several research questions to help guide the undertaking of the study. The following are six (6) research questions that were formulated accordingly in this study.

a) Does the participants' learning performance after treatment differ significantly from their learning performance before treatment?

b) Does the participants' motivation after treatment differ significantly from their motivation before treatment?

c) Do the participants who used CoMARLA differ significantly from the participants who used similar application on desktop computer in terms of learning performance?

d) Do female participants' learning performance differ significantly from male participants' learning performance?

e) Do the participants who used CoMARLA differ significantly from the participants who used similar application on desktop computer in terms of motivation?

f) Do female participants' motivation differ significantly from male participants' learning performance?

1.6 Research Hypotheses

Correspondingly, the researcher formulated six (6) null research hypotheses to assist answer the research questions as follows:

a) The learning performance of participants after treatment would differ significantly from their learning performance before treatment.

b) The motivation of participants after treatment would differ significantly from their motivation before treatment.

c) The learning performance of participants who used CoMARLA on mobile phone would differ significantly from the learning performance of participants who used similar application on desktop computer.

d) The learning performance of female participants would differ significantly from the learning performance of male participants.

e) The motivation of participants who used CoMARLA on mobile phone would differ significantly from the motivation of participants who used similar application on desktop computer.

f) The motivation of female participants would differ significantly from the motivation of male participants.

1.7 The Significance of the Study

The findings from the proposed research would provide several important insights – both from the theoretical and practical perspectives – to all the stakeholders of the Competency of ICT curriculum: instructional designers, instructors, teachers and policy makers. Learning the course, as one of the mandatory university courses, at the foundational year in Malaysian public universities has been a great challenge for many lecturers, because undergraduates may not have adequate and well-developed knowledge or skills, which may be due to their poor learning performance and low motivation during their secondary schooling. This inadequacy can result in them to lose motivation, self-belief, and hope to follow the subject matter, which eventually can lead to poor performance, low motivation, or both.

Arguably, the mobility and flexibility factors associated with mobile learning using mobile devices may have a huge impact on the way students collaborate online, as emphasized by Sung *et al.*, (2016), who argue that such factors are critical factors in mobile learning. Furthermore, through greater insights, the complex interplays or interactions between the gender factor and learning method can be better explained to help researchers and scholars to undertake further research using different learning contexts. Furthermore, the potential impacts of such mobile learning tools or applications on students' collaborative learning can be accurately predicted or ascertained with some degree of certainty.

From the practical perspective, the research findings can help teachers and instructors to learn the proper method in using technology-enhanced learning tools to improve their current teaching practices. Furthermore, developers of such learning applications can utilize or adapt the development framework as proposed in the study to help them design effective, efficient learning tools or applications, which can bring many benefits to both teachers and learners.

1.8 The Scope and Limitations of the Study

The scope of the present study was based on the learning of a particular topic of the Competency of ICT course, namely *Computer System (Computer Hardware and Computer Software*) topic. Given the increasing emphasis on understanding computer technology, the researcher purposely chose this particular topic as the focus of the study. The sample size was limited to 120 non-technical undergraduates from the student population of about one thousand two hundred. The participants were recruited from four intact classes to which the researcher had been assigned to teach on the first semester of the academic calendar. The learning treatments were carried out in eight hours spread out equally in four consecutive weeks, with each lasting for two hours. Hence, the findings of this study should be taken with some degree of caution, as the representativeness of the study sample may call into question.

Furthermore, this study was limited to studying the impacts of learning method and gender on student learning of the subject matter. Arguably, there are other critical factors, which have not been taken into account, such as computing skills, learning styles, spatial abilities, or age. As such, the research findings have to be interpreted in this limited context. In addition, the learning treatments was only limited to studying only one topic of the subject matter. Ideally, more topics should be selected for learning treatments to ascertain the full impact of the novel learning tool on student learning across the full spectrum of such a course.

1.8.1 The Conceptual Framework of the Study

In undertaking research, it is imperative that the concepts or factors needing investigation are conceptualized to highlight the constructs and the relations among them. To aid such conceptualization, diagrams are used to depict the relevant concepts, together with their predicted relations, as synthesized from the process of literature review. With such conceptual framework, the researcher can confidently and accurately formulate appropriate research questions, and research hypotheses, to articulate her or his research. In short, such conceptual framework serves as the foundation to gesticulate the ensuing activities of research.

More pertinently, how researchers think about a particular problem or how they represent the complexity of a phenomenon can be best captured through relevant conceptual frameworks. Such frameworks will emphasize appropriate variables and outcomes, and their inter-relatedness (Bordage, 2009). In this regard, conceptual frameworks help clarify, explain, and justify methodological decisions (Ravitch & Riggan, 2012:9). Thus, the decision to adopt a particular research method hinges on the appropriate conceptual framework, without which can lead the researcher to making methodological errors in their study.

In this study, there are four factors that were conceptualized to be important in studying the learning of ICT Competency course among fresh undergraduates. These factors were treated as the pertinent variables by which they were categorized into two dependent variables, one independent variable, and one moderator variable. The dependent variables (response variables) were students' learning performance and motivation in learning. The independent variable, which was the learning method, comprised two levels, namely the learning method that used CoMARLA (running on mobile phone) and the learning method that used similar application (running on desktop computer). The moderator variable, which was also a categorical variable, consisted of two levels, namely females and males. Figure 1.8.1 depicts the conceptual framework of the study, highlighting the relevant concepts or factors with their presumed relations.

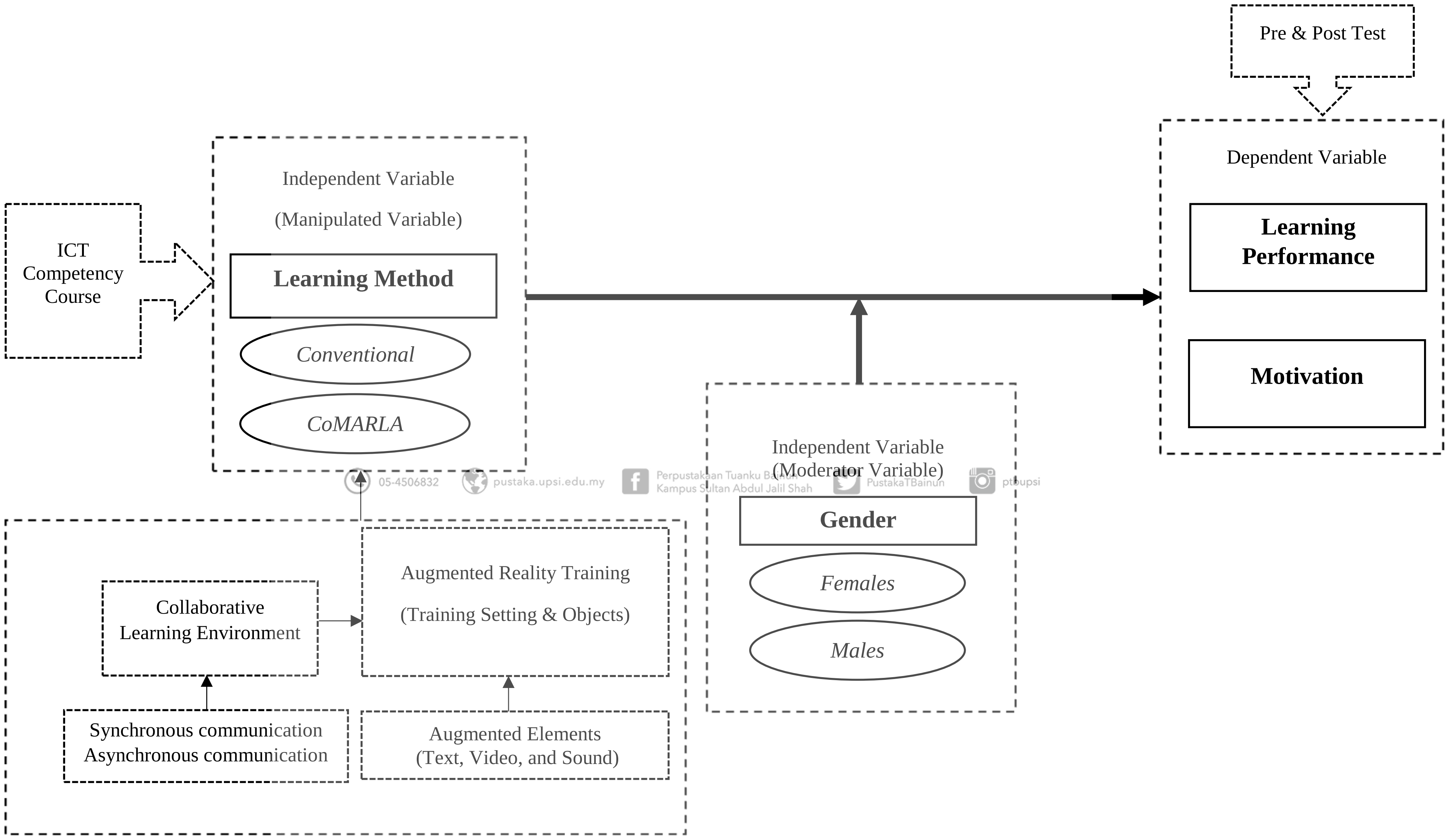

Figure 1.8.1. The Conceptual Framework of the Study

1.8.2 The Theoretical Framework of the Study

All scholars agree that the importance of using a theoretical framework in a research study cannot be stressed enough. In fact, the theoretical framework is the foundation from which all knowledge is constructed for a research study. In essence, it serves as the structure and support for the rationale for the study, the problem statement, the purpose, the significance, and the research questions. The theoretical framework provides a grounding base, or an anchor, for the literature review, and most importantly, the methods and analysis (Grant & Osanloo, 2014).

In this respect, the necessity of identifying one's theoretical framework for a research study is one of the most important steps needed in a scholastic inquiry. Eloquently, Lysaght (2011, p. 572) asserts that "A researcher's choice of framework is not arbitrary but reflects important personal beliefs and understandings about the nature of knowledge, how it exists (in the metaphysical sense) in relation to the observer, and the possible roles to be adopted, and tools to be employed consequently, by the researcher in his/her work. (p. 572).

As such, without a theoretical framework, the structure and vision for a study is unclear, much like a house that cannot be constructed without a blueprint (Grant & Osanloo, 2011). Thus, the theoretical framework consists of the selected theory (or theories) that undergirds researchers' thinking with regards to how they understand and plan to research their topic, as well as the concepts and definitions from that theory that are relevant to their topic on interest. In contrast, a research plan that contains a theoretical framework allows a study to be strong and structured with an organized flow from one chapter to the next.

Based on the critical literature review, the theoretical framework of this research is underpinned by the underlying theoretical principles of existing and contemporary learning and motivation theories. Specifically, this research's theoretical framework contains the fundamental precepts of Constructivist Learning theory, namely endogenous, exogenous, and dialectical principles; ARCS motivation theory, namely attention, relevance, confidence, and satisfaction; and Self-Determination theory, namely autonomy, competence, and relatedness. Figure 1.8.2. shows the theoretical framework of this study, clearly highlighting the theoretical principles and their relationships to help guide this academic endeavour.

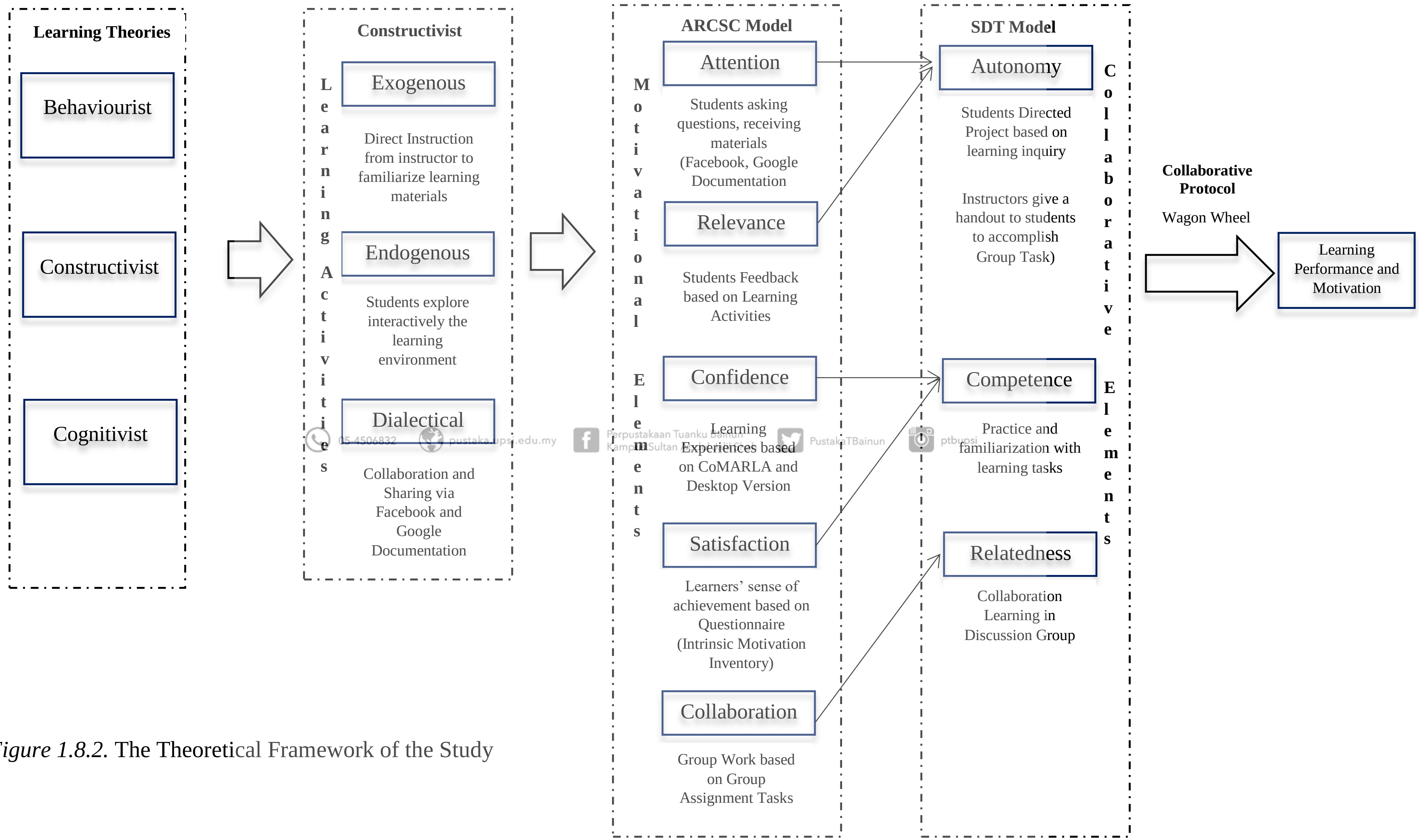

Figure 1.8.2. The Theoretical Framework of the Study

1.9 Operational Definitions

The following are the definitions of terms for the concepts, variables, methods, or processes to which this dissertation refers.

***Augmented Reality*:**

Augmented Reality is the technology that overlays digital information (e.g., images, audio narration, or video clip) onto real world entities to engender fascinating and engaging learning experience (Cheng & Tsai, 2012; Wu, Lee, Chang, & Liang, 2013).

***Multimedia*:**

Multimedia is the computer-controlled text, graphics, drawings, still and moving images (video), animation, audio, and any other media where every type of information can be represented, stored, transmitted, and processed digitally (Liarokapis *et al*., 2002). In this study, multimedia elements such as video, audio and images were embedded together to help foster deep learning performance and improved motivation.

***Mobile learning*:**

Mobile learning is defined as "learning across multiple contexts, through social and content interactions, using personal electronic devices" (Crompton, 2013). As a form of distance education, mobile learning involves users who use various forms of mobile devices to access educational materials at their convenience (Crescente & Lee, 2011). In this study, mobile learning involved a collaborative learning environment that was accorded by CoMARLA using Aurasma.

***Learning Performance*:**

This term refers to the actual performance of students in a particular test, which reflects their reasoning ability or cognitive ability in solving problems in a specific area of knowledge (Topping & Trickey, 2007; Broadbent & Poon, 2015). In this study, the learning performances were based on the pre- and post-test measurements of the participants' ability to answer questions pertaining to a chosen topic of the ICT *Competency* Course.

Learning Method:

This term refers to the methods of learning received by the participants in the present study, which were based on learning using CoMARLA (which ran on mobile phone) and learning using similar application (which ran on desktop computer). For the former method, the participants used their mobile devices to access the mobile AR learning contents online. Being online and mobile simultaneously, the participants used both modes of communication (synchronous and asynchronous communication), which could help students to collaborate in solving a particular group assignment or project (Yılmaz & Yurdugül, 2013; Szeto, 2014). For the latter method, the participants used similar application running on desktop computer to access similar learning materials to perform a similar task as that of the former.

***Non-technical undergraduates*:**

This term refers to undergraduates who are majoring in social sciences or humanities, (Hakan & Münire, 2012). In this study, the non-technical students were undergraduates who were majoring in academic programs related to Arts, Languages, Music, Islamic Studies, Geography, Economics, Accounting, and Education.

***Motivation*:**

Motivation is defined as "a human psychological characteristic that add to a person's degree of commitment. Principally, motivation helps stimulate, channel, and prolong human behaviour over time (Gottfried, 1990). For this research, motivation refers to the participants' willingness, readiness, and persistence in partaking the learning activities from beginning to the end.

User Acceptance:

This term refers to the technical construct of a technological application or tool that will subjected to some specific testing, with the main aim to determine the level of acceptance of end users with its performance in the real world (Zhao *et al*., 2012). For this study, the UTAUT instrument was used to measure the user acceptance of CoMARLA after the learning treatment.

1.10 Summary

In this chapter, the issues confronting non-technical undergraduates in learning one of the mandatory university courses, ICT Competency, were discussed briefly, which clearly showed their learning performance and motivation were not encouraging. As such, this research was undertaken, which was guided by a relevant theoretical framework, which was synthesised and developed based on the constructivist learning theory, ARCS motivation theory, and Self-Determination theory. Effectively, this framework helped formulate the research objectives, questions, and hypotheses. In addition, the significance, scope, and limitations of the study were highlighted accordingly.

1.11 The Outline of the Dissertation

This dissertation comprises six main chapters. The brief summary of each chapter is outlined as follows:

Chapter 1 – The Introduction – provides an account of the prevailing issues, namely poor learning performance and low motivation of students in the learning of ICT *Competency* course. The chapter highlights the appropriate research objectives, research questions, research hypotheses, significance of the study, and the operational definitions used in this present study.

Chapter 2 – The Literature Review – provides the discussion of the critical review of related literature pertaining to the problems in learning the relevant subject matter based on a number of recent studies by concentrating on their research focuses, methodological approaches, findings, and conclusions. This chapter also provides the discussion on learning and motivation based on the contemporary learning theories, especially the constructivist perspective, the types, educational applications and benefits of mobile AR technology, and the mapping of mobile AR learning capabilities with the constructivist learning principles with several recommended examples.

Chapter 3 – The Research Methodology – highlights the discourse on the methodological approach used in this present study, covering all the important elements with regard to the research design, participants and sample size, sampling procedure, experimental procedure, research instruments and materials. This chapter also highlights the appropriate statistical analyses of the collected data.

Chapter 4 – The Development of CoMARLA and Conventional Group – provides a discussion on the design and development of the collaborative mobile AR learning application. Specifically, this chapter highlights the theoretical underpinnings from the constructivist perspective as explicated by the relevant interpretations of such learning view: endogenous, exogenous, and dialectic components to guide the development of the learning tool.

Chapter 5 – The Research Findings – provides the report on the findings of the statistical analyses performed on the empirical and survey data. Both descriptive and inferential statistics are presented to highlight the main effects and interactions of the chosen variables on the participants' learning performance and motivation before and after the interventions.

Chapter 6 – The Discussion, Implications, Recommendations, and Conclusion – provides a detailed discussion on the major findings of the present study by relating the findings (as reported in Chapter 5) with the relevant research hypotheses (as highlighted in Chapter 1). More importantly, the significant findings observed in this present study are discussed appropriately with reference to their potential impacts on the current learning practices. The discussion also deals with the proper use of such a novel tool by focussing on the proper context and approach to which the impact of the tool as a collaborative tool can be optimized. This chapter encloses with a conclusion about the overall impact of the novel tool on students' learning of the subject matter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an in-depth review of the teaching and learning of Information Communication and Technology (ICT) that has been contrived into a mandatory course for non-technical undergraduates in public universities throughout Malaysia. In particular, issues arising from the current learning context are elaborated by focussing on students' learning performance and motivation that have been reported to be declining. To help alleviate this predicament, several methods, especially those that use novel technologies, have been introduced but are fraught with some constraints. In light of these developments, the researcher discusses the development and implementation of novel technologies that have been used in the teaching and learning of ICT. More specifically, the mobile augmented reality (MAR) technology is discussed by focussing on its impacts on the learning process and motivation of students in pursuing the subject matter. This chapter also provides a detailed review of the established learning theories (i.e., behaviourism, cognitivism, and constructivism) and motivation theories (i.e., ARCS Motivation Theory and SDT theory) regulate and explicate the process of learning and motivation of students. Notably, the discussion delves into the process of learning through collaboration in helping students to learn more efficaciously. In addition, the use of technologies to facilitate collaborative learning is also elaborated in this study.

2.2 The Importance of Information and Communications Technology (ICT) in Today's Economic and Educational Realms

Upon ushering into a new century and a new millennium, many new changes, transformations, and reforms have been taking place in many nations across the globe. These changes encompass a wide range of the human's facets, such as the economy, politics, culture, technology, and education. From the economic perspective, nations need to be competitive and resilient to face new, emerging economic challenges. In other words, all nations need to have vibrant, sustainable economies to provide economic security to their citizenry. Clearly, to attain such economic posturing, these nations need to have sound, robust educational systems that are capable to produce a vast pool of talents to spearhead the nations' economic initiatives.

In this new dawn, a number of technologies, especially Information and Communications Technology (ICT), have emerged as important tools to help nations move forward with greater ease and efficiency. More importantly, the people of a nation have to be literate enough to use such technologies so much so that they can perform their duty more efficiently. Undisputedly, the use of ICT literally swamped the humans' lives – in fact, it has become totally indispensable. For example, design engineers will rely on specialized equipment, notably ICT-based hardware and software, to analyse the mechanical properties and dynamics of components in their designs. Likewise, environmental scientists will use an array of ICT systems to gather and analyse a huge amount of environmental data to make precise weather predictions or forecasts. Similarly, financial analysts need to rely on sophisticated finance applications to examine the fluctuating trends of the financial markets to help economists make proper economic decisions.

In the same vein, teachers need to use ICT learning tools to help them deliver and explain important concepts to their pupils (Kreijns *et al*., 2013; Copriady, 2014; Umar & Yusoff, 2014; Aesaert *et al*., 2015; John, 2015; Umar & Hassan, 2015; Tsiotakis & Jimoyiannis, 2016). All of the above examples underscore the prevalent use of ICT in the workplace, schools and, even at, homes. Hence, it is not surprising that many nations have begun putting in every resource available to improve the ICT literacy of their populace. Only through such competency can the nations move ahead smoothly in this challenging time.

India, for example, which was once an economic backwater of Asia, has surmounted the odds by becoming a powerhouse, both in terms of technology and economy. Arguably, India's meteoric rise owes much to its unyielding effort to improve its educational system which, among others, places a strong emphasis on ICT learning and teaching (Kim *et al.*, 2012; Barge & Londhe, 2014; Jena, 2015).

Although not in the same league, Malaysia has also made such an effort with a series of initiatives to make Malaysians ICT literates. At the governmental level, the Malaysian government has set up and launched an ambitious initiative called the "Multimedia Super Corridor", which is a flagship program that aims to help produce the required workforce that is competent in ICT (Ramasamy *et al*., 2004; Karim *et al.*, 2010; Cheah & Merican, 2012; Foo, 2013; Yigitcanlar & Sarimin, 2015). Despite such commendable effort, its target for such a workforce is far short, thus forcing the Malaysian government to hire foreign ICT experts, programmers, and analysts to fill the void.

In tandem with such initiative, the Malaysian government, through its Ministry of Education (MOE), has continually revamped its educational policy by introducing important changes to its primary, secondary, and tertiary educational curricula and academic programs (Sua, 2012; Cheah & Merican, 2012; Arokiasamy *et al.*, 2015). For example, all primary school pupils will now have learned the basic of ICT, starting from Year Four to Year Six, totalling three years of learning the subject matter. For the secondary schools, the course *ICT literacy* serves an elective course by which the secondary school students can learn at the lower secondary level, namely at Form 2 and Form 3. In addition, students can also learn *Programming* and *Multimedia Production* courses at the middle, secondary level, namely at Form 4 and Form 5. At the tertiary level, many Malaysian public universities mandate their "non-technical" and "non-ICT" fresh undergraduates to take one of the university compulsory course, notably *ICT Competency*. Only when students are equipped with the knowledge and skills in ICT can they learn more efficaciously, as today's learning realm is

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characterized by the use of digital contents and deliveries. Devoid of such ability can render students ineffective or lost in their pursuit of academic excellence, be it as the primary or tertiary levels.

2.3 The learning of Information and Communications Technology (ICT) in Malaysian Educational Context

The continually evolving nature of education is a natural process as humans are always seeking the "best" way to deal with prevailing situations. Particularly, in education, every nation is compelled to refine or to reform its school curricula so as to keep abreast with the current needs and requirements, which are invariably driven by the current technology. In today's realm, the reliance on technology, especially ICT, has become more intense as evident from its prevalence in virtually everything that humans do.

As highlighted in Section 2.2, the educational landscape of Malaysia too has undergone a series of transformations that is in line with the rapidly changing technology, notably ICT. In this regard, new curricula have been introduced in primary, secondary and tertiary education. This introduction has incurred a huge amount of monies, running into billions, to upgrade the computer laboratories throughout the nation. This upgrading work includes the construction of new laboratories, the procurement of both hardware and software, and the training of teachers to use the tools and equipment (Sua, 2012; Cheah & Merican, 2012; Wan-Hamdan *et al*., 2011; Trif & Popescu, 2013; Bennett *et al.*, 2015; Vally & Daud, 2015). Like any other colossal projects of this kind, the implementation of the new curricula in Malaysian schools has been painstakingly challenging and the desired impact of such a massive investment has thus far been minimal (Osman *et al*., 2010; Salimi & Ghonoodi, 2011; Bandu & Jelas, 2012; Kaur & Mahmor, 2014).

Several researchers have studied the impact of such implementation, and they found out there was a myriad of problems, which impeded the progress of ICT initiatives in Malaysia, encompassing educational, logistical, and socio-cultural aspects (Sua, 2012; Lee *et al.*, 2014; Ayanso & Lertwachara, 2015; Arokiasamy *et al.*, 2015). From the learning perspective, the achievement of the secondary school pupils in *ICT literary* subject has been found to be just average (Kim *et al*., 2013; Ivankovic *et al*., 2013; Kim *et al*., 2014; Lee *et al*., 2014). This relatively poor academic achievement is more prevalent among students living in sub-urban and rural communities. Apparently, some demographic factors have contributed partly to this learning problem. Arguably, students living in these areas are disproportionately disadvantaged both economically and culturally due to their parents' low social economic status (SES) compared to the more affluent counterparts. Research has shown that, in general, students from the lower SES are less academically talented as their access to learning opportunities is limited, suggesting that poor academic background or ability will lead to poor achievement in the taught subject (Potter & Roksa, 2013; Gaddis, 2013; Greiff & Neubert, 2014; Kodzi *et al*., 2014).

It is also important to note that the learning of the subject matter in most schools across the nation is notoriously challenging due to a host of problems. Being an elective subject, most school administrators place less emphasis on the teaching of the subject matter compared to other core subjects, such as Science, Mathematics, English, and Bahasa Melayu. Thus, less financial and logistical support is accorded to the current practice to further improve the teaching of the subject matter. Many of the computer laboratories are in dire need for repair and maintenance (Kerem & Aydin, 2011; Tanty *et al*., 2015). Given this predicament, many students have to share computers to carry out their in-class assignments, thus impairing the concentration and effort to learn in a conducive learning environment. Furthermore, unresolved, this situation can also demotivate students to acquire this important subject, which ultimately can result in fewer students to pursue ICT-related programs at the college and university levels.

At the tertiary level, all Malaysian public universities have made *ICT Competency* as one of the mandatory university course, as such non-technical students too need to be trained to use the latest ICT applications in their future carriers, such as teachers, executives, or lawyer's, among others (Cheah & Merican, 2012). Such a bold move to mandate the learning of Competency of ICT for such undergraduates is not only commendable, but also necessary, especially for those pursuing educational degree programs to become future teachers. With growing emphasis on technology-assisted learning, naturally such teachers are expected to be conversant with and articulate in using novel learning applications to help improve the delivery and utilization of learning contents with higher quality, the impact of which can make their students learn more efficiently and effectively (Liu *et al.*, 2014).

However, the realization of such desired impact seems quite far-off as some studies have shown that most Malaysian teachers and trainee teachers have not fully made use of ICT in their teaching and learning process (Hew & Leong, 2011; Ismail *et al.*, 2013; Raman & Yamat, 2013; Thang *et al.*, 2016; Yunus *et al.*, 2009). These revelations of the underutilization of ICT in teaching suggest that these teachers might lack of proficiency or motivation, or both, in using technology-based learning applications or tools. Arguably, such problems might have stemmed from their poor performance, low motivation, or both, in ICT learning or training, among others, during their secondary schooling.

In addition, studies have also shown that, in general, male students tend to outperform their female counterparts in learning the subject matter. These finding run parallel with other findings of research focussing on the learning achievements of technical and science-related subjects among secondary school pupils or middle-graders (Bogar *et al*., 2012; Hong *et al*., 2013; Zhan *et al.*, 2015; Lee, 2015; Valeriu, 2015). One possible interpretation is that boys are more technically-oriented, or savvier, in using computers compared to girls due to the former's early exposure to video games or computer games, thus giving the former a comfortable head start. Naturally, over the years, the boys will quickly develop the dexterity of using the computer hardware. Consequently, boys will also develop a strong inclination to learn any subjects that require extensive use of computers. In all likelihood, male students will also develop strong motivation in learning this subject compared to female students.

From the teaching standpoint, it is equally important for teachers to allocate sufficient time to allow students to work in a team or group in the classroom. Unfortunately, the prevailing situation does not permit such opportunity as the time allocated for the teaching of this subject is limited. Students are forced to take home their assignments, but completing such tasks is quite impossible, as many students do not have the right platform to collaborate. A vast majority of schools, colleges, and universities in Malaysia are not fully equipped with the right teaching and learning platform to help students complete their assignments, tasks, or reports.

Thus, a new and an affordable learning platform is entailed to provide undergraduates with the learning space in which learning materials and communication tools can be used for their learning benefits. In fact, collaborative learning has become commonplace in many developed nations given its many learning benefits, such as enhanced reasoning, better social interaction, and increased motivation (Martín-Gutiérrez *et al*., 2014; Kwon *et al*., 2014; Shorfuzzaman *et al*., 2015; Anaya *et al*., 2015; Nookhong & Wannapiroon, 2015; Quintana *et al*., 2015; Chen & Law, 2015).

2.4 Learning Theories

Clearly, it is important to recognize and understand what really takes place when students are engaged in learning or training activities, which affects a change in their cognitive and affective levels. This entails a review of the current learning theories, and their instructional applications in learning or training. Baruque and Milo (2004), contend that learning theories play an important role in the design and development of learning or training objects, and according to Suaalii and Bhattacharya (2007) the environments using such objects can facilitate meaningful learning or training. In this respect, three learning theories have dominated and shaped the learning landscape of the educational realm, namely behaviourism, constructionism, and constructivism. The details of these learning theories are discussed and elaborated in the following subsections:

2.4.1 Behaviourism

Early discussions of what is learning lean towards the notion of observing behavioural changes. Kimble (1961) argues that learning results in "… [a] relatively permanent change in behavioural potentiality that occurs as a result of reinforced practice". This indicates that any behavioural change constitutes learning and the occurrence of learning is attributed to the specific change in behaviour brought about by experience. In the same vein, Buckley (1989) asserts that learners' responses to environmental stimuli shape their behaviours; therefore, in the view of the behavioural theorist, learning is simply "the acquisition of new behaviour." Classical conditioning, operant conditioning, and reinforcement are some of the important and widely applied concepts that have arisen from behaviourism.

However, some psychologists oppose the idea of approaching learning as an outcome (i.e., the product of some process). They argue that not all changes in behaviour resulting from experience involve learning. It would seem fair to expect that if learning has taken place, experience should have been used in some way. A change in behaviour may result from conditioning, but the change may not involve drawing upon experience to generate new knowledge. There is a concern with what happens when learning takes place. Learning could be thought of as a process by which behaviour changes due to experience. Gaining knowledge or ability through the use of experience is the focus for learners. Through the two approaches in understanding learning as an end product or as a process has resulted in several learning theories and perspectives, namely behaviourist, cognitivist, and constructivist.

The study of overt observable, measurable behaviours is the pivotal point of the theory of behaviourism based on treatises of Pavlov, Watson, Thorndike and Skinner (Good & Brophy, 1990). Behaviourists contend that learning consists of the formation of links between specific stimuli and responses through the application of rewards. The mind is viewed as a ‘black box’ in the sense that response to stimuli can be observed quantitatively, totally ignoring the possibility of thought processes occurring in the mind. The objective of behavioural learning is summed up in “specified, quantifiable, terminal behaviour” (Saettler, 1990). This entails breaking down a learning task through analysis into specific, measurable tasks. The learning success may be measured by tests developed, peculiarly to measure each objective in this study.

2.4.2 Cognitivism

Cognitivism, as opposed to behaviourism, is a learning theory that tries to explain certain social behaviours and internal mental processes that were not addressed by behaviourist perspective. Knowledge is assumed to exist separate from the individual that can be transferred into the learner and learning involves associations established through contiguity and repetition. Cognitivists also acknowledge the importance of reinforcement, although they stress its role in providing feedback about the correctness of responses. However, cognitivists put the mind back into the learning equation. While accepting such behaviouristic concepts, cognitive theorists view learning as '…involving the acquisition or reorganization of the cognitive structures through which the human processes and stores information' (Good & Brophy, 1990).

Essentially, cognitivism focuses on unobservable changes in mental knowledge, which is based on the assumptions that some learning processes are unique to human beings, cognitive processes can be studied, learning is a process of relating new information to previously learned information, knowledge is organized, individuals are actively involved in the learning process, and objective, systematic observations of human behaviour should be the focus of scientific inquiry. As such, the implications of such assumptions are that cognitive processes influence learning, children become increasingly capable of more sophisticated thought as they mature, learners tend to organize the information and skills that they learn, learners acquire knowledge more easily when they are able to associate it with something they already know, and learners control their own learning (Cunia, 2007).

The main objective of instruction based on cognitivist learning focuses on the communication or transfer of knowledge to learners in the most efficient, effective manner possible. The teacher assists learners in developing meaning by providing activities that they can work through. The teacher provides a structure and/or helps learners to create a structure to which is added new learning. Learners are provided with opportunities to examine the same activity under different conditions or

situations. New information is presented during the use of a well-known activity to facilitate the creation of meaningful links between the old and new information. Students are provided with positive feedback to guide their future thinking and symbolic or model creation.

2.4.3 Constructivism

Philosophically, constructivism asserts that learners create their understanding of the world they live in by reflecting on their own personal experiences. In other words, constructivism postulates that learners actively construct their own knowledge and meaning from their experiences. However, constructivists argue strongly that knowledge constructions do not necessarily bear any correspondence to external reality. That is, they do not have to reflect the world as it really is to be useful and viable. Learning results in changes in the whole person in values and perspectives, not merely changes in behaviour and cognitive processes. Some of the established and influential constructivist theorists are Kant, Piaget, Vygotsky, and Dewey. The constructivist view of learning can be explained in terms of three broad principles. As individual constructs his or her own knowledge, therefore, no two people's knowledge can be the same.

This principle was originally articulated by Kant and was later adopted by Dewey (Von Glaserfeld, 1984). The second principle, normally attributed to Piaget informs that learning occurs when, during active exploration of the knowledge domain, learners uncovers a deficiency in their knowledge or an inconsistency between their current knowledge representation and their experience (Mclnerney & Mclnerney, 1994). The third principle takes on a social context in that learning occurs through social negotiation, and that interaction between learners and their peers is a necessary part of the learning process (Vygotsky, 1978). Moshman (1982) classified three distinct interpretations of constructivism - endogenous, exogenous and dialectical – to which these approaches draw on constructivist learning.

Emphasis on the individual nature of each learner's knowledge construction process and the role of the teacher as a facilitator in providing experiences that are likely to result in challenges to learners' existing models is the key in endogenous constructivism. On the other hand, exogenous constructivism views that formal instruction, in conjunction with exercises requiring learners be cognitively active, can help learners to form and refine their knowledge representations. Dialectical constructivism is the view that learning occurs through realistic experience, but that learners require scaffolding provided by teachers or experts as well as collaboration with peers. Hudak (2007) emphasizes that a determine understanding of the learning theories is important in conceptualizing the learning objects to improve the learning process. Moreover, she contends that a systematic plan for education should include consideration of the learning theories together with pedagogic frameworks to develop learning objects or environments using appropriate taxonomies of learning and instructions.

As such, the role of the constructivist teacher is "to provide complex questions and to create a collaborative, problem-solving environment [in which] students are free to make discoveries and to construct meaning from these discoveries" (Hesse *et al.*, 2001). The role of the student is constructed knowledge by thinking about and interpreting his or her experiences, making and testing hypotheses, and looking for generalizations (Hesse *et al.*, 2001).

Naturally, it is reasonable to ponder which theory is the most effective after closely examining these learning theories. Of course, the answer is not that straightforward, as that there is no one perfect learning theory that is applicable in every learning situation. In fact, the appropriate instructional approach should be based on the characteristics of the targeted group of learners and the level of cognitive processing required in order to achieve and master the instructional goals and objectives. Fortunately, a set of guidelines by Connor (2002) is available to help guide teachers and trainers to select a particular learning approach. Tasks requiring low-level processing are most often accomplished with behaviourism. In contrast, cognitive strategies fit with subjects that require more advanced processing, classifications, identifying rules, procedural exceptions, and problem solving. For tasks requiring high-level processing, constructivist approach is the most appropriate learning approach. Hence, for this study, constructivist approach was chosen in carrying out the learning treatments of the research subjects as the focus of learning was on high mastery of the subject matter.

2.4.4 User Acceptance and Use of Technology (UTAUT)

Understanding individual acceptance and use of information technology is one of the most mature streams of information systems research. In this respect, several theoretical models, primarily developed from theories in psychology and sociology, utilized to explain technology acceptance and use (Venkatesh *et al.* 2003). A systematic review and synthesis of eight models of technology such as Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivational Model, the Theory of Planned Behaviour (TPB), the combined TAM and TPB, the model of Personal Computer Utilization, the Innovation Diffusion Theory and the Social Cognitive Theory resulted in the unified theory of acceptance and use of technology (UTAUT) (Venkatesh *et al.* 2003).

UTAUT has distilled the critical factors and contingencies related to the prediction of behavioral intention to use a technology and technology use primarily in organizational contexts. In longitudinal field studies of employee technology acceptance, UTAUT explained about 70 percent of the variance in behavioral intention to use a technology and about 50 percent of the variance in technology use. In essence, UTAUT has four key constructs, namely *performance expectancy, effort expectancy, social influence*, and *facilitating conditions*, which influence *behavioral intention* that in turn affects *use behavior*. Performance expectancy is the degree to which individuals believe that the use of technologies will result in performance gains. This may also be viewed as the perceived usefulness of the technologies. Effort expectancy is the ease of use of the technologies. Social factors is the extent to which an individual believes that other people believe that he or she should use the technologies. Facilitating conditions is the perceived extent to which organizational and technical infrastructure are required to support such technologies. According to UTAUT model, performance expectancy, effort expectancy, and social influence are theorized to influence behavioral intention to use a technology, while behavioral intention and facilitating conditions determine technology use. In addition, individual difference variables, namely age, gender, and experience are theorized to moderate various UTAUT relationships. In recent years, these constructs and definitions have been adapted by many researchers to suit their research contexts of various disciplines and fields, particularly in education, economics, and marketing. In such cases, some of these constructs were removed from the models, while others incorporated additional constructs, depending on the research focuses being investigated.

For this study, *performance expectancy* is defined as the degree to which using a CoMARLA will provide benefits to the research participants in performing their learning activities. Effort expectancy is the degree of ease associated with the participants' use of CoMARLA. Social influence is the extent to which participants perceive that important others (e.g., lecturer and friends) believe they should use this learning tool. Facilitating conditions refer to participants' perceptions of the resources and support available to perform such a behavior. Figure 2.4.4 shows the constructs and their relations adopted in this study.

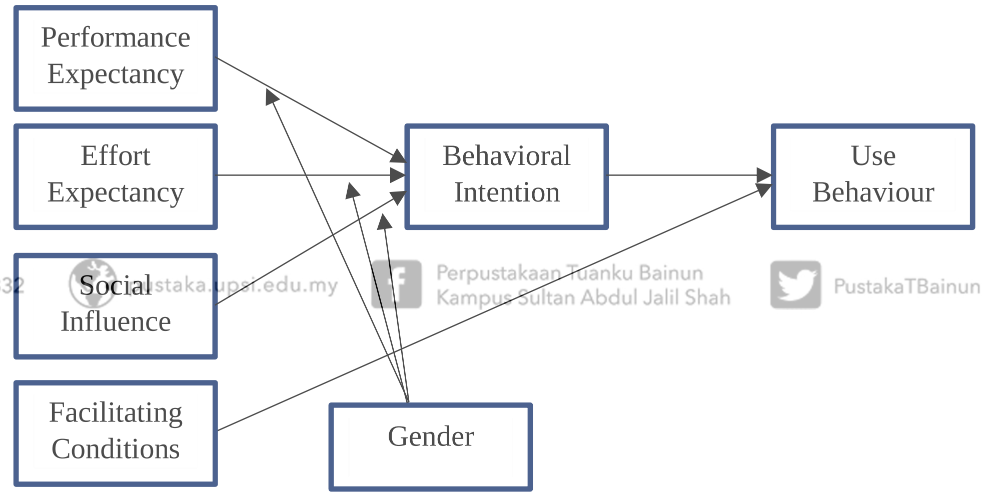

Figure 2.4.4. Simplified UTAUT Constructs and their Relations (Adapted from Venkatesh *et al.*, 2003)

2.5 Motivation

Without doubt, motivation plays an important role in any human endeavour, which help individuals to strive in achieving specified goals. Knowing that this motivation construct is important, it is thus not suspiring that many scholars and researchers have devoted their time and effort to study the impact of motivation on training and learning. With high motivation, workers can carry out their tasks with greater commitment, and students can learn with higher engagement.

According to Ryan and Deci (2000), motivation can be divided into two main categories, namely extrinsic motivation and intrinsic motivation. Performing a behaviour or engaging in an activity to earn a reward or avoid punishment is a form of extrinsic motivation. With extrinsic motivations, students will get to cogitate a good grade, involve in a sport to win awards, or participate in a contest to win a scholarship, among other things. In contrast, intrinsic motivation refers to people's behaviours that seek personal reward, particularly in carrying out a task for its own sake rather than the desire for some external reward. Some examples of activities related to this type of motivation are involved in a sport because people find the activity enjoyable, solving a word puzzle because people find the challenge, fun and exciting, or indulging in a game because people find it exciting.

Both types of motivation can also play a significant role in learning environments. On one hand, there are scholars who argue that the traditional emphasis on external rewards such as grades, report cards, and gold stars undermines any existing intrinsic motivation that students might have. On the other hand, some scholars suggest that activities related to extrinsic motivation assist students feel more competent in the classroom, thus enhancing intrinsic motivation. To explicate the impact of extrinsic and intrinsic motivation on performance and creativity, Meyers and Turner (2006) describe the motivation as the interest to offer when the reward is used to control the output of the expected job. In addition, the reward can also motivate to the high performances and creativity. Clearly, the Meyers and Turner (2006) statements underscore the importance of rewarding people, especially learners, with encouraging words that recognize their good deeds, which effectively enhance their feeling of competence. Differently, the discussion on intrinsic and extrinsic motivation could be unrelated or evenly significant related together (Cameron *et al.*, 2005).

2.5.1 The Impact of Motivation on Learning

According to Bandura (1977), one of the leading scholars in social learning, motivation will have more of an effect on peoples' actions than their learning. He asserts that people's motivation is affected by others through vicarious experiences. If someone put forth effort to accomplish something, achieve it and be rewarded as a result, then his or her act of observation motivates others to engage in that practice. People's motivation is increased through the vicarious experiences of observing others. Thus, for learning context, it is essential that teachers ensure that there are opportunities for students to observe effective models who are reinforced for taking the desired actions. Teachers should also encourage students as a way to enhance their self-efficacies and thus improve their learning.

Thus, finding the means to motivate students in learning is important. Without motivation, learning will be not effective, thus depriving students from meaningful learning. In this respect, the role of motivation in learning must be fully grasped by teachers and instructors alike. With high motivation, students will carry out their work diligently and strive persistently to achieve their goal. In addition, motivation can help expedite the learning process by which students will remain focused to achieve their learning goals. Furthermore, motivation can help improve learning performance as students will be more energetic and resilient.

Research has shown that students with high motivation tend to be successful in learning compared to students with low motivation (Brown, 2001). Apparently, the latter was less committed and less focused on the learning process, which ultimately resulted in an inadequate learning engagement leading to poor performance. In fact, motivation helps students to be consciously aware of their responsibility to put in every effort in their learning activities. It is therefore incumbent upon teachers to create a learning environment that can nurture students' motivation so that learning will take place with great efficacy.

Naturally, the creation of such learning environment relies on a host of factors – both pedagogical and technological – that need to be carefully crafted and implemented. In unison, these two main factors students can inspire students to partake in learning efficaciously through appropriate feedback and scaffold, which reinforce their desire to achieve their learning goals (Rehman & Haider, 2013). Likewise, DePasque and Tricomi (2015) articulate that students' intrinsic motivation can be vigorously expressed in learning environments by prompt feedback, which strengthens reasoning during learning. In this study, the researcher aggregating two motivational architectural, namely as *Attention, Relevance, Confidence, Satisfaction and Confidence* (ARCSC) and Self Determination Theory (SDT) and pertaining these motivational components to learning performance and motivation.

2.5.2 ARCS Motivation Theory

In recent years, several motivational theories that have been proposed to help improve the practice of teaching, learning, and training. Particularly, most of these theories have been studied to help understand on how both instructors and learners can be motivated to engage in the teaching and learning process, respectively. For the current learning landscape, which has given more emphasis on collaborative learning, motivation plays an influential role. Furthermore, the use of technology in the teaching and learning process has become more intense and pervasive.

As such, students must have the interest or motivation to engage in technology-supported learning environments, in which they can learn more effectively and efficiently (Huang *et al.*, 2017). Clearly, of late, almost all students are using mobile devices for both formal and informal communication. Hence, such use can be exploited to improve mobile learning by students can rely on an array of mobile tools to support their learning activities anywhere, anytime. To achieve such a goal, students must be motivated to partake in mobile learning (Nikou & Economides, 2017).

In this respect, the ARCS motivation theory was applied in this research to help guide the present study in which a group of students used a novel mobile learning application such as to improve their learning performance and motivation. In fact, the principles of this theory were implemented to assist the researcher to develop such a tool and to frame the discussion of the research findings based on the motivation construct. To help understand the term "motivation", Keller's (2000, 2009) ARCS model serves as a starting point. Based on Keller's (1987) ARCS model, motivation refers to "the direction and intensity of behaviour", which is influenced by four categories – *attention, relevance, confidence*, and *satisfaction*.

Essentially, attention is the prerequisite of the learning activity, and it refers to the interests of learners (Keller, 2010). Furthermore, this category can be divided into three subcategories, namely *perceptual, inquiry arousal,* and *variability*. At the start of learning, students' attention and curiosity should be aroused over time, and then the learning process will proceed. For example, in this study that used CoMARLA, learning materials were presented using a variety of multimedia that attract students' attention. Furthermore, students were given several tasks of different difficulty levels that further aroused their attention, and they became more inquisitive. Based on the above two learning characteristics, the attention of students in this study was secured and maintained throughout the learning sessions.

After students' attention is obtained, they may want to know how the given learning materials relate to their interests and goals, which is called relevance. Moreover, relevance can be divided into three subcategories, namely *goal orientation,* *motive matching*, and *familiarity*. The basic approach is that students have to know their learning activity closely relate to their experience, knowledge or interests, such as explaining new concepts by using newly gained concept, telling the future use of the new knowledge or rewarding the active participants (Di Serio *et al.*, 2013). In other words, relevance can be acquired through examples or speeches that are familiar to students. In this study, the participants were explicitly informed of the main aims of the collaborative learning activities, thus aligning with goal orientation. The mobile learning application contained relevant materials, notably 3D objects, that were developed based on the course contents, thus making them in line with motive matching and familiarity.

The third category, confidence, can divided into three subcategories, namely *learning requirements*, *success opportunities*, and *personal control*. If relevance is perceived to be useful in accomplishing students' given task, and they know they may be successful before completing the task, students will feel somewhat confident. Arguably, only confident students can autonomously inquire unknown knowledge and fields. During learning, the tasks that teachers provide should be neither too difficult nor too easy, which will prevent students from gaining a meaningful sense of success. If the achievements of students' efforts are keeping the same as their expectancy and they feel confident of these outcomes, the learning motivation will be remained and sustained.

In other words, confidence makes learners feel they can or will success. In this study, the mobile learning application contained features that helped the participants to access a vast array of learning resources and guided them to complete their assignments, thus effectively supporting the learning requirements, success opportunities. In addition, the mobile learning application provided an interactive environment in which the participants were empowered with interaction and selection features with which they could achieve a greater control of their learning. Thus, this type of learning facilitated to achieve the personal control of students.

Finally, satisfaction is the consequences of learning and refers to successful accomplishment with intrinsic motivation and extrinsic rewards, which is the reinforcement and conditioning of learning. According to Keller (2010), satisfaction can be subdivided into three subcategories, namely *intrinsic reinforcement, extrinsic rewards*, and *quality*. In this study, each participant was given the opportunity to convey and communicate with each other to demonstrate his or her work and to amend his or her work based on mutual evaluation among the participants. In fact, the mobile learning application enabled the participants to share, exchange, and edit their work collaboratively using social media. Through active social interaction and negotiation, especially during the presentation, the participants would be able to feel a sense of accomplishment, thus making them satisfied and contented. Such a claim is not that too far fetched, as research has shown that collaborative learning using mobile augmented reality technology would be able to increase the level of engagement of students and intensify the learning process (Chaiprasurt & Esichaikul, 2013).

2.5.3 Self Determination Theory (SDT) Theory

A widely used theory that helps explain the role of motivation in human endeavours is the Self-Determination Theory (SDT), which was proposed by two leading scholars, Edward L. Deci and Richard M. Ryan in the mid 1980s. In essence, SDT is a framework that conceptualizes the motivation which underlies the choices people make (Deci & Ryan, 1985). SDT indicates there are two basic types of motivation: *intrinsic* and *extrinsic*. Intrinsic motivation comes from within. For example, people reading a new book by their favourite author are probably not difficult to motivate themselves to finish the book because it is enjoyable. In fact, they experience intrinsic motivation when the task is inherently interesting, enjoyable, fulfilling, and absorbing. In contrast, students reading a book for an examination will not be inherently satisfying, because such an act is to ensure they will get through their study. This is an example of extrinsic motivation, by which people perform activities to reap positive external rewards or to avoid punishment.

A central tenet of self-determination theory (Deci & Ryan, 1985) is that human beings have three basic types of psychological needs, namely *autonomy*, *competence*, and *related*ness. These needs are defined as required ‘inputs’ that contribute additively to human thriving, in the same way that plants require certain vital inputs in order to thrive (Ryan, 1995). Autonomy involves feeling internal assent regarding one’s behaviour, rather than feeling controlled or pressured. Competence involves feeling efficient, effective, and even masterful in one’s behaviour, rather than incompetent and ineffective. Relatedness involve feeling meaningfully connected to others, rather than feeling alienated or ostracized. Moreover, the needs are defined as evolved and species typical, and are thus thought to be universally relevant within all people and all cultures (Deci & Ryan, 2000).

Inherently, humans tend to be proactive in engaging their physical and social surroundings and to assimilate ambient values and cultural practices. Put simply, human are innately curious, interested creatures who possess a natural love of learning and who desire to internalize the knowledge, customs, and values that surround them. Thus, such tendencies could, and should be, cultivated and harnessed by educators to teaching and learning. Nonetheless, the current practice is that teachers and instructors use external controls, close supervision and monitoring, and evaluations (accompanied by rewards or punishments) into learning climates to ensure that learning occurs (Niemiec & Ryan, 2009). In essence, such practices reflect both external pressures on teachers and their beliefs that motivation is best developed through external contingencies of reinforcement than by facilitating students' inherent interests in learning. Under such controlling conditions, however, the feelings of joy, enthusiasm, and interest that once accompanied learning are frequently replaced by experiences of anxiety, boredom, or alienation (Niemiec & Ryan, 2009).

Self-determination theory (SDT) is a macro-theory of human motivation, emotion, and development that focus on factors that either facilitate or forestall the assimilative and growth-oriented processes in people (Ryan & Deci, 2000). Hence, SDT plays an important role in the educational domain, in which learners' natural tendencies to learn represent the greatest resource to which teachers can exploit.

Unfortunately, external controls have been regularly used, with the misplaced belief that such external contingencies promote students' learning.

To present better understand the concepts and the role of SDT in learning, it is important for researchers to examine the concept of intrinsic motivation and those factors that support or undermine it in the classroom. Equally important for the researcher is to scrutinize the innate tendency of people to internalize new knowledge and practices acquired through socialization, and those factors that nurture or thwart the process of internalization. More importantly, researchers should also examine the learners' basic psychological needs for autonomy, competence, and relatedness. Such needs when supported would result in intense learning engagement and better learning outcomes; otherwise, when these needs are not supported, learners would become academically disengaged and perform poorly in academic assessment.

2.5.4 Intrinsic Motivation and Learning

Intrinsic motivation refers to behaviours carried out without external impetus that are inherently interesting and enjoyable (Ryan & Deci, 2000). For instance, intrinsically motivated students would tend to play, explore, and engage in educational activities for the inherent fun, challenge, and excitement of doing so. Essentially, this kind of behaviours is experienced as emanating from the self rather than from external sources and is accompanied by feelings of curiosity and interest (Deci & Ryan, 1985).

SDT postulates that intrinsic motivation is sustained by satisfaction of the basic psychological needs for autonomy and competence. The need for autonomy refers to the experience of behaviour as reflectively self-endorsed and volitional. For instance, students who willingly invest their time and energy in their study are considered autonomous. The need for competence refers to the experience of behaviours as effectively enacted. For example, students who feel they are able to meet the challenges of their assignments or tasks are deemed competent. More importantly, satisfaction of both autonomy and competence needs is critical to maintaining students' intrinsic motivation. As such, students who feel competent, but not autonomous, will not maintain intrinsic motivation for learning. In this regard, several studies have supported the SDT's postulation that both autonomy and competence are necessary conditions for the maintenance of intrinsic motivation (Sheldon & Filak, 2008).

A number of researchers have applied the SDT framework to intrinsic motivation in educational contexts. For example, Deci *et al.* (1981) assessed public elementary teachers' reports of their orientations toward supporting students' autonomy versus controlling their behaviours. Their findings showed that children assigned to autonomy supportive teachers, relative to those assigned to controlling teachers, registered increased intrinsic motivation, perceived competence, and self-esteem over time. Likewise, Ryan and Grolnick (1986) found a similar findings based on students' perceptions of teachers' autonomy support and control. In real learning setting, evaluative pressures have been observed to undermine students' intrinsic motivation in learning classroom topics and materials and their academic performance. In contrast, autonomy support helped increase students' intrinsic motivation, as evidenced from their improved academic performance (Grolnick & Ryan, 1987; Kage & Namiki, 1990).

Similar findings have been found in other studies as well. For instance, Tsai *et al.,* (2008) study, which focused on primary school children, found that students' interest was enhanced for lessons in which teachers were autonomy supportive, whereas students' interest was diminished for lessons in which teachers were controlling. Similarly, in a Canadian educational context, Burton *et al.*, (2006) encountered that intrinsic motivation was associated with psychological well-being, independent of academic performance. Such findings were again replicated in a study by several British researchers (Standage *et al.*, 2006), who found that perceived autonomy support was associated with higher autonomous self-regulation, including intrinsic motivation, which in turn was associated with greater effort and persistence in physical education. Likewise, Jang *et al.*, (2009) discovered that a group of public school students in South Korea was more intrinsically motivated when they experienced feelings of autonomy and competence.

2.5.5 Extrinsic Motivation and Learning

Extrinsic motivation denotes to behaviours performed to obtain some outcome separable of the activity itself (Ryan & Deci, 2000). SDT specifies four distinct types of extrinsic motivation, namely *external regulation*, *introjected regulation*, *identified regulation*, and *integrated regulation.* External regulation is the least autonomous type of extrinsic motivations, whereby behaviours are enacted to obtain a reward or to avoid a punishment. Such behaviours are poorly maintained once the controlling contingencies (e.g. grades) have been removed (Vansteenkiste *et al.*, 2008). For instance, a student might study for an exam to earn a good grade, simply that the student would probably not seek out additional information on the topic once the exam is finished. Introjected regulation is the second least autonomous type of extrinsic motivations, whereby behaviours are enacted to satisfy internal contingencies, such as self-aggrandizement or the avoidance of self-derogation. For example, with introjected regulation, the student who originally studied to perform well on the exam now studies to feel pride or to avoid feeling guilty for not having studied enough. Both external regulation and introjected regulation are perceived as emanating from outside the self. Accordingly, those forms of behavioural regulation are experienced as relatively controlling.

Moving closer toward greater autonomy, behaviours that are enacted because they are considered valuable or important are considered to exemplify *identified regulation*. For example, a student might study anatomy and physiology because mastery of such information is important for future competence in medicine. The most autonomous type of extrinsic motivation is *integrated regulation*, whereby those identified regulations have been synthesized with other aspects of the self. For example, a student might study medicine because doing so enables her to enter a profession in which she can help those in need, which is consistent with her abiding values and interests. Both identified regulation and integrated regulation are perceived as emanating from the self, and accordingly, those forms of behavioural regulation are experienced as relatively autonomous.

Several studies have examined the psychological and academic outcomes associated with autonomous self-regulation for learning. For instance, Niemiec *et al.* (2006) found that high school students who reported higher autonomous self-regulation for attending college reported higher wellbeing (vitality, life satisfaction) and lower ill-being (depression, externalizing problems). Likewise, Black and Deci (2000) found that college students who reported higher autonomous self-regulation for learning organic chemistry reported higher perceived competence and interest in the course material, as well as lower anxiety. In addition, Williams and Deci (1996) found that medical students who reported higher autonomous self-regulation for continuing to learn about doctor–patient relations were rated as more autonomy supportive by standardized patients. As such, internalization of extrinsic motivation is critical for effective psychological and academic functioning among students at all educational levels.

Clearly, internalization of extrinsic motivation is essential for students' self-initiation and persistent volition for educational activities that are not inherently interesting or enjoyable. Furthermore, from primary to tertiary levels, students can learn better and report higher levels of psychological health when they have well-internalized extrinsic motivation for learning. Taking cognizance of the knowledge that more autonomous types of extrinsic motivation are associated with enhanced student learning, understanding how to facilitate internalization becomes an important educational pursuit. In this respect, SDT asserts that, when students' basic psychological needs for autonomy, competence, and relatedness are supported in the classroom, they are more likely to internalize their motivation to learn and to be more autonomously engaged in their studies.

Students' autonomy can be supported by teachers' minimizing the salience of evaluative pressure and any sense of coercion in the classroom, as well as by maximizing students' perceptions of having a voice and choice in those academic activities in which they are engaged (Niemiec & Ryan, 2009). Indeed, research suggests that autonomy-supportive teaching practices are associated with positive outcomes in the classroom. For example, Chirkov and Ryan (2001) encountered that students' perceptions of both teacher and parent autonomy support were associated with greater internalization of academic motivation. Another important aspect of autonomy support that facilitates internalization is that teachers provide students with a meaningful rationale for why a learning activity is useful. Such notion is best exemplified by the Reeve *et al.*, (2002) findings that pointed the provision (versus absence) of an autonomy-supportive rationale explaining the importance of a learning activity facilitated students' internalization, which in turn was associated with the students' greater effort to learn.

Students' competence can be supported by teachers introducing learning activities that are optimally challenging, which enables the former to test and to expand their academic capabilities. Additionally, it is vital that teachers provide students with the appropriate tools and feedback to promote success and feelings of efficacy. Arguably, students will only engage and personally value activities that they can actually understand and master. Therefore, it is important that feedback downplays evaluation and emphasizes students' effectance, thus providing relevant information on how to master the tasks given to students.

In addition to the needs for autonomy and competence, SDT postulates that satisfaction of the need for relatedness facilitates the process of internalization. Students tend to internalize and accept as their own the values and practices of those to whom they feel, or want to feel, connected, and from contexts in which they experience a sense of belonging (Niemiec & Ryan, 2009). In the classroom, relatedness are deeply associated with students feeling that their teacher genuinely like, respect, and value them. In fact, students who report such relatedness are more likely to exhibit identified and integrated regulation for the arduous tasks involved in learning, whereas those who feel disconnected or rejected by teachers are more likely to move away from internalization and thus respond only to external contingencies and controls.

As discussed, the above findings provide strong evidence for the SDT's postulation that satisfaction of students' basic psychological needs for autonomy, competence, and relatedness is critical for their internalization of academic motivation. Specifically, in classroom contexts, that support the satisfaction of autonomy, competence, and relatedness, students tend to be more intrinsically motivated and more willing to engage in learning, and to value academic activities.

Moreover, with higher volition, students will be able to accomplish better learning outcomes and enhanced well-being.

2.5.6 Instructional Strategies to Support Students' Satisfaction of Autonomy, Competence, and Relatedness

As discussed in the preceding section, evidence suggests that intrinsic motivation and autonomous types of extrinsic motivation relate positively to important academic outcomes. Furthermore, classroom practices that support the students' satisfaction of autonomy, competence, and relatedness are associated with both greater intrinsic motivation and autonomous types of extrinsic motivation. It is therefore conforming the imperative of teachers and instructors to use appropriate strategies to facilitate the process of making students to become intrinsically motivated. The following sections highlight some of the strategies that can be deployed to help satisfy the students' psychological needs in the classroom activities.

2.5.6.1 Instructional Strategies to Support Students' Satisfaction of Autonomy

Strategies for enhancing autonomy include providing choice and meaningful rationales for learning activities, acknowledging students' feelings about those topics, and minimizing pressure and control. For example, to start a learning session, the teacher can provide some introductory statements for their students. He or she can provide some assurance to the students by saying (as an example): "Students, it is time to begin. First, here is some general information that you need to know". Likewise, in a class in which student is about to conduct an experiment, the teacher can say the following: "In this experiment, I just want you to freely use all the tools available, learning to use them in your own way. You can choose which tools to use, and you can choose which procedure you want to try first. Just try to get into it, and see where it goes". Thus, this strategy that is based on autonomy support manipulations helps emphasize choice, self-direction, and students' perspective upon the task.

In contrast, students in non-autonomy, learning may instead hear: "In this experiment, you must do exactly as I say, learning to do the procedures our way. In order to achieve the intended learning outcomes, I cannot let you have any choice about which tools to use, nor about which order you perform the procedure. I know what you will be doing, so just follow my instructions exactly, please". In such a case, teacher control and the absence of choice are emphasized.

In the context of learning using learning tools, students should be given explicit instructions on how to use such tools, but they must be given the assurance that they can use such tools to the best of their ability. Specifically, the students must be assured that they can have the option to use or not to use the learning application. Such reassurance helps students to experience a sense of freedom, flexibility, and control, which ultimately helps satisfy their needs for autonomy.

2.5.6.2 Instructional Strategies to Support Students' Satisfaction of Relatedness

Strategies for enhancing relatedness include conveying warmth, caring, and respect to students. For example, in relatedness-support learning, the teacher may say the following: "One thing you need to know is that to me, everybody is unique. I care about each person as an individual, and am trying to understand your learning style. So, I hope you'll share your experiences with me after we're done". In addition, the teacher may say: "Just to remind you: remember, I care about you and your unique learning style. So, please be sure to remember what you were thinking and feelings, so we can discuss your reactions late Thus, acknowledgement, caring, and interest in the students' experiences is emphasized.

In contrast, in non-relatedness learning, students may hear their teacher saying: "Another thing you need to know is that to me, everybody is the same. I am not concerned about you as an individual; I only care about your performance in this class. So, please keep your observations to yourself during the process". Alternatively, the same teacher may say: "Just to remind you: to remember, I am not really interested in your reactions and ability. So, please keep your questions and observations to yourself, as we go through the procedure". Thus, disinterest in the student as a person is conveyed.

In the context of learning using collaborative learning applications, the teacher can advise his or her students to choose appropriate collaborative features of such an application, especially social media such as Facebook, Tweeter, or Instagram, among others. Students should be encouraged to use such applications for exchanging ideas, sharing materials, and discussing important facts. To achieve this, the teacher needs to play the role of a facilitator, who will provide guidance and encouragement for students such that collaborative and supportive engagements can materialise in a conducive, friendly environment. As a result, students' needs for relatedness can be satisfied and sustained, which will lead to improved motivation.

2.5.6.3 Strategies to Support the Students' Satisfaction of Competence

Strategies for enhancing competence include providing reflectance-relevant feedback, and optimally challenging tasks for students, as opposed to norm-based evaluative. For example, in a competence-support learning setting, the teacher may say the following: "One thing to keep in mind is that this task is quite challenging. The task involves finding as many solutions as possible. Just do the best you can, and you will improve quickly. I have confidence in you!" Likewise, the teacher may say these assuring statements: "'OK, like I said before, this first challenge is to give us a sense of how well you can do at the beginning. In fact, other students have done this quiet well. I will give you 15 minutes to seek the solutions, and just relax and get into it, I'm sure you'll do well". Such statements encourage positive expectancies and flexible learning orientations.

In contrast, in a non-competence condition, the teacher may instead say: "One thing to keep in mind is that this task is quite difficult. The task involves finding as many feasible solutions as possible, and beginners (like you) will usually face some difficulties. Still, do the best you can, even if seems hard. Maybe you will be lucky!" Alternatively, the teacher may say: "OK, like I said before, this first task is to give us a sense of how poorly you do at the beginning. In fact, previous students have done quite badly at this, initially. I will give you 15 minutes to find as many solutions as possible. Just try as hard as you can, and hopefully you won't do too badly". Clearly, such statements emphasize low expectancies and the role of chance.

In the context of learning using novel applications, students should be encouraged to use relevant features of such applications in performing their tasks or assignments. Specifically, such features should serve as cognitive tools by which students could use to help them solve given problems efficiently and effectively. For example, students could use a modelling tool of such applications to create virtual artefacts, of which they could manipulate and test to learn its behaviours or characteristics. As such, students could have more opportunities to learn in diverse learning orientations, thus satisfying their competent needs, which would lead to increased motivation and enhanced learning.

2.6 Augmented Reality

Technology has always played an important role in the teaching and learning process since its inception. Its use has become more and more commonplace nowadays as every facet of the human life is affected by technology. In fact, technology, especially computing technology, is an integral part of the learning process to improve the delivery of learning content, engage students, and enhance classroom management. Among the technologies involved, the computer is the technology that has made, and continues to exert, tremendous impact on education. Its early impact can be traced back to early 1968s, which saw the first interactive computer terminal and input device (Sutherland, 1968).

Spurred by Sutherland's (1968) invention, other newer technologies, both in terms of hardware and software have been developed and used, especially in the research and military domains, such as Immersive Technology, Virtual Reality (VR), and Augmented Reality (AR). Particularly, AR technology, which was developed by Boeing, has made a vigorous presence initially in the military and now in education (Caudell & Mizell, 1992). Essentially, AR technology is a mishmash of real-word elements such as text, pictures, video and three-dimensional (3D) models, and animation, which when used properly in the proper learning context can be potentially beneficial (Martín-Gutiérrez *et al.*, 2014).

Initially, AR technology mainly ran on expensive engineering workstations, then it migrated to less inexpensive personal computers, and now it can run on mobile devices, such as the hand phone. More interestingly, its use based on the mobile computing platform has led to a new variant of the AR – Mobile Augmented Reality (MAR) (Nincarean, *et al.*, 2013). In essence, MAR helps the user to view and interact with the system-generated objects superimposed or merged with real surroundings

(Billinghurst, 2002). More specifically, MAR has the following three characteristics: (i) an environment consisting of real artefacts and virtual information, (ii) real-time interaction, and (iii) 3D registration. These three attributes capacitate the development of innovative learning tools or applications to help students learn more efficaciously (Lucke & Zender, 2011). Furthermore, such learning tools or applications may permit to design their own avatars that help create intense engagement and collaboration in the learning process (Saleeb & Dafoulas, 2013).

2.6.1 Definitions and Attributes of Augmented Reality

There are many definitions of Augmented Reality (AR), and one of the earliest definitions is that AR refers to a mixture of real and virtual images that are mutually perceived at the same time (Azuma, 1997). New definitions of AR have been proposed by other researchers such as Wu *et al*. (2013), Chiang *et al*. (2014), Fonseca *et al*. (2014), Pengcheng *et al*. (2015), and Scholz and Smith (2015), albeit some of which are overlapping with one another. Table 2.6.1.1 and Table 2.6.1.2 highlight such definitions offered by the above researchers.

In this study, the definitions of Augmented Reality (AR) denoting to the definition of Scholz & Smith (2015), that defines the AR as digital information that combines several elements, namely as graphics, texts and images to overlay the objects in the real world like computer board and the learners experience these hybridized realities throughout the mobile phones in teaching and learning environment.

Table 2.6.1.1

Definitions of Augmented Reality (AR)

Authors	Year	Definition
Azuma	1997	"Augmented reality refers to technologies that enhance the sense of reality, allowing the coexistence of digital information and real environments. In addition of that, it also allows the user to see the real world, with virtual objects superimposed upon or composited with the real world" (p. 2)
Sumadio *et al.*	2010	"An Augmented reality as an advance technology that enable users to interact with the virtual and real world in real time application can bring more natural experience, raises attention and motivation to students with a high potential to enhance the learning experience" (p. 1).
Nincarean *et al.*	2013	"… AR has an ability to encourage kinaesthetic learning. Furthermore, since AR use 3D registration of virtual and real objects, it could allow a user to view the learning content in 3D perspectives"(p. 659)
Di Serio *et al.*	2013	"… An educator's challenge is to use physical immerse capabilities of AR technology to foster student engagement in learning activities."(p. 587).
Wu *et al.*	2013	"… AR technologies help learners engage in authentic exploration in the real world, and virtual objects such as texts, videos, and pictures are supplementary elements."(p. 43).

(*continued*)

Table 2.6.1.2 (*continued*)

Authors	Year	Definition
Chiang *et al.*	2014	"…acquiring information through this technology is more intuitive, it can stimulate learners during the learning process to actively observe, to formulate multiple assumptions through observations, to carefully assess the validity of observed phenomena and the rationality of proposed hypotheses, and to formulate a final hypothesis after refuting multiple proposed hypotheses" (p. 98).
Pengcheng *et al.*	2015	"Instead of creating a complete virtual world as in Virtual Reality; AR technology integrates virtual objects with the real environment. This will make the users of Augmented Reality feel an authentic new environment" (p. 1).
Scholz & Smith	2015	"The layer/world metaphor aptly captures the basic idea of augmented reality: marketer layer digital information (e.g., text, pictures, videos) over objects and spaces in the physical world (e.g., product packaging, advertisements, street scenes), and consumers experience these hybridized realities via digital screens (e.g., smart phones, video installations) or projections (e.g., holograms)" (p. 2).

Like many other new, novel technologies, AR technology was almost exclusively used in several critical fields, especially in the military and medical (Edgcumbe *et al*., 2015; Oden *et al*., 2015). However, with improvements over the years, it becomes more affordable to be deployed in other public-domain fields such as education (Dunleavy & Ded, 2014) and entertainment (Chen *et al*., 2015). To help explain the various fields in which AR has been making inroad, Azuma (1997) has classified six applications of AR technology based on the relevant fields, namely as medical tablets of the memory, maintenance and repair, annotation, robot path planning, entertainment, and military pilotage and also training as summarized in Table 2.6.1.3.

Table 2.6.1.3

List of Fields and Roles of Augmented Reality Technology

Researcher	Field	Role of Augmented Reality
Edgcumbe *et al.*, 2015	Medical	Displaying the path of blood vessels.
Fiorentino *et al.*, 2014	Maintenance and repair	Technical maintenance associated with interactive augmented reality instructions.
Blanco-Fernández *et al.*, 2014	Annotation	Improve their learning about historical battles and wars.
Jun *et al.*, 2015	Robot path planning	A tracked mobile robot to pass over uneven terrains, which can expeditiously explore for stability sub-optimal paths.
Chen *et al.*, 2015	Entertainment	Search fishing fields to discover appurtenant baits for certain fish, and to gather sufficiency ocean species to form as many food chains as possible.
Oden *et al.*, 2015	Military navigation and aiming	Infantry immersion trainer by providing Emotional Intelligence and head mounted augmented reality to simulate real war.

Previously, AR technology, just like its predecessors such as VR technology, was cumbersome to use as it heavily required expensive, heavy head-mounted displays to achieve the sense of presence and interaction. Definitely, wearing such a heavy head-mounted display or helmet attached to a computer worn on the user's back has limited practical application to the ordinary user. In fact, the practicality of its usage for mainstream applications such as in schools is severely limited. On top of that, it is prohibitively expensive maintenance cost and lack of robustness arising from the complex, intricate hardware and software setup make its appeal for schools less attractive.

The concept of mixed reality is the coalescence of augmented reality between augmented virtual as depicted in Figure 2.6.1.1 According to Milgram *et al*. (1994), the term "mixed reality" be equal to "[an] environment in which real-world and virtual-world objects are delivered together within a single display" (p. 283).

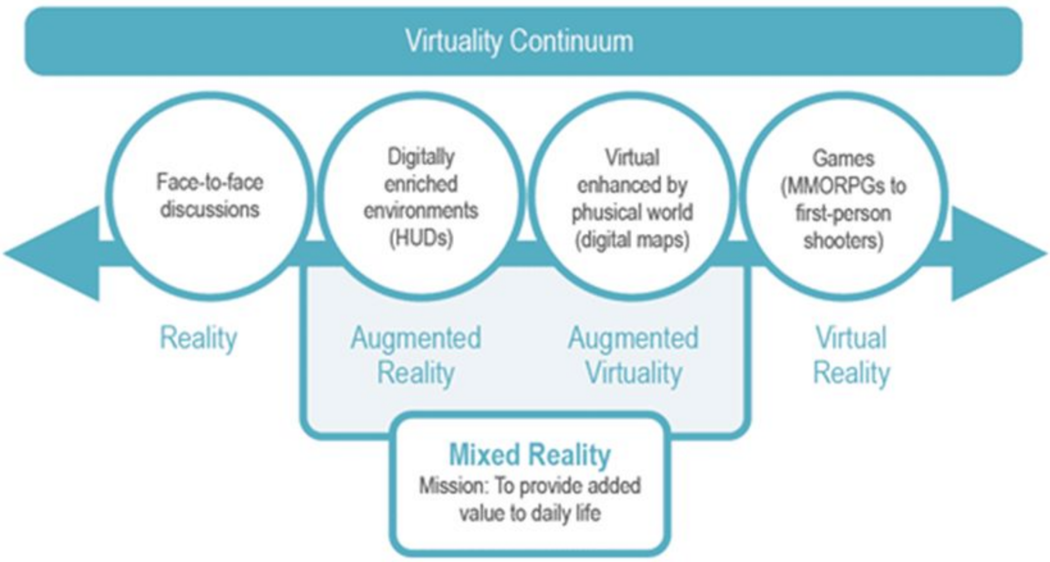

Figure 2.6.1.1. The Virtual Reality Continuum

This continuum comprises two extremities, namely the “Reality” on the one end and “Virtual Reality” on the other end. From the technical standpoint, an AR system synthesizes the real environment or surroundings of the user with virtual elements in real time through a tracking system that registers virtual elements as three-dimensional space of real environment to stipulate a sense of perceived augmented reality (Jeřábek, *et al*., 2014). Immersed in such reality, the user will experience a vivid sense of presence and control that can be exploited to engender not only a meaningful learning setting (Ariyana *et al*., 2012), furthermore the element can motivate student learning as well (Serio *et al*., 2013)

2.6.2 Applications of Augmented Reality

Mobile Augmented Reality (MAR) is a subset of Augmented Reality technology owing to the adoption of mobile devices, such as the hand phones, tablets or portable laptops, as opposed to the cumbersome, heavy head-mounted displays (Schmalstieg & Wagner, 2007). Furthermore, the appeal to use MAR for educational purpose has been spurred by the continually and rapidly changing communication technology by which the computing speed has increased exponentially and the cost of ownership has dropped significantly. These two main changes have made MAR a very attractive learning solutions by which both teachers and students can take advantage to improve teaching and learning process.

Technically, MAR can be categorized into two classifications, namely as “Marker- Based” Augmented Reality and “Markerless” Augmented Reality. Both categories of AR will typically use the camera of the hand phone to scan QR codes or coded images to launch the virtual objects (e.g., 3D objects, audio, and video) that will be superimposed onto the environment as seen through the camera (Ke *et al*., 2015). In addition, both categories of MAR can help the user to experience a sense of immersion and presence by the combination of the real and virtual objects or environment. There are numerous examples of MAR application reported in the literature.

For example, a MAR application called *HuMAR* has been developed and used to help a group of students to learn human anatomy (Jamali *et al*., 2015). Using this novel learning application, students were found to be more engaged and motivated, the impact of which they learned more efficaciously as they could interrogate the anatomical structure with ease and better control. Moreover, the accompanying supporting materials that provided relevant information further intensified their understanding. Another example involved the development and use of context-aware library management system that helped improve the suitability, efficiency, and accuracy of library management (Shatte *et al*., 2014). More specifically, this innovative MAR application helped all concerned to gain access to up-to-date information anywhere, anytime.

In the medical field, several interesting MAR applications have been developed and used to help the stakeholders in the health care in a number of tasks. For instance, an MAR application has been used to help train new staff in certain procedures and to deal with the problem of locating corpses (Galvao, 2013). Of late, many educational MAR have been developed to help improve existing current teaching and training practices involving a wide range of subject matters. In essence, some of these educational MAR have been found to be able to facilitate and support learning by means of scaffolding mechanisms (Ibanez *et al*., 2015).

Given the huge educational potential of MAR in learning, many developers and researchers have begun developing novel, innovative learning tools or applications to help students learn science, technology, engineering and mathematic (STEM) subjects. For instance, a MAR learning application was used to support the learning of Physics remotely (Gu *et al*., 2013). The main aim of this mobile application was to assist students learn basic electrical circuitry, electrical components, and their functions. Using this application, students were capable to experiment such a circuit design in various contexts, such as in an earthquake, which would give them several learning perspectives. Ultimately, the various situations in which they made use of the mobile application had enhanced their understanding of electrical circuitry in various settings (Yamashita *et al*., 2012).

2.6.3 Types of Augmented Reality System

Currently, a number of AR applications or systems has emerged in various fields, including education and training. As expected, these applications have been used with great enthusiasm and excitement given its novelty that appeals to most of the users.

These systems come with a range of capabilities, depending on their hardware requirements, which can be either basic or advance.

The basic hardware requisites of an AR system incorporate the presence of a video camera to capture the live images, substantial storage space for virtual objects, a efficacious processor to either composite virtual and real objects or manifest a 3D simulated environment in real-time, and an interface that allows the user to interact with both real and virtual objects (Azuma, 1997; Billinghurst, *et al*., 2001). In addition to the above requirements, other technologies may be resorted to in order to aggrandize the comprehensive experience for the user (Johnson *et al*., 2010). Such advanced technologies accommodate Global Positioning Systems (GPS) technology, speakers and sound systems, image recognition software, internet access, and internet access (Johnson *et al*., 2010).

Furthermore, the GPS technology enables the system to take the user's real world location in a real time, insure that the content of virtual data is synchronized precisely to the signing location. In addition to that, the software for image recognition also accredits the real world images and object to be as triggers for multimedia and overlay model, as well as acts as an anchor to the virtual in the data environment. The speakers and sound systems enable relevant sounds and audio recordings to be played. Moreover, the internet access furnishes a means of storing, retrieving, and sharing content utilizing social media and Web 2.5 technologies. Differently, the intuitive interfaces involving touch screen, gyroscope, and haptic input technologies render more natural entails to interplay with manipulate virtual objects (Johnson *et al*., 2010). Occupying on the hardware and software, AR system can be separated into two main categories namely *Marker-based Augmented Reality* and *Markerless Augmented Reality* (Johnson *et al.*, 2010). The following sub-sections detail these two types of AR technology.

2.6.3.1 Marker-based Augmented Reality Technology

As it name implies, Marker-based Augmented Reality systems uses visual markers that when scanned by the user's camera will launch an AR application. Typically, these markers are based on a pattern of black and white squares, and the most commonly used marker is the QR codes. Normally, these codes when scanned will be processed by the user's device to deliver the contents, encompassing a range of elements such as 2D images, 3D objects, audio, video, and animations to the user. Figure 2.6.3.1.1 demonstrates the visual marker of a marker-based AR system.

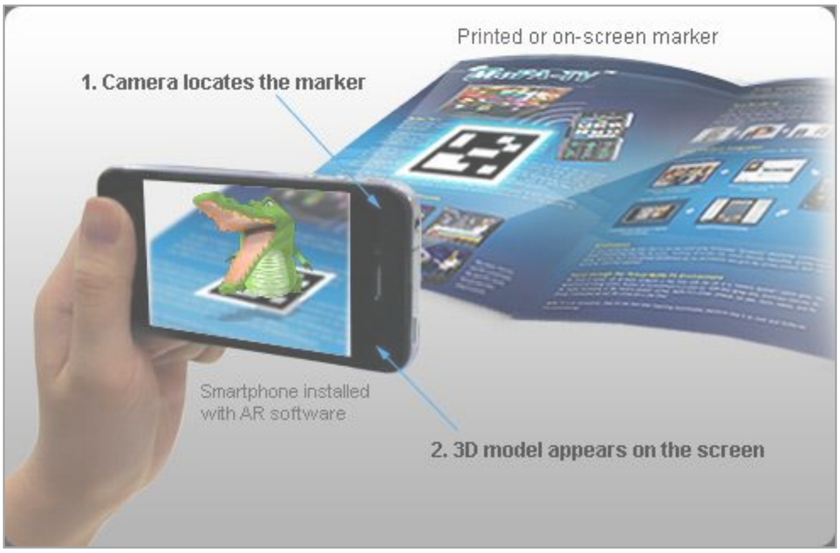

Figure 2.6.3.1.1. A Visual Marker of an AR Application

In essence, these markers can be thought of as a reference point of such AR applications. Hence, for this approach, visual marks that have been printed previously need to be safely kept for future uses. Nonetheless, applications based on marker-based AR have a major drawback where their performance relies heavily on the tracking method for visual marker detection (Torr, 2000; Wang *et al.*, 2013) and pose estimation (Khandelwal *et al.*, 2015), which is compounded by the design of the visual marker that differ from one to another. As a result, visual markers are constrained to a range of photos or objects encapsulated within a border to create them, thus limiting the interactivity of such application. Moreover, such markers tend to clutter the user's view, thus lowering the overall visualization quality of such systems (Huang *et al.*, 2012).

2.6.3.2 Markerless Augmented Reality

Due to the inherent drawback of the marker-based AR system, markerless AR technology uses a better technique to improve the interactivity of such systems. Beside of that, in markerless augmented reality systems, whatever component of the real environment may be expended as a target that can be trailed systematically to place virtual objects – thus, eliminating the need for visual markers. Such tracking is normally carried out by the combination of features such as Global Positioning System (GPS), camera, accelerometer and other features of a communication device, such as a mobile phone (Tuters, 2001). Thus, the possibility of sharing this rich information is almost endless with the use of mobile devices to run the AR applications (Rehman, 2004). Premised in educational setting, AR learning contents and materials can be shared to help students learn more effectively, as such information engenders multimodal interaction (Gunatunge *et al*., 2014). Figure 2.6.3.2.1 shows a browser interface that display the AR contents on a mobile phone screen.

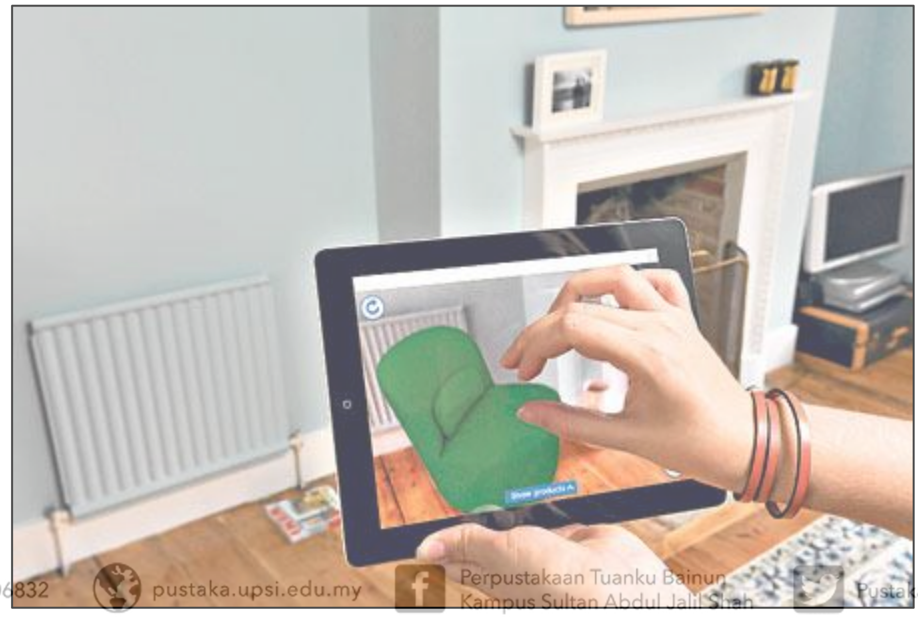

Figure 2.6.3.2.1. A Browser Interface displaying the Markerless AR Contents

In order to perform the object tracking, markerless augmented reality systems rely in natural features instead of visual markers. Hence, here lies a major advantage of such systems, as there are no ambient intrusive markers, which are not really part of the environment. Moreover, markerless augmented reality makes use of existing specialized and robust trackers already available. Another advantage of the markerless systems is the ability to extract from the environment characteristics and information that may later be used by them. However, a major downside of markerless augmented reality systems is that tracking and registration techniques become more complex.

2.7 Case Studies involving the Use of Mobile Augmented Reality Learning Tools

As experienced by previous technologies used in learning and training, many educators have been very cautious – obviously for the right reason – in using AR technology as a learning tool in the classroom. The pedagogical values of such novel technology have to be demonstrated and validated before AR can be accepted as one of the mainstream educational tools in the educational realm. In this regard, several researchers have conducted studies to examine the impacts of AR on learning and training, encompassing a wide spectrum of subjects, including biology, physics, architecture, and mathematics. Through such studies, several educational benefits have been unearthed, which can wield a huge impact on the student learning. The following are three recent case studies in which mobile AR applications have been

used to help students learn various topics involving biology (Jamali, Shiratuddin, Wong, & Oskam, 2015), mathematics (Barraza Castillo, Cruz Sánchez, & Vergara Villegas, 2015), and natural science (Chiang, Yang, & Hwang, 2014).

2.7.1 Case Study 1: The Learning of Human Anatomy

This case study was based on the development and pilot testing of a mobile AR learning tool called *Human Anatomy in Mobile-Augmented Reality* (HuMAR) carried out by a group of researchers at the Murdoch University (Jamali *et al.*, 2015). The aim of this study was to measure the usability of the novel learning tool to help students in learning human anatomy based on a survey involving academics, technology experts and students. The HuMAR application ran on Android-based tablet, which had a multimodal interface that helped facilitate better interaction and understanding of the topic with the use of virtual 3D objects (see Figure 2.7.1.1). The selected topic was the bones of the lower appendicular skeleton. Using this application, students could initiate their learning anytime and anywhere, without having to use their biology laboratory in which the actual physical bones were kept for learning purpose in normal learning setting.

In this application, four lower limb parts of the bones, such as the pelvis, femur, tibia and fibula and foot were used. To develop the AR learning environment, the researchers used the Software Development Kit (SDK), which is a collection of software package that enables developers to build software applications. Essentially, the development of HuMAR involved the creation of target image-markers, 3D modelling, and device calibration to produce a mobile AR environment. To use HuMAR, several markers were used to detect and allow any assigned image to be recognized, and then be displayed on the tablet's screen. In this case, the markers were images on any surface and the tablet camera functioned as an image scanner. In HuMAR, each image of the bone was taken from the unit, laboratory manual that were later assigned with a specific marker. In this application, each image was detected as a marker, and was measured by its width and specific dimensions. Once a marker had been recognized, HuMAR would display and superimpose the respective 3D computer-generated object on the tablet screen.

Figure 2.7.1.1. The HuMAR Interface

In this case study, 30 students, consisting of 22 female students and 8 male students, were randomly recruited from three Malaysian public universities. The mean age of the participants was 20 years. Given the different locations of study, the researchers ensured that the procedures and settings were the same as well as the same set of questionnaires and target audiences. The participants were a tablet each with HuMAR installed by which they explored and learned the specific parts of human anatomy in a prescribed duration. Each session was conducted in a three different venues in each respective university. In the usability testing, several learning aspects were measured based on students' opinions, namely learning improvement, enhancement of understanding, motivation, and retention.

The main finding of this study was that all the participants agreed that this novel learning tool had helped understand the topic better. Specifically, they opined that several features of the application had made learning more efficacious and motivating. For example, the ability to change the viewing angle of the 3D objects spurred their interest and desire to learn, and the textual information (labels) provided to improve their memory where they retained the gathered information longer. Furthermore, they believed that viewing the 3D objects freely by rotating them in any direction was vital in helping them to examine the intricate parts of human anatomy more closely and thoroughly, thus enabling them to learn more effectively. Arguably, such multiple-viewing and rich information about the learning artefacts provided the participants with a learning setting that was appealing and engaging. Consequently, they could learn the topic not only with improved efficacy, but also with greater keenness.

2.7.2 Case Study 2: The Learning of Mathematics

This case study was based on a pilot study involving the utilization of mobile augmented reality for interactive experimentation in quadratic equations carried out along a group of researchers at the Ciudad Juarez Autonomous University, Mexico (Barraza Castillo *et al.*, 2015). The main objective of this cogitation was to analyze the impact of a novel tool called *pARabola*, which is a plotting application, on undergraduates' conceptual understanding of quadratic equations. Students at the undergraduate level were expected to possess sufficient knowledge on this topic, however, some of them seemed were observed to be struggling in learning this topic (Barraza *et al.*, 2015). Thus, the pARabola application was designed by the group of researchers that was used as a complementary tool for the mathematics, peculiarly for the topic of quadratic equations. The conventional method of learning this topic typically involved solving the equations and plotting the relevant graphs on papers, which was laborious and taxing. From the teaching perspective, the constant necessity of redrawing the plot on the blackboard to show a detail behaviour of the parabola when one of its parameters is altered was painstakingly slow.

The development of this mobile AR plotting application encompassed a number of subsystems, namely presentation subsystem, world model subsystem, context subsystem, tracking subsystem, and interaction subsystem. Furthermore, the demonstration subsystem is dependable for exhibiting video output of the real world and rendering the 3D augmentations for the user. In particular, this subsystem contains a particle generator to plot equations in 2D or 3D space. The aim of world model subsystem is to store and provide access to a digital representation of the real world, including fiducial marker patterns, point's data, and 3D objects for

augmentation. Context subsystem is responsible for providing the entire system with contextual information about the status. Tracking subsystem manages thresholding, filtering, marker detection, and pose estimation of this mobile plotting application. In addition, all the information annexed is relayed to the rendering system to add the virtual elements and compose the final scene that will be displayed to the user. The interaction subsystem collects and processes any input that the user does intentionally. For this application, a touch based graphical user interface (GUI) was selected and implemented.

The participants of this study were made up of 59 undergraduates from different levels and academic programs. They were assigned into three groups, with the first, second, and the third group comprising 27, 22, and 10 students, respectively.

All of the participants had adequate experience in using mobile devices, notably smart phones and tablets. Each group was exposed to two sessions of learning. The first session involved a lecturer explaining the elements involved in the quadratic equations using textbooks, slides, and whiteboard examples. Later, the second session followed up with an explanation offered to the students about the use of the pARabola plotting application. The explanation included information about the inclination of the tablet in front of the marker to detect and display the plot, the functionality of the sliders, and the sections of the questionnaire. Subsequently, the participants explored and tested the use of the pARabola application. To test the pARabola application, two tablets and their correspondent markers were provided for the participants. Two participants would simultaneously test the application, and once completed, another two participants would do the same. The same was replicated until all the participants had a chance to test the application. On average time, each participant spent 7 minutes to use this mobile application. Figure 2.7.2.1 shows a participant using the pARabola application in this study.

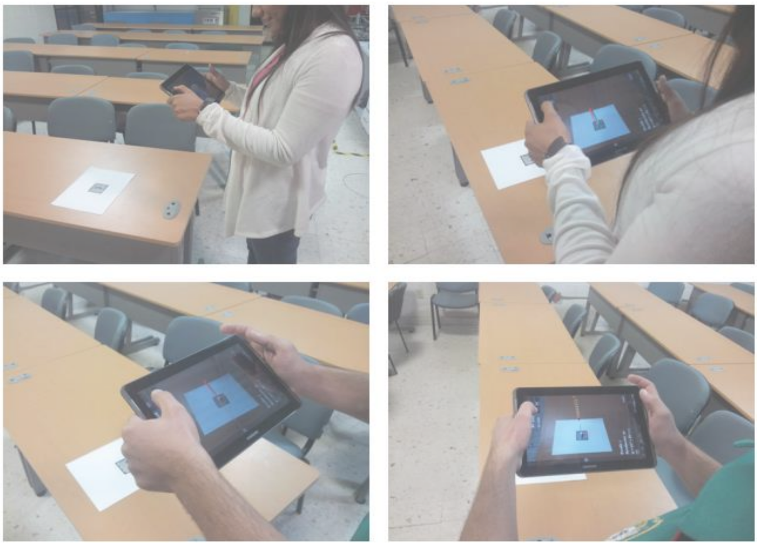

Figure 2.7.2.1. Students Performing the Pilot Study with the pARabola Plotting Application

The effectiveness of the mobile AR application was measured through a survey after the completion of learning sessions. The survey revealed that a majority the participants helped them learn the principles of quadratic equations more effectively, as they could recall the parts of a parabola and its plot more fluently. More specifically, the dynamic plotting facilitate them to visualize the characteristics of quadratic equations as their parameters were altered. By experimenting with the parameters, they could observe the 3D plots of equations almost instantaneously. Moreover, the use of different colours representing the data points were helpful in highlighting the resultant profiles based on the parameters of such an equation. Clearly, this feature made learning more attractive and appealing. Put simply, this novel application provided the participants with the capability to observe, and to interact with the learning content in real time, engendering a sense of rich, engaging experience.

2.7.3 Case Study 3: The Learning of Natural Science

This case study was based on an inquiry-based study of learning natural science using an innovative mobile augmented reality carried out by a group of researchers at an elementary school in Northern Taiwan (Chiang, Yang, & Hwang, 2014). The main designation of this study was to examine the effectiveness of the mobile AR learning tool in improving the learning achievement and motivation among a group of fourth graders in learning natural science, as compared to other students who learned using conventional (non-mobile) AR learning method. In this case study, the students ventured into a target learning site containing exotic aquatic animals and plants, which constitute an integral part of the natural science learning.

A mobile AR system was developed by the researchers using JAVA, Oracle, and Xcode for the website, database, and iPad mini devices, respectively. The hardware architecture of this tool comprises a camera, image editor, a digital compass, a three-axis gyro, an accelerometer and an AR display module. This novel learning system provides several functions, namely a mobile AR learning function, an online chat room function, and an investigated portfolio function. The mobile AR learning function appropriates students to discover about the target learning objects, to associate the supplementary materials, to apprehend their observations, to annotate and to comment on the images, and to browse other students' observations. The online chat room function enables students to discuss their investigation immediately from different locations. The investigated portfolio function collects each user's observed portfolio, participated portfolio, and reflected portfolio. Effectively, these functions, establishes an inquiry-based learning environment that is highly interactive, collaborative, and reflective. Figure 2.7.3.1 demonstrates the basic function of the mobile AR learning tool.

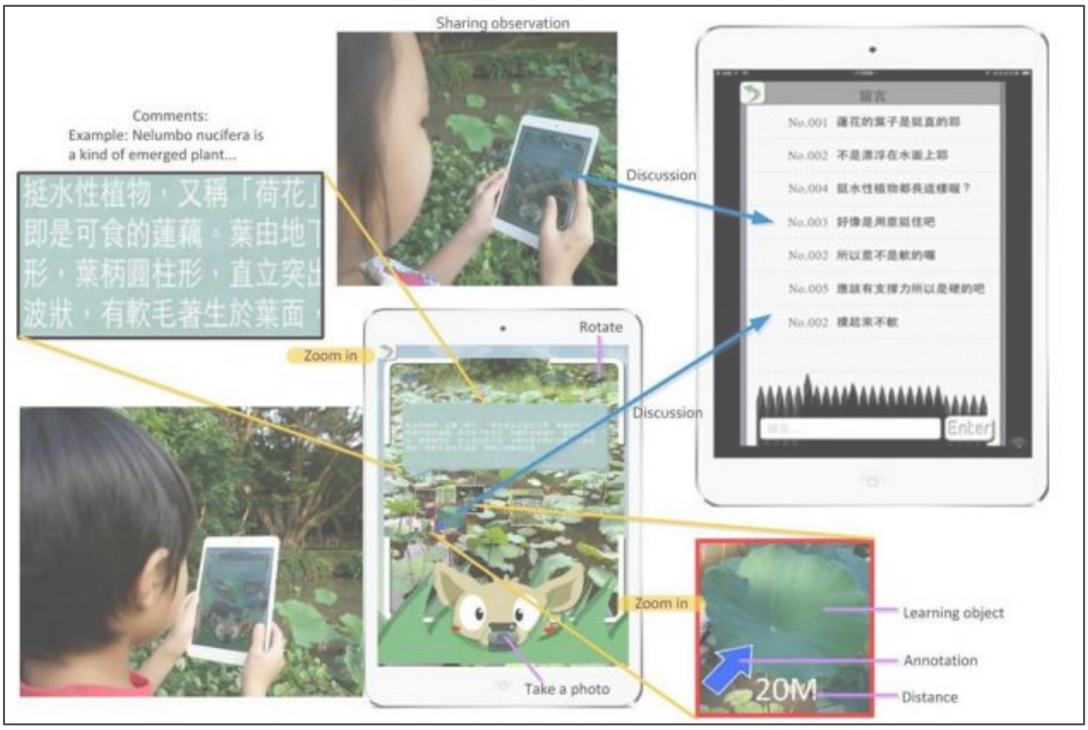

Figure 2.7.3.1. The Basic Function of the Mobile AR Learning Tool

An experimental method was used to measure the effectiveness of this mobile learning tool involving 57 fourth grade students, with their age ranging between 9 and 10 years. These students were recruited from two classes, with one class being the experimental group, and the other being the control group. For both groups, the same instructor was responsible to facilitate the learning activities. The learning activities began by introducing aquatic plants to the students by the instructor for 90 minutes. Then, they sat for a 30-minute pre-test to establish whether both groups of students had an equivalent basic prior knowledge of the natural science course content. A basic training session followed to help them practice to operate the mobile learning devices. The experimental group and the control group learned with the mobile AR learning approach and conventional inquiry-based mobile learning approach, respectively, for 120 minutes. For the latter, students explored the aquatic pond, scanned and captured learning objects (e.g., water hyacinths), annotated captured images, shared these images, and discussed with their peers interactively using their iPads.

Analysis of the empirical data revealed that students that used the mobile AR learning tool outperformed their counterparts that used the conventional inquiry-based learning method. Likewise, the former students expressed higher learning motivation than the latter students. Furthermore, the cognitive load test performed in both groups showed there was no significant difference between them, suggesting that both groups learned with the same level of cognitive load in terms of mental load and mental effort. Interestingly, the experimental group's mental mean score of mental effort was slightly lower than the control group, indicating that mobile AR learning tool helped them linked the real-world contexts with supplementary materials at the right place

and the right time (Chiang, Yang, & Hwang, 2014). Overall, the findings of this case study are promising in that the use of mobile AR learning tool in an inquiry-based learning activities can be effective, motivated, and to a certain extent, less effortful as compared to the conventional inquiry-based learning approach.

2.8 Commentary of the Case Studies

The three case studies that are presented in the previous sections clearly highlight the positive findings of mobile AR technology on students' learning performance and motivation. Arguably, each case study has its own merits, and downsides, depending on an array of interrelated factors, notably learning context, methodological approach used, and implementation strategy. Hence, such findings have to be considered with extreme caution as they were based on case studies, the results of which may not replicate in other learning contexts. For example, the first and second case studies involved college and university undergraduates. In contrast, the third case study involved a group of elementary students. Typically, university students have more experience and skills in using new technologies, including AR technology, making them more adaptable to learning in unfamiliar learning settings for the first time. Arguably, such settings would not excessively overwhelm or intimidate the students, as demonstrated by the findings of the first two case studies. The same positive findings may not realize in different learning contexts involving younger students, who may lack computing experience and skills.

Furthermore, the assessments of learning performance and motivation of the first and second cases were purely based on student feedback based on surveys, the results of which can be subjective. It could be argued that the positive opinions pertaining to the usefulness of the novel learning tools were influenced by their obsession with the technology itself and not by their perspective of the educational values of the applications (Spiegel & Rodríguez, 2016). Unlike the first two case studies, the method of assessment of learning achievement and motivation of the third case study was more reliable. In fact, for the third case study, students' understanding of the learning contents was measured by means of well-designed multiple-choice questions. Effectively, such findings are more objective than the other two findings.

From the methodological standpoint, the third case study differed from the first two case studies as the former used pretest posttest research design; whereas, the latter case studies used only posttest research design. More importantly, the third case study was based on an inquiry-based approach. Clearly, the methodological approach of the third case study was more systematic and sound, yielding convincing and reliable findings. In addition, the third case study used both experimental and control groups; in contrast, the first two case studies only used experimental groups without any control groups. Thus, the findings of the former case study may have greater practical significance for the practitioners, such as teachers, lecturers, or instructors. Apparently, the first two case studies were explorative, and the third case study was confirmative in nature. Nevertheless, the findings of the first and second case studies do provide important lessons in discovering potential impacts of such novel learning tools.

The main purposes of the deployment of the mobile AR learning tools were also different. For instance, the learning tool for the first case study was to assist students interact with the learning objects interactively and to examine delicate anatomy structures more easily. Hence, the learning tool serves as an interaction and visualization tool. For the second case study, the learning tool used was to help students visualize the plots of quadratic equations as certain parameters were changed. Effectively, this learning tool serves as a visualization tool. For the third case study, the novel learning tool was primarily used to help students capture, annotate, and share relevant images of the learning objects. Effectively, this learning tool served as a collaborative tool.

From the theoretical perspective, the development of the learning tool for the last case study was based on a strong theoretical framework, specifically focussing on learning by inquiry. However, such framework seemed absent in the first two case studies based on their reports. It could be that relevant frameworks might exist, but they were not reported. In light of this revelation, the mobile AR learning tool for the last case study is deemed more reliable sound, having been designed and developed on powerful theoretical footing. With such foundation, the learning tool would become a formidable aid to assist the learning process more efficaciously.

As demonstrated, each case study is unique in its own right. Each has its strengths and weaknesses, with each serving different purpose. The positive impacts of such novel, innovative learning tools depend on a myriad of interrelated factors. The onus is on the developers to harmonize all the delicate factors to help create learning tools that both effective and motivational. More importantly, the development of such learning tools needs to be based on a sound theoretical framework, the failure of which can be detrimental to the learning process. Overall, the lessons learned from the case studies can help guide other researchers to develop and implement future mobile AR learning applications, systems, or tools more systematically.

2.9 The Educational Benefits of Mobile Augmented Reality

Recent studies on the use of mobile AR learning tools, applications, or systems in the learning domain have provided promising evidence, reinforcing the contention that new technology can be applied to help create learning settings that are not only efficacious but also motivational. And, of course, the usefulness of such technology-based learning tools depends on the learning context (i.e., the learning topic, students' background, level of technology), implementation strategy, and method of assessment, among other things. Without doubt, the use of mobile AR technology in learning and training is gaining greater traction as new knowledge emerges in the literature to inform the educational benefits of this novel technology. The following are the potential benefits of the mobile AR technology-enhanced learning tools.

First, students will not only see learning objects, but they will be able to “touch" these objects through interaction using their input devices, such as the PC mouse. This kind of interaction engenders a sense of control that heightens the learning experience when compared to just looking at the learning contents or materials (Barraza Castillo *et al*., 2015; Jamali *et al.*, 2015). Put simply, learning or training activities can become highly interactive, not boringly passive (Donahue, 2016; Wei *et al*., 2015; Martín-Gutiérrez *et al*., 2015). Thus, AR promotes “active” teaching, maximizing the opportunity for interaction and encouraging critical response and the adoption of new perspectives and positions. This type of student-centered learning is in contrast with the teacher-centered traditional didactic methods.

In the former approach, students become active participants in the learning process, rather than passive recipients in the latter approach (Jamali *et al*., 2015).

Second, students will become more enthusiastic as they interact with the core learning objects while referencing auxiliary materials through visual triggers (Chiang *et al*., 2014). For example, augmented visual 3D models that overlay a physical image or artefact can be invoked using touch gestures that allow students to confront the materiality of objects more compellingly. In such a learning setting, they become immersed in both virtual and real worlds (Chen *et al*., 2016). The juxtaposition of the physical materials and virtual contents can spur their interest to partake in the learning process. This enthusiastic engagement of students in the learning process is not surprising given the richness and diversity of information that is relevant to their learning.

Third, students can now remember and retain a greater amount of the information presented to them. In contrast, the conventional learning method can only help them retain a very small amount of the information that is delivered, and thus they can only recall a small percentage of what is shown to them. Moreover, well-crafted supplemental materials (which typically consist of multimedia elements such as sound narration, video demonstrations, animations or images) overlying the physical learning objects in the AR learning setting can help further improve learning as students are presented with more than one stimulus, which is mostly visual in nature, but other stimuli are also presented such as hearing and touching. According to Mayer (2009), this type of learning – aptly called multimedia learning (Park *et al*., 2016; Chiu & Churchill, 2015) – can help optimize student learning as it taps on both the verbal and visual processors of the human's brain, meaningfully making sense of what is being learned (Song *et al*., 2016; Stahl, 2016).

Forth, concepts or ideas can be better presented, thus enhancing the learning environment in which students can have access to in situ learning contents. Previously, physical models used to explain such concepts were cumbersome (which was due to their varying scales and sizes – either being too small or too big) and high cost of ownership. Invariably, these physical models were only used by teachers, not by students, for instructional purpose. Fortunately, this learning constraint can be virtually eliminated with the use of AR as students use digital models of abstract concepts to help gain a better perspective of abstract concepts (Barraza Castillo *et al*., 2015).

Fifth, AR can help create a collaborative learning environment to support student learning through the involvement of their peers and teachers. Effectively, this technology can harness both asynchronous and synchronous communications to foster such learning collaboration. For example, the former can be achieved through a web-based email; whereas the latter can be realized by utilizing any available online discussion tools. In unison, these communication modes can efficiently help students partake in group assignments or projects online, anywhere, anytime – transcending time and place. In such learning setting, they become more committed and accountable as each of the students become socially aware of their important position in relations to their peers and instructor (Chiang *et al*., 2014).

The use of an AR learning application, in general, does not impose a steep learning curve, as most students will have the basic computing skills (i.e., the ability to use interaction and navigation tools effectively) that help them familiarise with the new learning setting. Students will quickly make a quick transition in learning the AR learning applications from other computer-based learning applications or tools. With such a smooth transition, they can immediately focus on the learning process, and not being bogged down by the technicality of the novel application. Thus, unnecessary delay is avoided, which otherwise can consume students' time and effort to the point of making them frustrated and demotivated (Jamali *et al*., 2015).

2.10 Mapping Mobile Augmented Reality Capabilities with Constructivist Learning Principles

As highlighted in the preceding sections the application of mobile AR learning tools would be able to exert a positive impact on students' learning performance and motivation in learning in a variety of disciplines, such as anatomy, mathematics and natural science (see Sections 2.7.1, 2.7.2, and 2.7.3). Such an immense impact of the mobile AR learning tools of learning must be the direct result of learning activities that had assisted students learn effectively and keenly to achieve the desired learning goals. Arguably, the learning activities such as a novel learning tool to prepare students mentally, to stimulate students' thinking, and to guide and support students' cognitive processes are in line with some underlying principles of learning. With such principles, such learning tools, when used appropriately, would generate learning settings in which students could engage in meaningful learning experiences. Clearly, the realization of engaging learning experiences owes to the unique features or characteristics of the technology itself, enabling them to learn effectively and motivationally. More importantly, the pedagogical values of these features of mobile AR learning tools need to be examined closely under the lenses of contemporary learning standpoints, notably the constructivist perspective.

In the literature, there is a plethora of learning principles, models, or paradigms; however, they can be broadly classified into three primary learning theories, namely as behaviourism, cognitivism, and constructivism (Forrester & Jantzie, 1998). Essentially, behaviourism is deeply rooted in the "stimulus-response-reinforcement-repetition" precept. On the other hand, cognitivism deals with the "act and process of knowing". In contrast, constructivism focuses on "knowledge creation". Among these three learning theories, constructivism dominates the current educational literature given its wide appeal in terms of a learning process that is learner-centered and socially negotiable (Andrews, 2012) – a paradigm that suits today's societies, in which people are constantly engaged in communication using mobile devices.

The main principle of constructivism is that "… learning is constructed and, that learners build new knowledge upon the foundation of previous learning" (Hoover, 1996). Hence, constructivism radically contrasts with previous learning theories, especially behaviourism, the latter in which learning involves one individual transmitting information to another individual passively – a view which reception, in contrast to construction, is the main process. Two precepts precipitate from the notion of knowledge construction.

First, learners conception new apprehensions established on what they already know. In essence, learners engage learning situations with knowledge gained from previous experience, and that prior knowledge determines what new or altered knowledge they will construct from new learning experiences. Second, learning is not passive, but rather it is active. Learners come to terms with their understanding in view of what they encounter in the new learning situation. If what learners encounter is discrepant with their current understanding, their discernment is capable of the multifariousness to accommodate new perspicacity. Throughout this process of accommodation, learners are constructing and reconstructing knowledge actively (Hoover, 1996).

The literature is replete with a number of strands of constructivism, but they can be generally categorised into three main types of constructivism, namely cognitive constructivism, radical constructivism and social constructivism (Doolittle, 1999). The main tenet of cognitive constructivism is that "that knowledge acquisition is an adaptive process and results from active cognizing by the individual learner". In contrast, radical constructivism is based on the notion that "knowledge acquisition is an adaptive process that results from active cognizing of the individual learner, rendering an experiential based mind, not a mind that reflects some external reality" (Doolittle, 1999). Apparently, social constructivism shares the above two views, but it emphasizes the social nature of knowledge, and the belief that knowledge is the result of social interaction and language usage, and thus is a shared, rather than an individual, experience (Doolittle, 1999).

The amalgamation of three constructivist perspectives develops to the following principles that represent the constructivist learning characteristics. More importantly, bringing forth the constructivist learning experience of learners based on these principles entails harnessing the capabilities of mobile AR technology as deemed appropriate for the learning of a particular subject (see Table 2.10.1).

Table 2.10.1

The Mapping of Constructivist Learning Principles with the Capabilities of Mobile AR Technology

Constructivist learning principles	Descriptions	Capabilities of mobile AR
a) Learning should take place in authentic and real-world environments.	Authentic experiences are important so that the individual may construct mental structures that are viable in meaningful situations. Experience provides the activity upon which the mind operates. For the cognitive constructivist, authentic experiences are essential so that the individual can construct an accurate representation of the "real" world, not a contrived world.	Actual, real world (as seen through the camera lenses) is augmented with relevant virtual objects that can be programmed to respond to the learner's actions. There is no need to create additional 3D models to represent the real world environments, thus preserving their important aspects. For example, pointing a mobile phone camera to a certain historical site will play an audio narration explaining a brief history of such an important place.
b) Learning should involve social negotiation and mediation.	Social interaction provides for the development of socially relevant skills and knowledge, as well as providing a mechanism for perturbations that may require individual adaptation. In addition, as an individual gains experience in a social situation, this experience may verify an individual's knowledge structure or it may contradict those structures. If there is a contradiction or confusion, then the individual must accommodate this contradiction in order to maintain either an accurate model of reality or a coherent personal or social model of reality (Spivey, 1997).	The use of both asynchronous (e.g., email or threaded discussions) and synchronous (e.g., chatting or video teleconferencing) can be performed on the mobile phone. Furthermore, social network sites (SNSs), such as Facebook, can be integrated into the mobile AR learning tool to facilitate collaborative works. For example, the teacher can create his or her Facebook page in which students can use as a collaborative platform to discuss issues pertaining to their group project. With this discussion platform, learners can communicate more openly and confidently to articulate a certain problem, thus arriving to a solution consensually agreed by all group members (Toland, 2013).

(*continued*)

Table 2.10.1 (*continued*)

Constructivist learning principles	Descriptions	Capabilities of mobile AR
c) Content and skills should be made relevant to the learner	Knowledge serves an adaptive function, thus the knowledge attained (i.e., content and skills) must be relevant to the individual's current situation, understanding, and goal. This relevancy is likely to lead to an increase in motivation (Pintrich & Schunk, 1996), as the individual comes to understand the need for certain knowledge. Ultimately, experience with relevant tasks will provide the individual with the mental processes, social information, and personal experiences necessary for enhanced functioning within one's practical environment.	The Mobile AR learning tool is capable of delivering vast amounts of diverse information, knowledge, and skills available to the learner. Besides textual information, appropriate graphics, animations, audio narration, and video demonstration can be presented to learners during the learning activities. The augmentation of carefully crafted multimedia learning contents in the real world learning setting can help learners achieve improved cognitive skills, culminating in better understanding (Liu, 2003). For example, a video demonstration of an assembly of computer components can help learners learn the proper configuration of a working computer. Alternatively, learners can change certain parameters (e.g., temperature) of a greenhouse model to observe adverse potential impacts on ice in the Artic.

(*continued*)

Table 2.10.1 (*continued*)

Constructivist learning principles	Descriptions	Capabilities of mobile AR
d) Content and skills should be understood within the framework of the learner's prior knowledge	Learning begins within an individual's prior knowledge. Understanding a student's behaviour requires an understanding of the student's mental structures, that is, an understanding of the student's understanding. Only by attempting to understand a student's prior knowledge will the teacher be able to create effective experiences, resulting in maximal learning.	Attempting to examine learners' prior knowledge entails a transaction between learners and the mobile AR learning environment. Their prior knowledge can be probed at the beginning of instruction in either synchronous communication or asynchronous communication. Based on their feedback, the teacher may adjust the learning activities accordingly. For example, initial communication threads of a group project Facebook page between learners and the teacher can reveal the former's current understanding of the learning issues being discussed.
e) Learners should be assessed formatively, serving to inform future learning experiences.	The acquisition of knowledge and understanding is an ongoing process that is influenced by a student's prior knowledge. Thus, to take into account an individual's current level of understanding in this ongoing teaching and learning process, a teacher must continually assess the individual's knowledge.	Assessing learners' learning progress requires constant examination on their work throughout the learning process. In mobile AR learning setting, there are a number of ways to formatively assess their work. For example, learners can take a series of snapshots (using screenshot software installed on their mobile phone) of the work or project and post these images to their teacher through image hosting web sites (e.g., Flickr) or instant messaging applications (e.g., WhatsApp). Likewise, these images can also be made available to their teacher using the appropriate links on their group project Facebook page.

(*continued*)

Table 2.10.1 (*continued*)

Constructivist learning principles	Descriptions	Capabilities of mobile AR
f) Learners should be encouraged to become self-regulatory, self-mediated, or self-aware.	Learners are active in their construction of knowledge and meaning that involves mental manipulation and self-organization of experience, and requires that students regulate their own cognitive functions, mediate new meanings from existing knowledge, and form an awareness of current knowledge structures.	Making learners self-regulatory or self-mediated requires learners to be more involved and more persistent relative to the educational environment. Such self-regulation or self-mediation can be attained when learners become confident, motivated, and persist in their learning activities (Lynch & Dembo, 2004). For these attributes to manifest, the learning environment in which they are engaged in must be supportive. Appropriate technological features of learning tools can be exploited to help learners become self-regulatory. For example, in the mobile AR learning setting, learners can use the interactive tool to interact with a learning object, and then observe the response of such object, and finally monitor their actions appropriately.
g) Instructors should provide for and encourage multiple perspectives and representations of content	Experiencing multiple perspectives of a particular event provides learners with the raw materials necessary to develop multiple representations. These multiple representations provide students with various routes from which to retrieve knowledge and the ability to develop more complex schemas relevant to the experience.	Multiple perspectives on a certain event can be achieved by providing learners with a diverse range of learning materials or contents in various contexts (Kurnaz & Sağlam Arslan, 2014). For example, in learning human anatomy, interactive 3D object of such biological structure can be developed to enable learners examine it from various orientations, thus giving them a holistic view of such matter.

(*continued*)

Table 2.10.1 (*continued*)

Constructivist learning principles	Descriptions	Capabilities of mobile AR
		Coupled with relevant multimedia information (e.g., audio narration and highlighted textual cues), learners can experience meaningful learning resulting from the appropriate cognitive configuration and mapping of relevant information (Schnotz & Bannert, 2003).

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2.11 Summary

Through this chapter, the learning of ICT Competency course was elaborated and clearly highlighted two main problems confronting students, namely poor learning performance and motivation. In fact, such problems were due to a lack of practice and collaboration. More importantly, for establishing learning and motivation theories, notably constructivism and self-determination theory were discussed to help highlight the underlying principles that can assist to enhance student learning. Emerging technologies, particularly mobile augmented reality (MAR) technology, were reviewed to identify their inherently unique characteristics that can be exploited for learning purposes. In particular, the mapping of the characteristics of MAR technology with the constructivist learning principles was discussed in detail, which could help develop a development framework for novel learning applications.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this chapter is to discuss the research methodology used in the present study in addressing the research objectives (see Section 1.4, Chapter 1). The discussion of this chapter first focuses on the conceptual framework of the study that highlights the variables of interest and their presumed causal relations. The discussion then centres on the research design used in this study, namely the experimental design, by detailing the sample of the experimental study, randomization of the participants, procedure of the experimental treatment, instructional tasks and materials, and research instruments. Finally, the discussion of this chapter delves into the statistical procedures in testing the research hypotheses of the study.

3.2 Research Methodology

Principally, the research methods are not plainly a tool, but methods to facilitate researchers in envisioning and canvassing the connection between different viewpoints on the nature of social reality (Bryman & Bell, 2007). Succinctly, Oliver (2004) states that "the term methodology is used in a general sense to refer to both theoretical and practical aspects of the conduct of the research". More specifically, the utilization of research methods facilitates the process of collection and analysis of data (Hart, 1998). Furthermore, the selection of a research method and an approach to conduct research is an important issue that needs to be deliberated wisely by all researchers, as it will greatly affect the outcomes of research studies (Sekaran, 2003). Moreover, the appropriate research method is also significant to convincingly support a more valid conclusion and inferences that can be drawn from the research findings (Ryan *et al.*, 2002).

Thus, the appropriate research methodology adopted by researchers can help guide them to achieve the research objectives, to validate the research findings, and to enhance the reliability of the findings. However, before selecting the appropriate research methods, researchers need to familiarize with the background of their research and to have sufficient knowledge in the specific area of research to establish a strong foundation. In other words, researchers should examine and understand the relevant philosophical concepts or worldviews, which shape their reasoning.

In empirical studies, there are a number of experimental research designs that can be used by the researcher to examine a certain phenomenon of interest. Generally, the experimental research designs can be divided into three main categories, namely pre-experimental design, true experimental design, and quasi-experimental. Naturally, the selection of any one of these designs depends on the level by which the researcher can control the sources of all internal validity. Among the three, the true experimental design should be aimed for as “[it] represents no compromise between experimental design requirements and the nature and reality of the situations in which studies are undertaken” (Tuckman & Harper, 2012, p. 152).

For this category of research design, the pretest posttest control group design is highly recommended, which typically involves a control group and an experimental group (Ary *et al.*, 2006; Gay *et al.*, 2006). However, the true experimental design is not always feasible due to practical and logistical constraints faced by most researchers. It is, therefore, quite common for researchers to use the quasi-experimental design in their study.

3.2.1 Quasi-Experimental Research

In this study, the quasi-experimental research method was used to help the researcher address the research objectives and research questions. Specifically, this method was carried out using the pre-test, post-test control group design to help the researcher to carry out an empirical study to help examine the main effects of learning method and gender on students' learning performance and motivation. Two groups were formed, namely an experimental group and a control group, that were subjected to two different learning treatments.

The experimental group learned a particular topic of the subject matter collaboratively using CoMARLA on mobile phones, whereas the control group, used similar application on a desktop computer. Both groups were first tested for their learning performance and motivation before the intervention, then they were exposed to two different learning methods, and finally they were tested for the same measures after intervention using the same research instruments. As such, learning method was the manipulated independent variable, and learning performance and motivation were the dependent variables. The moderator variable of this study was the gender factor (comprising two levels: female and male). Table 3.2.1 highlights the The pretest posttest control group design of the study.

Table 3.2.1

The Pretest Posttest Control Group Design of the Study

Group	Pre Test	Treatment	Post Test
Experimental Group	√	Learning using CoMARLA on mobile phone	√
Control Group	√	Learning using similar application on desktop computer	√

3.2.2 Internal and External Threats

The quasi-experiment, also known as ‘field-experiment’ or ‘in-situ experiment’, is a type of experimental design in which the researcher has limited leverage and control over the selection of study participants. Specifically, in quasi-experiments, the researcher does not have the ability to randomly assign the participants and ensure that the sample selected is as homogeneous as desirable (Levy & Ellis, 2011). Accordingly, the ability to fully control all the study variables and to the implication of the treatment on the study group(s) may be limited. Nonetheless, quasi-experiments still provide fruitful information for the advancement of research (Leedy & Ormrod, p. 155, 2010).

In pursuing experimental studies, researchers are faced with a dilemma, in that they have to address two types of validity, namely the internal validity and external validity. Internal validity refers specifically to whether an experimental treatment makes a difference to the outcome or not, and whether there is sufficient evidence to substantiate the claim. On the other hand, external validity refers to the generalizability of the treatment outcomes across various settings. Factors that may endanger the internal and external validity are as follows:

a) *History*: the specific events which occur between the first and second measurement. b) *Maturation*: the processes within subjects which act as a function of the passage of time.

c) *Testing*: the effects of taking a test on the outcomes of taking a second test. In other words, the pretest becomes a form of "treatment."

d) *Instrumentation*: the changes in the instrument, observers, or scorers which may produce changes in outcomes.

e) *Selection*: the biases which may result in selection of comparison groups.

f) *Experimental mortality*: the loss of subjects. Those who stayed in an experiment to its completion may be more motivated to learn and thus achieved higher performance.

g) *Reactive or interaction effect of testing*: a pretest might increase or decrease a subject's sensitivity or responsiveness to the experimental variable.

h) *Reactive effects:* of an experimental arrangement may occur when an experiment or a study is conducted using unnatural conditions.

The followings are eight steps or procedures taken by the researcher to control or to minimize such threats in this research. The learning treatments were conducted on the same day, place, and time, which essentially might expose both control and experimental groups to similar events, if any. In such a case, this procedure helped eliminate or minimize history factor. Moreover, the duration between pre-testing and post-testing was only three weeks, thus eliminating any possibilities of students developing any kinds of cognitive or affective developments, in addition to the intended aims of the study. In addition, all the participants were of similar age, with a mean age of 19.5 years. Together, they eliminated the effect of maturation factor. Given that both groups received the same pre-test and post-test measurements, the effect of instrumentation factor was minimized or eliminated in this experimental study.

Furthermore, the effect of selection of subjects was avoided as the convenience sample of 120 students divided into two equivalent groups using stratified random sampling procedure. In other words, these students were not divided based on self-selection. Fortunately, all the participants managed to remain throughout the entire duration of learning treatments. As such, the effect of experimental mortality did not materialize in this study. In addition, this study employed the Analysis of Covariance (ANCOVA) procedure, which might reduce the potential threat of reactive or interaction effect of testing. Finally, the experimental setting of this study mirrored the same learning setting of the general population, which effectively assisted understate the effect of reactive effects.

3.3 Sampling

Sampling is the process of selecting units such as people, organizations, or students from a population of interest so that by studying the sample the researcher may fairly generalize their results back to the population from which they were chosen (Taylor, 2005). There are many methods of sampling to choose from when carrying out a research study, such as simple random sampling, convenience sampling, stratified sampling (random within target groups), systematic sampling (every n^{th} person), and cluster sampling (all in limited groups). Among these methods, simple random sampling is the ideal, but researchers seldom have the luxury of time or money to access the whole population, so many compromises often have to be made (Walliman, 2010). For this

study, the convenient and stratified sampling methods were used, given the prevailing constraints faced by the researcher.

3.3.1 Convenience Sampling

Convenience sampling (also known as availability sampling) is a specific type of non-probability sampling method that relies on data collection from population members who are conveniently available to participate in a study. In other words, this sampling a type of sampling, where the first available primary data source will be used for a study without additional requirements (Given, 2008). This sampling technique has both advantages and disadvantages. Its advantages incorporate the simplicity of sampling and the ease of research, implementation that is cost- and time-efficient than alternative sampling methods, and shorter duration of data collection. Its disadvantages include high sampling error, high vulnerability of selection bias, and compromised reliability.

As such, the use of the convenience sampling technique is discouraged by many researchers due to the above disadvantageous (Hatch & Lazaraton, 1991). Nevertheless, convenience sampling may be the only option available in certain cases for researchers. In this study, the researcher expended the convenience sampling method to recruit undergraduates from four existing intact classes, to which he was assigned to teach. Overall, 120 undergraduates were recruited for this study. To recruit undergraduates from

other classes was beyond the means of the researcher, as other instructors would be reluctant to forego their classes for many days or weeks.

3.3.2 Stratified Random Sampling

Stratified random sampling is a probability sampling method and a form of random sampling in which the population is divided into two or more groups or *strata*, according to one or more attributes. Stratified random sampling intends to guarantee that the sample represents specific sub-groups or strata. Accordingly, the application of stratified sampling method involves dividing the population into different sub-groups or strata in a proportionate manner.

In this study, stratified random sampling was used to assign 120 participants, consisting of 75 female students and 45 male students, into an experimental group and a control group, with equal proportion of both genders. The technique used to achieve an equal proportion of both genders for both groups involved first separating them into two sub-group, namely a female sub-group and a male sub-group, as shown in Figure 3.3.2.1. Then, each student from male sub-group and female sub-group was randomly assigned to either the experimental group or the control group. Finally, female students in the experimental group were combined with male students in the experimental group to represent the total number of participants in the experimental group. Likewise, the same technique was applied to form the control group.The Figure 3.3.2.1 depicts the stratified random sampling technique implemented in this study.

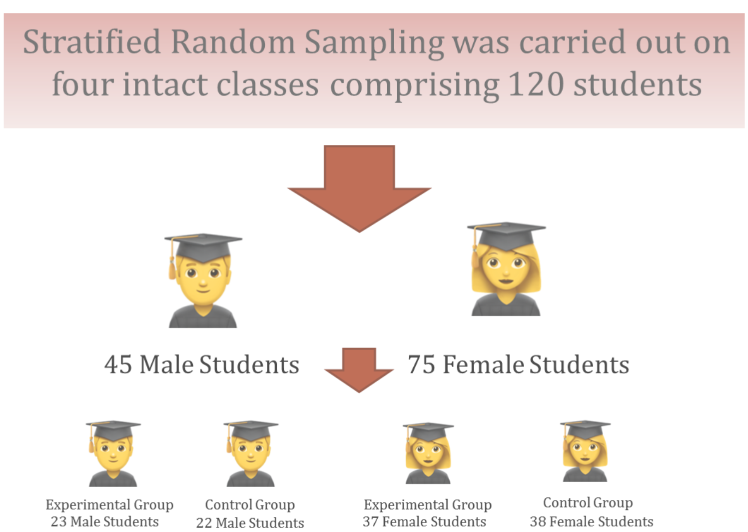

Figure 3.3.2.1 . The Stratified Random Sampling Procedure

3.4 The Research Participants

The participants of the experimental study were 120 non-technical undergraduates of Universiti Pendidikan Sultan Idris, consisting of 75 female undergraduates and 45 male undergraduates, with a mean age of 19.5. These students were first semester social science and humanities majors who had to enroll in the Competency of ICT course, peculiarly in Universiti Pendidikan Sultan Idris (UPSI) and moreover its a required university course for all non-technical and non-ICT students in all public universities in Malaysia. The selection of the study sample was based on four intact classes that the researcher was assigned with to teach, as recruiting other classes involving other lecturers were not feasible in light of the vast differences in lecture timetables. Thus, the researcher adopted a quasi-experimental research study by randomizing the students of the intact classes into a control group and an experimental group. Compared to the pre-experimental design, the quasi-experimental design provides relatively better control of the threats to validity (Tuckman & Harper, 2012, p. 158).

3.5 The Sampling of the Participants

For the present study, the sampling method employed was *stratified random sampling* rather than simple random sampling or systematic sampling. The choice of this sampling method was to take into account the different characteristics of the student population, namely gender and academic achievement (Conley, 2012). In other words, these characteristics are the population strata, which are the subgroups that the researcher has identified in advance before conducting the research. In essence, this sampling method involves first dividing the population into homogeneous subgroups and then selecting subjects from each subgroup, using simple random or systematic procedures, rather than the population as a whole (McMillan, p. 88, 1996). Furthermore, this method is more efficacious than depicting a simple random sample because it assures appurtenant representation of elements across strata.

There are two reasons why stratified sampling is preferred by many researchers. First, as long as the subgroups are identified by a variable (e.g., gender or academic achievement) related to the dependent variable in research that result in more homogeneous groups, the sample will be more representative of the population than if taken from the population as a whole. Second, the stratified sampling is used to ensure that an adequate number of subjects are selected from different subgroups. For instance, if a researcher is studying students' motivation in learning science or engineering and believes that there may be important differences between boys and girls, using simple random or systematic sampling would probably not result in a sufficient number of males (or females) to examine the differences.

In such a scenario, it would be significant for the researcher to stratify the population of students into male and female students and then to select subjects from each subgroup. For this study involving two moderator variables (i.e., two strata), the study sample was first divided into two different groups based on gender, and then followed by dividing each group into two more groups based on academic achievement. Once the groups had been stratified by academic achievement, random samples were selected from each of the four subgroups as depicted in Figure 3.5.1. Such stratified sampling resulted in an experimental group consisting of 37 female and 23 male participants, and 37 female and 23 male participants, respectively. Table 3.5.1 summarizes the number of participants in each group based on the participants' gender.

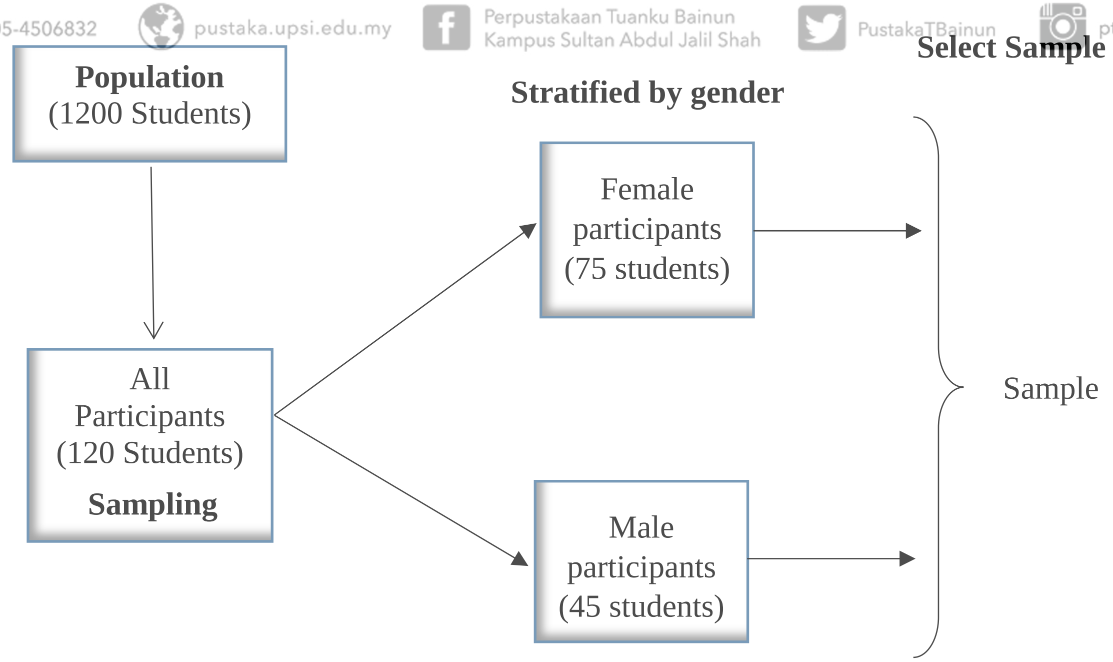

Figure 3.5.1. Stratified Random Sampling Based on Gender

Table 3.5.1

The Number of Participants in the Experimental and Control Groups Based on Gender

Gender	Group	
	Experimental	Control
Female (*n*)	37	37
Male (*n*)	23	23
Total (*N*)	60	60

3.6 Instructional Tasks and Materials

In this study, the participants in both the experimental and control groups experienced the same instructional materials; the only difference being the conditions under which they were used. The tasks and materials represented neither the dependent nor the independent variables; rather than being the treatments themselves. Each participant was given a handout containing all the information pertaining to the study, namely a learning plan detailing the objectives of the group assignment, the allocated time to complete their assignment, the procedure in performing their work, and the method of assessing their understanding. Supporting learning materials required for the assignment were provided for all students, albeit in different forms, depending on the type of treatments that they received. All the learning materials were related to Computer System, which is one of the units of ICT Competency course.

In this unit of learning, the participants had to learn the basic components of a computer hardware, the function of each of the components, the assembly of these components into a working system, and the various configurations of the components. For the control group, these materials were in printed form; whereas in the experimental group, the same materials were made available in digital form (e.g., graphics, audio narration, and video) that could be accessed using a server in which all the learning materials were kept (please refer to Chapter 4.4). For the latter group, the mobile Augmented Reality (AR) learning application CoMARLA was installed on each participant's mobile hand phone on the first learning session. In addition, a few participants who did not own such mobile devices were provided with several mobile hand phones to be used throughout the learning sessions. Each smart phone (either android or iOS) was assured to ensure the touch screen, speaker, and camera, among others, were in immaculate condition so establish a smooth learning sessions free from any interruptions, which otherwise would confound the research findings. For the control group, similar learning application and materials were provided to the participants, except that they were running on personal computers.

3.7 Research Instruments

Three research instruments were utilized in this study to measure the dependent variables (i.e., learning performance and motivation in learning) and user acceptance of using the learning application. These instruments were Computer System Unit Test Items, Intrinsic

Motivation Inventory, and unified theory of acceptance and use of technology (UTAUT) inventory. The details for each research instrument is discussed in the following subsections:

3.7.1 Research Instrument for Learning Performance

The first research instrument consists of 30 multiple-choice questions, which were selected from a pool of past semester examination papers dealing with the *Computer System Unit*. The selected multiple-choice questions measured the participants' understanding of the computer system architecture and its functions, the basic hardware components and their functions, and the configuration of these components in a computer system (see Appendix I).

In fact, all the examination questions had been checked and validated by the examination test papers committee, typically consisting of university lecturers who are expert and experienced in teaching Information and Communication Technology (ICT) and Computer Science to both undergraduates and postgraduates. As such, these questions had been rigorously and carefully vetted to ascertain their quality and integrity. Effectively, the expert judgments of the lecturers helped establish both the reliability and validity of the instrument used to measure the participants' learning performance.

3.7.2 Research Instrument for Motivation

The second research instrument, which is the *Intrinsic Motivation Inventory*, was based on the work carried out by a group of researchers in Malaysia (Leng, Wan Ali, Baki, & Mahmud, 2010) to verify and validate a Malay version that was translated from the original English version developed by Edward Deci and Richard Ryan from the University of Rochester, US.

Essentially, this research instrument consists of 29 items that can be used to assess participants' interest and enjoyment, perceived competence, effort and importance, pressure and tension, value and usefulness, and perceived choice while performing a given activity. Each item contains a statement entailing a participant to rate using a scale of "1" to "7", with "1" being "not true at all" and "7" being "very true." (see Appendix 2). The Cronbach Alpha reliability coefficient of the intrinsic motivation instrument was computed to be .84, which is above the recommended threshold value of .70, thus making it a highly reliable research instrument to measure the motivation construct.

3.7.3 Research Instrument for User Acceptance

The third research instrument is based on the unified theory of acceptance and use on technology of UTAUT model (Venkatesh *et al.*, 2003), comprising 21 items. The objective of this model explain technology acceptance based on six technology acceptance theories or models. It consists of several important constructs, namely as effort expectancy, performance expectancy, social influence, facilitating conditions, behavioural intentions and use behaviour. Answering this inventory entailed the participants to rate each statement of the item based on 5-point Likert type scales, ranging from “1” (Strongly disagree) to “5” (Strongly agree) (see Appendix II).

In this study, the computed reliability coefficients for effort expectancy, performance expectancy, and social influence were .9, .85, and .77, respectively. For facilitating conditions, behavioural intentions and use behaviour, the computed reliability coefficients were .71, .86 and .77. Overall, this instrument was deemed reliable given most of the reliability values were above .70, which is the acceptable level of any research instruments. Table 3.7.3.1 summarizes the Cronbach’s Alpha coefficients of the six constructs of UTAUT calculated in this study based on respondents’ responses. Furthermore, this motivation construct is to further the understanding issues that could be a surrounding acceptance of mobile augmented reality by the students of ICT Competency course and this is favored with the suggestion of Venkatesh *et al.* (2003).

Table 3.7.3.1

Cronbach's Alpha of the UTAUT Constructs

UTAUT Construct	Cronbach's Alpha
Effort Expectancy	.90
Performance Expectancy	.85
Social Influence	.77
Facilitating Conditions	.71
Behavioural Intention	.86
Use Behaviour	.77

3.8 Procedures for Pre-testing, Learning Treatment, and Post-testing

In this study, carrying out the experimental research entailed three stages that were carried in a sequence. First, the participants were pre-tested for learning performance and motivation measures using the Computer System Unit Test Items and Intrinsic Motivation Inventory, respectively. Then, the participants were divided into the control and the experimental group that were exposed to learning using CoMARLA on mobile phone and to learning using a similar application on the desktop computer, respectively. Finally, on the last learning session, they were post-tested for the same measures using the same research instruments used in the pre-testing. Such procedures followed the phases of a research based on the pre-test, post-test control group design (Ary *et al.*, 2006; Gay *et al.*, 2006). Figure 3.8.1 summarizes the flow of the experiment involving pre-testing, treatment, and post-testing.

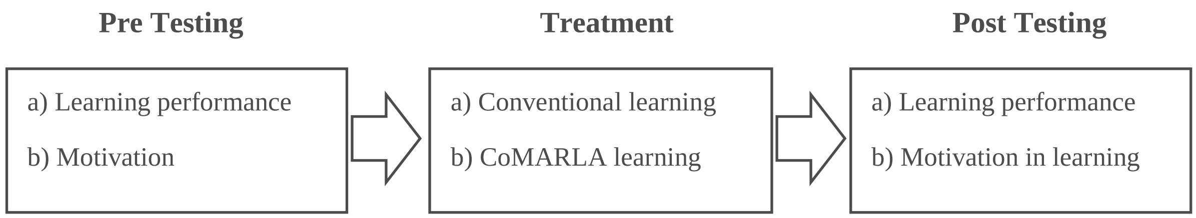

Figure 3.8.1. Pre-testing, Treatment, and Post-testing Stages

3.8.1 Pre-testing

On the first day of the experimental study, the participants in the experimental and control groups were placed in two adjacent computer laboratories. They were briefed on the aim of the measurement of the learning performance and motivation measures by the researcher. They were first given a set of multiple-choice questions pertaining to the topic on computer system, which measured their initial learning performance. The time given to answer all the questions was one hour. They were then a given 10minute recess before taking the pre-test on the motivation measure. After the break, all the participants were then given a set of questionnaire regarding motivation factor that they needed to answer in not more than 30 minutes. A research assistant was hired to help the researcher administer the pre-testing stage of the experimental study.

3.8.2 Learning Treatment

The learning treatment sessions spanned four consecutive weeks, with each learning session per week lasting for two hours. The distribution of such learning activities was in line with the recommendation by Druckman and Bjork (1991), who assert that spaced practices spread out over time will be ideal for long-term retention. To obviate external threats, both the experimental and control group performed their learning activities at the same time on the same day at the same building. In addition, the researcher and the research assistant alternated supervising the groups every 30 minutes to minimize experimenter bias.

On the first week of learning, the researcher briefed both the experimental and control groups of the main purpose of the study, which was to help them improve their understanding of the subject matter as well as to increase their motivation in such learning. They were assured that their participation was purely voluntary, and they could quit at any time if the experiment was deemed detrimental to their study. Each group was then briefed on the proper steps on how their group assignment would be conducted within the given period. For the experimental group, the participants were given enough time to familiarize with the CoMARLA application so that the ensuing learning would take place smoothly without any major point at issue. Likewise, similar protocol was also carried out for the control group that used similar application on a desktop computer.

The participants began learning collaboratively after the briefing and familiarization stage. In the learning process, both groups received similar relevant learning materials, albeit in different forms. These materials were related to learning of the *Computer System Unit* of the ICT Competency course. For the experimental group, the materials were made available by the CoMARLA application (installed on their mobile devices) by scanning the visual markers to download the information from the main server of the AR system developer, namely *Aurasma* at http://www.aurasma.com. For the control group, the same learning materials were made available using a similar application on the desktop computer.

In carrying out the assigned group assignment, the participants were tasked to work collaboratively. For the experimental group, the participants used appropriate links on the CoMARLA application to connect to social network sites (SNSs), such as Facebook and google doc. By utilizing such sites, the participants could establish an online communication platform by which they could post comments, provide feedback, and share information relevant to the learning task. In the control group, the participants learned in the same manner as that of the experimental group, but they used similar application on a desktop computer (See section 3.8.2.1). Moreover, the Table 3.8.2.1 summarizes the collaborative learning activities of the experimental treatment performed by the participants for four consecutive weeks.

Table 3.8.2.1

The Learning Activities of the Experimental Treatment

Week	Learning activity
1	• Briefing of the experimental treatment. • Pre-testing of learning performance and motivation. • Familiarization of the mobile and desktop learning applications. • Collaborative learning about the hardware components of a Computer Components and Computer Crime
2	• Collaborative learning about the functions of System Units, Computer Application , and Data types
3	• Collaborative learning of the assembly of hardware components as a functional computer system.
4	• Collaborative learning of the various configurations of a computer system and Computer Ethics (Email), and Computer Ethics (Social Media). • Post-testing of learning performance and motivation. • Survey of user acceptance measure on the experimental group.

3.8.2.1 Collaborative Protocol in Learning CoMARLA

Lately, collaborative-group work has been acknowledged as a potent, effective learning approach, which is deemed relevant to 21st century learning. Through collaborative learning approach, student learning becomes more intense, satisfying, and engaging, thus helping them to gain knowledge and acquire skills more effectively. In this study, the main objective of this type of work was to bring students together in such a way that they could learn the selected topic of ICT Competency course more efficaciously. In fact, through social negotiation, the participants would be able to enhance their understanding of the underlying principles of the subject matter and to generate new ideas of the practical applications of concepts being learned. To help realize such an effective collaborative learning, the researcher adopted the collaborative group work protocol called the *Wagon Wheel protocol*, as proposed by Moon (2004), who conceptualized such a protocol based on a one-year practice.

Essentially, this protocol helps stimulate powerful thinking between people who do not know each other and to create "a vivid image bank of a new idea in action to inform the planning process" (Dominguez *et al.*, 2005). In order to setup this protocol, each group is formed comprising four members and is seated in an arrangement consisting of four chairs placed back-to-back at the hub of a wheel and four chairs in the outer circle facing the chairs at the hub. For this study, a task based on six sub-topics were selected of which the participants were required to complete. Using the Wagon

Wheel protocol, the researcher developed five easy steps that helped guide students to learn collaboratively using CoMARLA, as depicted in Figure 3.8.2.1.1.

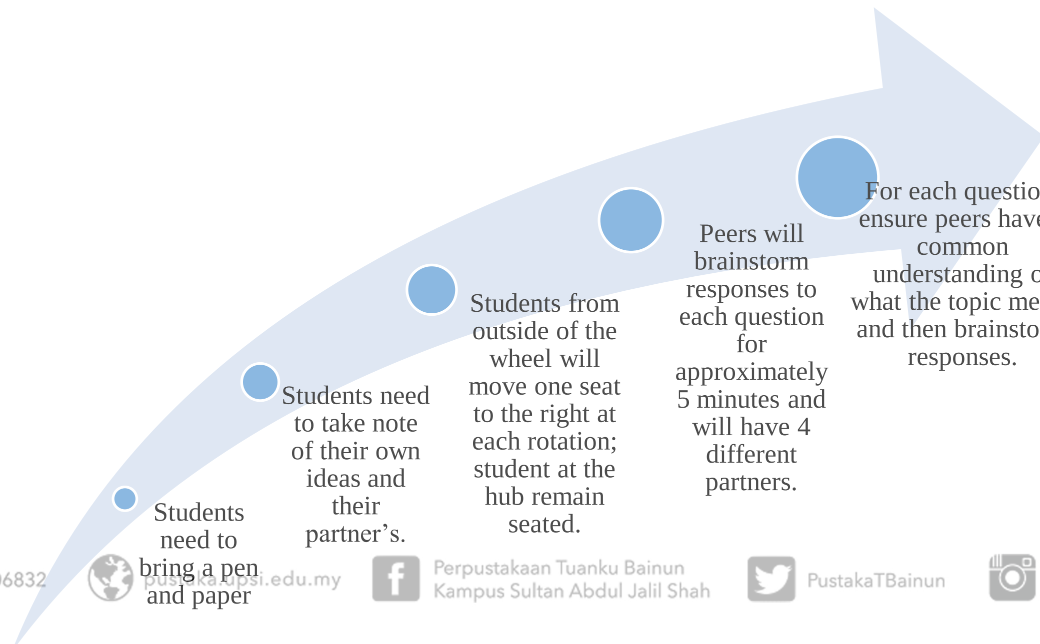

Figure 3.8.2..1.1. The Learning Protocol for Collaborative Learning using CoMARLA

Figure 3.8.2.1.1 shows the processes of collaborative work protocol for mobile learning using CoMARLA, where at the end of each rotation, each student sitting on the outside of the wheel is required to rotate one seat to the right and then to ask the next question. To generate a smooth flow of the collaborative learning process, each participant must have a common understanding of the basic concepts of the subject matter before brainstorming. As such, the selected sub-topics basic were chosen by taking into account the size of the group. In this study, the sub-topics to be discussed were *hardware components of a computer components*, *computer crime*, *functions of system units*, *computer application*, *data types*, *a computer system and computer ethics (email)*, and *computer ethics (social media).*

More importantly, each group had to demonstrate a common understanding of what had been learned at each round of the learning process. With such understanding, brainstorming at the first round helped to attain the intended outcomes of a particular sub-topic, as outlined in the instructional plan. The remaining rounds followed the same learning process. Finally, the last round of this collaborative learning process entailed each group to submit to the researcher a report of their completed task or assignment.

3.8.3 Post-Testing

Immediately upon the completion of their assignment on the fourth day of learning, post-testing of the participants' learning performance and motivation was carried out using the same research instruments (see Section 3.7 for details). The measurements of both pre-test and post-test measures helped the analysis in determining if there were any statistical significant differences in the mean test scores before and after learning, which would reflect any improvements in the participants' learning performance and motivation. In addition, the participants of the experimental group were surveyed using the unified theory of acceptance and use of technology (UTAUT) questionnaire to elicit their feedback on the perceived usefulness of the CoMARLA learning application. This measurement will be significant in determining the inclination and persistence of users to continue using such learning application in their learning activities in the future.

3.9 Data Analysis

Determining to what extent the statements in the research questions are valid by means of significant testing is a fundamental feature in any experimental research. Essentially, such research emphasizes the investigation of the differences of the measurements of factors before and after an intervention. Altogether, there are six research hypotheses that were formulated in the present study. Each hypothesis was tested that helped the researcher either to reject or not to reject it at a predetermined level of significance. In other words, the acceptance of such a hypothesis would support the claim that the learning treatments had resulted in significant outcomes. Otherwise, the opposite claim applied.

3.9.1 Paired Sample T-test Procedure

The first and second research hypotheses were tested by means of paired sample *t*-test procedure. This test is used to compare the values of means from two related samples, for example, in a “before and after” scenario (Leech *et al.*, 2005). For this research, this statistical procedure was used to determine if there was any significant difference between participants' learning motivation and motivation before and after treatment by comparing their mean percentage of learning motivation and the mean score of motivation after treatment with similar measurements before such treatment.

3.9.2 Analysis of Covariance (ANCOVA) Procedure

The remaining research hypotheses were supposed to be tested using the Multivariate Analysis of Covariance (MANCOVA) procedure. This procedure is used when there are two or more independent variables (each with a few categories or values) for a between-group analysis (Leech *et al.*, 2005). Furthermore, MANCOVA is useful in experimental situations where at least some of the independent variables are manipulated. It has several advantages over ANCOVA (Muijs, 2010).

First, by measuring several dependent variables in a single experiment, there is a better chance of discovering which factor is truly important. Second, it can protect against Type I errors that might occur if multiple ANCOVA's were conducted independently. Additionally, it can reveal differences not discovered by ANCOVA tests. However, the assumptions of the MANCOVA were violated as indicated by a series of testing, thus precluding its use in this study. In addition to that, for MANCOVA, the assumption is that these two variables must be moderately correlated with one another, with correlation coefficients ranging from .20 to .60 (Meyers *et al.*, pp. 212, 2013). However, a series of ANCOVA was used instead as the sample size of the study was quite large and the number of participants in both experimental and control groups was almost equivalent (refer to Section 5.5 for details).

This statistical procedure enabled the analysis of the effects of learning based on the independent factors or variables (i.e., learning method and gender) on the dependent variables (i.e., learning performance and motivation).

This procedure also facilitated the analysis of the interactions or interplays between the independent variables. Moreover, ANCOVA is a statistical model that is based on the General Linear Model (GLM). For this study, the model treated the learning method (2 levels: mobile and desktop learning) and gender (2 levels: females and males) as the independent variables and the post-test measures of learning performance and motivation as the dependent variables. All the assumptions of independence, normality, and homogeneity of variance were investigated prior to using this statistical model. The significance testing was set at the .05 significance level as recommended by most researchers. Table 3.9.1 depicts the statistical procedures implemented in testing the research hypotheses of the study.

Table 3.9.1

Statistical Procedures for Testing the Research Hypotheses

Research Hypothesis	Research Instrument	Statistical Procedure
a) The learning performance of participants after treatment would differ significantly from their learning performance before treatment.	Multiple Choice Questions	Paired *t*-test
b) The motivation of participants after treatment would differ significantly from their motivation before treatment.	Intrinsic Motivation Inventory	Paired *t*-test
c) The learning performance of participants who used CoMARLA on mobile phone would differ significantly from the learning performance of participants who used similar application on desktop computer.	Multiple Choice Questions	ANCOVA
d) The motivation of participants who used CoMARLA on mobile phone would differ significantly from the motivation of participants who used similar application on desktop computer.	Intrinsic Motivation Inventory	ANCOVA
e) The learning performance of female participants would differ significantly from the learning performance of male participants.	Multiple Choice Questions	ANCOVA

(*continued*)

Table 3.9.1 (*continued*)

Research Hypothesis	Research Instrument	Statistical Procedure
f) The motivation of female participants would differ significantly from the motivation of male participants.	Intrinsic Motivation Inventory	ANCOVA

3.10 Summary

In this chapter, the research methodology used in the study was discussed in detail by focussing on the selected research design (i.e., pretest-posttest control group design), sampling of participants, procedures of pre-testing, learning treatments, and post-testing of learning performance and motivation, research instruments used including their reliability and validity. In addition to that, the statistical analyses for testing the research hypotheses were also discussed.

CHAPTER 4

THE DEVELOPMENT OF THE COLLABORATIVE MOBILE AUGMENTED LEARNING APPLICATION (CoMARLA)

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4.1 Introduction

This chapter discusses the background that rationalizes the development of the collaborative mobile augmented learning application (CoMARLA) as a novel learning tool to help improve a group of fresh social sciences undergraduates' learning performance and motivation. The development of CoMARLA was carried out using the augmented reality development kit namely as *Aurasma*. A framework for the

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development of the learning tool was conceptualized based on the knowledge on the current theory of learning, notably the constructivist learning theory. Relevant principles derived from this learning theory were used to engender learning driven by endogenous, exogenous, didactic, and collaborative principles to enable the participants to learn in a collaborative fashion.

A review of the current learning contents of the ICT Competency course, especially the Computer System Unit, assisted the researcher to select and develop appropriate learning objects, which implemented during learning, would tap on appropriate mental processes, thereby eliminating spurious learning activities. Learning was primarily based on an assignment by which the participants worked collaboratively

in several groups to complete the task. In carrying the task, each participant would read all instructions carefully, study all the learning materials, discuss issues with their group members, and prepare a report of such a task. For the experimental group, learning activities were performed using CoMARLA on their mobile devices; for the control group, learning activities were performed using similar learning application and materials on a desktop computer.

4.2 The Background of the Development of Collaborative Mobile Augmented Learning Application (CoMARLA)

New, emerging technologies, such as augmented reality (AR) technology, are slowly being adopted in training and learning domains (Zydney & Warner, 2016). Furthermore, the application of these technologies in such domains will become more pervasive as they can also run on a mobile platform – a platform that is getting more affordable and efficient, which is evidenced by the plethora of mobile devices, namely the mobile phones (Fojtik, 2014). With continuing improvements in mobile technology and augmented reality content development software, the application of augmented reality will further expand into the education sector, enabling schools to experience immersive and interactive learning (Wu *et al.*, 2011).

Remarkably, AR contents will become readily available – almost with no cost – as non-proprietary AR development software is used to create such contents that will typically be kept in cloud storage (Rao, 2012). In light of this development, the application of AR technology in schools will be commonplace in the coming few years (Bhatt *et al.*, 2016). Arguably, just like other technologies that have been used for teaching and learning, the effectiveness in using mobile AR technology relies on a number of factors, traversing socio-cultural, economical, and cognitive dimensions (Kuo & Yen, 2009).

Only a good grasp of understanding of the complex relations of such factors can help develop and implement effective mobile AR learning tools (Hudak, 2007; Navarro-Pablo *et al.*, 2015). Effective implementation of mobile AR learning applications must be such that it should facilitates students’ cognition by its capability to provide relevant, readily available information, to attract students’ attention to the learning contents, and to facilitate students' short- and long-term memory (Dunston & Wang, 2011) as depicted in Figure 4.2.1.

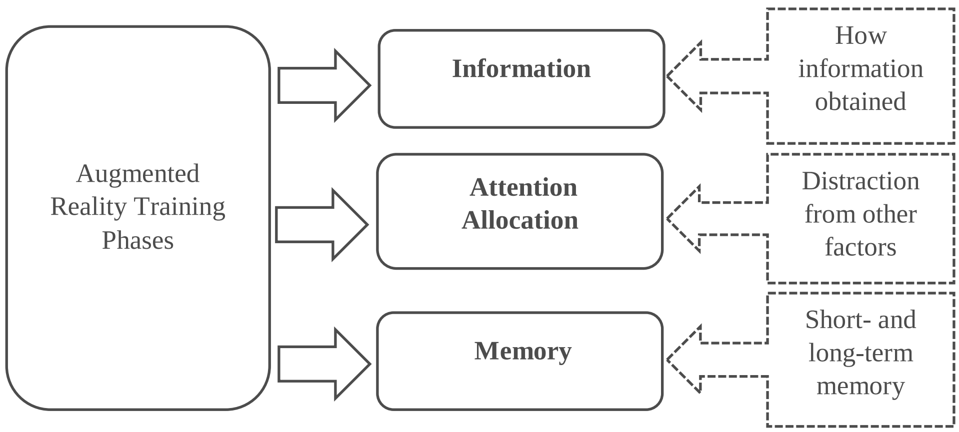

Figure 4.2.1. Three Major Factors to Consider for AR Learning

4.3 Theoretical Considerations in the Development of CoMARLA

Irrespective of the technology used, developing a learning tool or application must be guided by sound and robust learning principles, guidelines, or models, which have been derived from well-established learning theories. With such guidance, the application can help students learn efficaciously and smoothly. Put simply, the lack of or, more devastatingly, the absence of any guiding principles to guide the development of such learning application can render it ineffective at best or disruptive at worst. Thus, the development of the learning application is supported by sound theoretical underpinnings.

In the educational realm, three learning theories have dominated the learning and training landscape, namely behaviourism, cognitivism, and constructivism. In essence, each preceding theory has evolved into the following theory, with the latter being introduced to overcome some of the former's inherent weaknesses. Currently, constructivism is the learning theory that has been studied and applied extensively in a wide spectrum of training and learning activities. The popular adoption of this learning theory is spurred by the recognition of its strong psychological and philosophical precepts that are relevant to today's world of learning.

In essence, the basic tenet of constructivism is that learners construct knowledge by experiencing events and reflecting on those experiences. In encountering something

new, learners have to reconcile it with their previous ideas and experiences, such as modifying what they perceived to be true or rejecting the new information for being inconsistent or irrelevant to the current understanding. In constructivist teaching and learning, Dewey (cited in Dalgarno, 2002) asserts that each learner can synthesize his or her own depiction of knowledge. Furthermore, according to Piaget (1972), learners can become critical thinkers by reflecting on their learning experience, in which they may disclose the incongruity between their current knowledge and their experiences. In making adjudication about the information that they have just received, learners can further explore to make new conjectures or ideas about the learning event actively (Özerbaş, 2015).

From the social perspective, Vygotsky (1978) contends that learning transpires in a social context, and the synergism among learners and their peers is decisively part of learning cycle. His learning perspective hinges on two important precepts, namely More Knowledgeable Other (MKO) and the Zone of Proximal Development (ZPD). The first refers to someone who has a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The second is defined as the "actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). Taken together, the above two precepts establish the basis of a scaffolding component in teaching and learning, a component that is critical to the success of collaborative learning.

Learning collaboratively is gaining traction of late in view of the emerging trends in communication in today's society, with more and more people are being connected to collaborate in a range of tasks, notably in learning activities. In the literature, the term collaboration and cooperation have been used interchangeably, thus being interpreted as being a same concept. There is, however, a subtle nuance between the two as highlighted by Scanlon (2000), who asserts that:

> "Co-operation usually implies either splitting up the work or solving subtasks individually and combining the results into a final product. In contrast, collaboration can mean a coordinated attempt to solve and monitor a problem

together, with perhaps some division of labour on aspects of the problem" (p. 464-465).

In learning, collaborative engagement among students have been found to help improve students' problem solving skills and communication skills. In view of this immense potential, opportunity to work in a group or team should be encouraged by providing students an appropriate, conducive avenue either in the classroom or online (Roseth, 2012). In such learning environment, they can have a better chance to solve a given problem as they work through it in unison, rather than individually (Wu *et al*., 2014). In fact, this kind of learning benefits academically less knowledgeable students the most, with guidance and assistance rendered by their more knowledgeable peers.

Not surprisingly, the interpretation of constructivist learning is quite challenging, with many scholars offering many principles or point of views over the years. To reconcile such different views, Moshman's interpretation of constructivism helps clear the fog of confusion, in which he eloquently categorizes constructivism into three main categories, namely endogenous, exogenous and dialectical constructivism (Dalgarno, 2001). Endogenous constructivism stresses the significant of learner exploration during learning. Exogenous constructivism underscores the imperative of direct instruction, but with a strong emphasis of learners actively constructing their own knowledge representation. Dialectical constructivism plays the important role to facilitate the interaction among learners, their peers, and lecturers.

With such interpretations, the onus is on the lecturer to create the constructivist learning environment using appropriate learning contents, features, materials, and facilities. For example, in CoMARLA learning application, materials that draw on the endogenous standpoint are the multimedia contents, such as 3D objects, audio narration, demonstration videos. To invoke exogenous learning, instructional sheets, guidelines, and cognitive tools are available to help knowledge construction. Finally, collaboration and support tools that support dialectical learning consist of Facebook and Google doc. Figure 4.3.1 depicts the three types of constructivist learning and the appropriate tools to support them.

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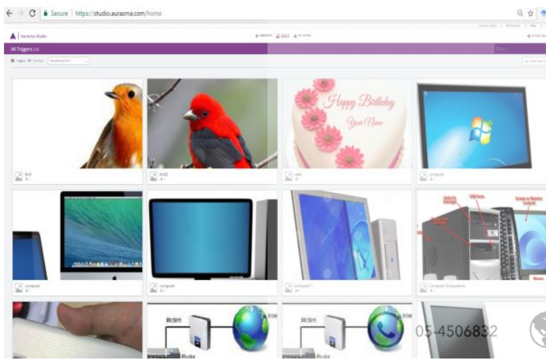
Exogenous

Accuracy & amount of details with direct instructions



The instructor prepares the materials and provides a guideline for students to familiarize the Aurasma applications

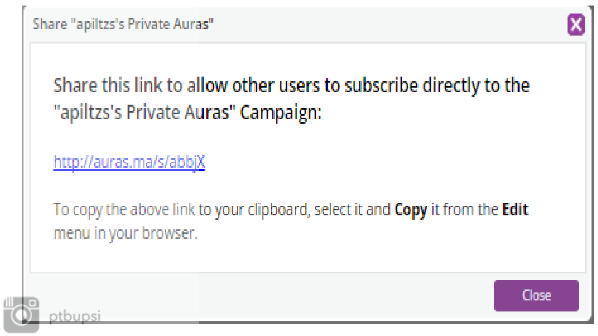
Endogenous

Discovery, creativity, invention, and exploration during learning

Students need to create a MAR contents based on an ICT Competency topic

Dialectical

Collaboration, teamwork, cooperation



Students collaborate with their peers in completing a task and share links via Facebook and Google Documentation

Figure 4.3.1. The Exogenous, Endogenous and Dialectical Learning Elements of CoMARLA

4.4 The Conceptual Framework of the Development of CoMARLA

In developing CoMARLA as an AR learning tool, the researcher had to focus on three important aspects, namely the concept and theory, implementation, and evaluation, as recommended by Wang *et al*. (2013), as shown in Figure 4.4.1. From the perspective of design and development, the three aspects represent three hierarchical layers, with the bottom one serving as the starting layer, upon which other layers will be built. Annotations overlays delineating the workspace environment that exemplifies the accustomed instructions by using texts or pictorial representations

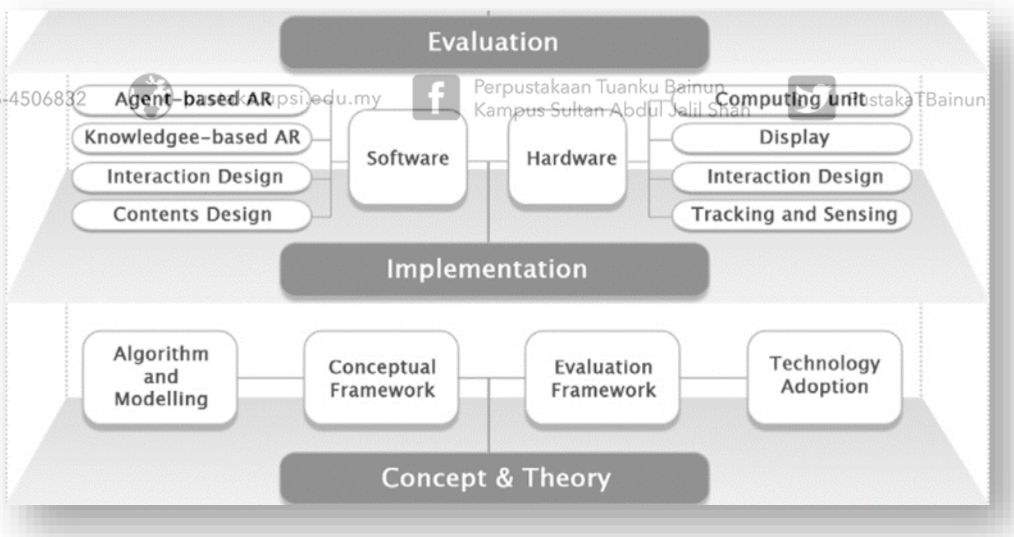


Figure 4.4.1. The Three Architectural Layers of an AR Environment

The first layer emphasizes the importance of the concept and theory relevant to the learning of a particular subject matter or the training of a certain skill. Essentially, a good grasp of such a concept or a theory helps the developer to develop an appropriate conceptual framework, from which evaluation framework, technology adoption, and algorithm and modelling are subsequently determined (Syberfeldt *et al*., 2015).

The second layer of the architecture involves the implementation of the elements of the AR learning tool and application in actual learning or training setting. The implementation of such an application comprises two parts, namely the hardware and software. The software consists of the type of AR, interaction design, and content design. Whereas, the hardware consists of computing units, display, interaction design, and tracking and sensing.

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Finally, the third layer of the architecture calls for the evaluation of the AR learning application against a set of performance criteria. The results of the evaluation will provide important information to the performance of the application, which may need further improvement, if any. Clearly, this hierarchical architecture of the development of AR applications underscores the imperative of having a strong, sound understanding of the concept and theory to conceptualize the relevant framework. Thus, developing a sound conceptual framework should be prioritized accordingly, as it lays the foundation on which other aspects of development can be strongly built.

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Thus, in this study, the researcher developed a conceptual framework to help guide the development of CoMARLA, which is a novel mobile AR learning tool to assist social sciences undergraduates to learn a topic of the ICT Competency course, namely the Computer System Unit. This topic consists of several subtopics, namely the Computer Hardware, Computer Software, and Network and Internet subtopics. Table 4.4 shows the conceptual framework highlighting all the concepts (factors) and their relations that helped create a collaborative learning environment, which is premised on the constructivist perspective.

Essentially, this framework comprises three constructivist learning elements, namely endogenous, exogenous, and dialectical elements. The endogenous learning element entails learners to actively partake in the learning process. The actualization of such learning depends on the learners' behaviours in learning, the conduct of which students become deeply engaged in the learning process. Through deep engagement, learners will be able to focus on the concepts, facts, or ideas to be learned, and not distracted by other factors, thus leading to improved learning. In this framework, the researcher has laid out three components of such learning activities, namely interactivity, dynamic exercises, and 3D animation.

Interactivity plays an important part in the learning process such that learners will be able to interact with the learning objects with ease and, as in a collaborative learning setting, communicate with one another more intensely. Highly interactive learning environment helps learners to perform tasks, projects, or assignments in a smooth manner. Learners become engaged and, more importantly remain focussed, throughout the entire learning duration. In addition, interactivity helps promote active exploration of learners in a learning environment, which could lead to making them feel accomplished or gratified (Courtney *et al*., 2015). Furthermore, such manifested active exploration can heighten the degree of student self-confidence in the classroom (Blasco-Arcas *et al*., 2013). The reverse is true in a learning setting that is less interactive, with learners having problems in accessing and using learning contents or communicating with their peers.

Dynamism is also an important element in a learning setting, with which learners can partake in performing learning exercises in a dynamic fashion, as opposed to a static one. The element of dynamism can be realized using dynamic exercises, where learners will be able to perform learning activities with a greater sense of control, as they can change some parameters of the learning contents using available assistive features of a novel learning tool or application. Such dynamic exercises are normally based on multimedia elements, which can be easily manipulated invoke compelling learning experience, thus improving cognition (Alessandrini *et al*., 2014; Fonseca *et al*., 2014). This capability is vital as learners can practically steer the direction of learning toward the intended learning objectives more forcefully. In other words, without such dynamism, such a learning process can become lethargic, the effect of which the learners can become demotivated, at best, or frustrated, at worst.

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Three-dimensionality is another element of learning setting that helps learners learn more effectively. The importance of this component, as exemplified by a 3D-learning environment, is such that learners could learn in a realistic learning setting, providing almost a “true” learning experience as if they were based on real-world experiences. With such environment, learning becomes more vivid, intense (Kose *et al*., 2013). In this regard, Molnár, and Benedek’s study (2015), who found that students using a 3D learning approach attained higher performance compared with those using conventional learning approach, exemplify such a benefit.

To further help learners learn, digital 3D-animations can be implemented in such a learning setting. More importantly, well-crafted animations will be able to help learners

learn faster and easier. In fact, such animations are also excellent aids, to lecturers when it comes to explaining difficult subjects. In particular, subjects that contain abstract concepts or vague ideas may be elaborated more clearly using digital animations. With the aid of digital animations, learning and teaching might become easier, faster, and entertaining.

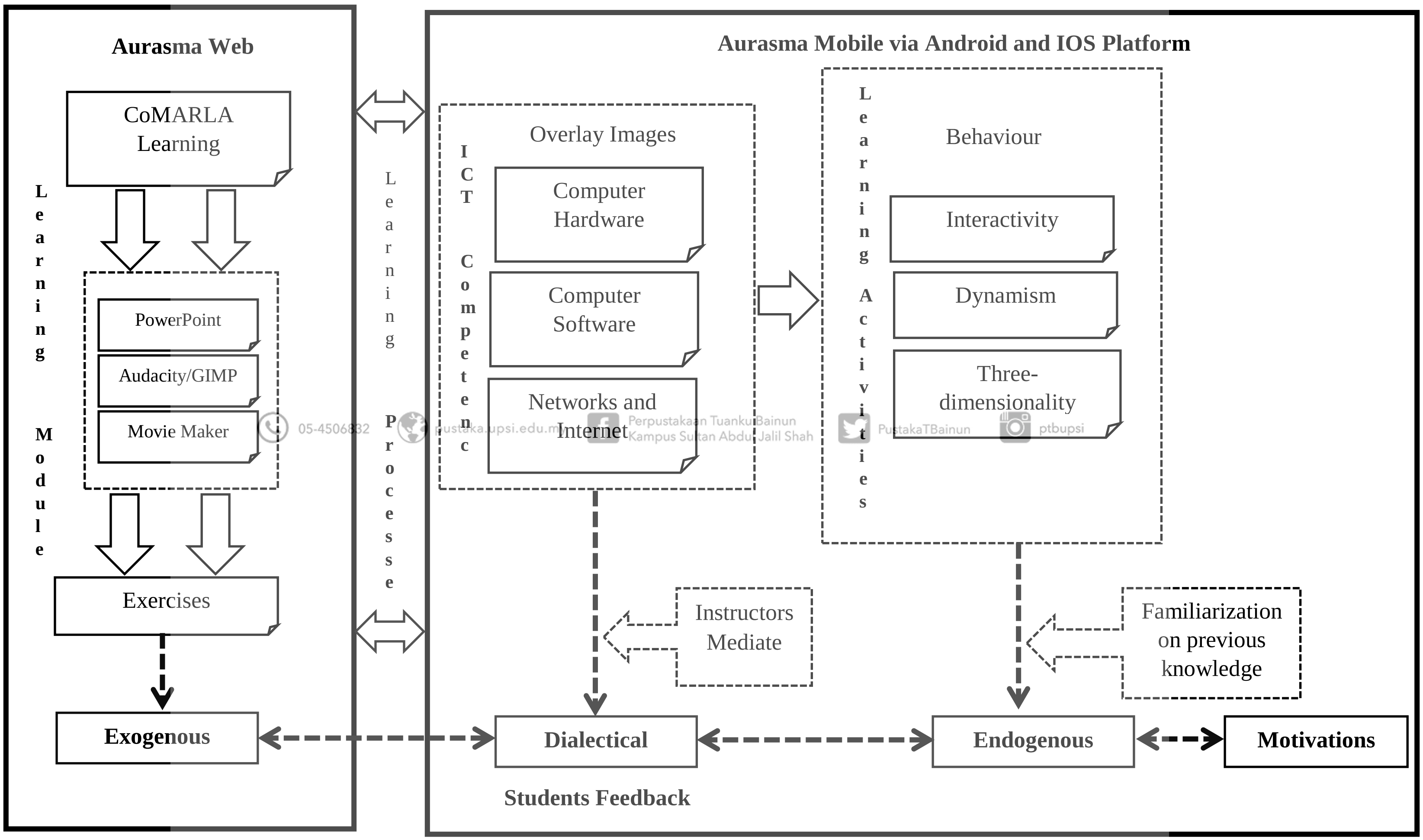

Figure 4.4.2. The Conceptual Framework of the Learning Processes Accorded by CoMARLA

The dialectical learning involves reasoning among learners with their peers and the *lecturer* to formulate a solution to a given problem through the exchange of logical arguments. In CoMARLA, this exchange of ideas is assisted using the online communication tools such as Facebook and Google doc. In this study, the participants utilized such communication tools to discuss and complete their assigned task pertaining to the Computer System topic, which was based on three subtopics, namely Computer Hardware, Computer Software, and Network. To assist dialectical learning, several overlays based on the three subtopics were prepared by the researcher (see Figure 4.4.2).

Typically, such overlays in an AR learning environment consist of texts, graphics, sound, or videos, which when used in a proper context can attract learners. Of course, there can be many types of overlays used for learning; nonetheless, according to Petersen and Stricker (2015), such overlays can be categorized into four main types, namely procedural overlays, active overlays, annotation overlays, and assessing overlays. In this study, the researcher selected the annotation overlays that helped delineate the workspace environment using customized instructions based on textual or pictorial representations.

Exogenous constructivist learning relies on direct instruction that helps learners to actively construct their own knowledge representation. Invoking this type of learning can be achieved by providing learners with appropriate information, such as instructional sheets, guidelines, and cognitive tools, to help learners develop a deep understanding of the subject matter being learned. In CoMARLA, all the necessary information, which was prepared in the form of exercise modules, was provided to the participants (see Figure 4.4.2). The cognitive tools of this mobile AR learning application comprise a presentation tool (e.g., Microsoft PowerPoints), a video-editing tool (Microsoft Movie Maker), a sound-editing tool (Audacity), and an image-editing tool (GIMP). The first and second tools are proprietary software, and the third and the last tools are non-proprietary software.

Using the cognitive tools in learning, learners can carry out their project or task efficiently. For example, with the video-editing tool (Microsoft Movie Maker), learners can record a video concerning a particular topic of interest using this learning tool. To enhance such a video, learners can add audio narration or on-screen texts, the impact of which the viewing of the video will be more attractive, compelling, as well as highly informative. Furthermore, the video can be uploaded to several videos hosting systems, such as YouTube (the global internet video host), allowing other learners to gain access. Having such access can spur information sharing among learners, thus leading to active collaboration among themselves (Orús *et al.*, 2016).

Learners can use the audio-editing tool (Audacity) to record a particular narration, explaining, for example, several concepts of learning to listeners. The same narration can be harmonized with interesting sound effects, which helps attract listeners to remain focused with the learning contents being verbalized. Furthermore, in using these editing tools (video and audio editing applications), learners will eventually become skillful, articulate, and mindful of their important role in a participative, collaborative learning in the classroom (Karabayeva, 2015). Likewise, such narration can be made available to all learners online by saving it into several compact audio file formats, notably MP3 (Chiper, 2013).

The image-editing tool (GIMP) is a user-friendly application that learners can use to edit static images. This tool enables learners to improve the quality of an image by using an array of features. Using these features, learners can add texts, embellish a scenery, or highlight a particular section. The presentation software (Microsoft PowerPoints) is an excellent tool by which learners can make a compelling presentation of their finished task, project, or product. Virtually, this tool has all the features that can help learners prepare not only an informative presentation but also a forceful one, the impact of which their audience can gain a better understanding of what is being delivered to them. Overall, with the cognitive tools of CoMARLA, learners can hone their technological artistry and communication skills, which are important learning skills in today’s educational realm (Brown, 2015).

Figure 4.4.3 demonstrates the learning process carried out the research subjects in this study. Learning began with the researcher introducing the basic information about Computer System topic to the participants. Essentially, they were briefed with the relevant information pertaining to Computer Hardware, Computer Software, and Networks and the Internet. The researcher provided basic demonstrations of the various cognitive tools for the participants by using the appropriate software (i.e., Microsoft PowerPoints, Microsoft Movie Maker, Audacity, and GIMP).

The learning process transpired in three phases. First, each group studied the Computer Hardware subtopic, then they proceeded to the Computer Software subtopic, and finally they carried on with the Networks and the Internet subtopic. This progression of learning was to ensure that they could perform all the necessary learning activities in a controlled, systematic manner; otherwise, learning might proceed erratically, thus impeding a smooth learning process.

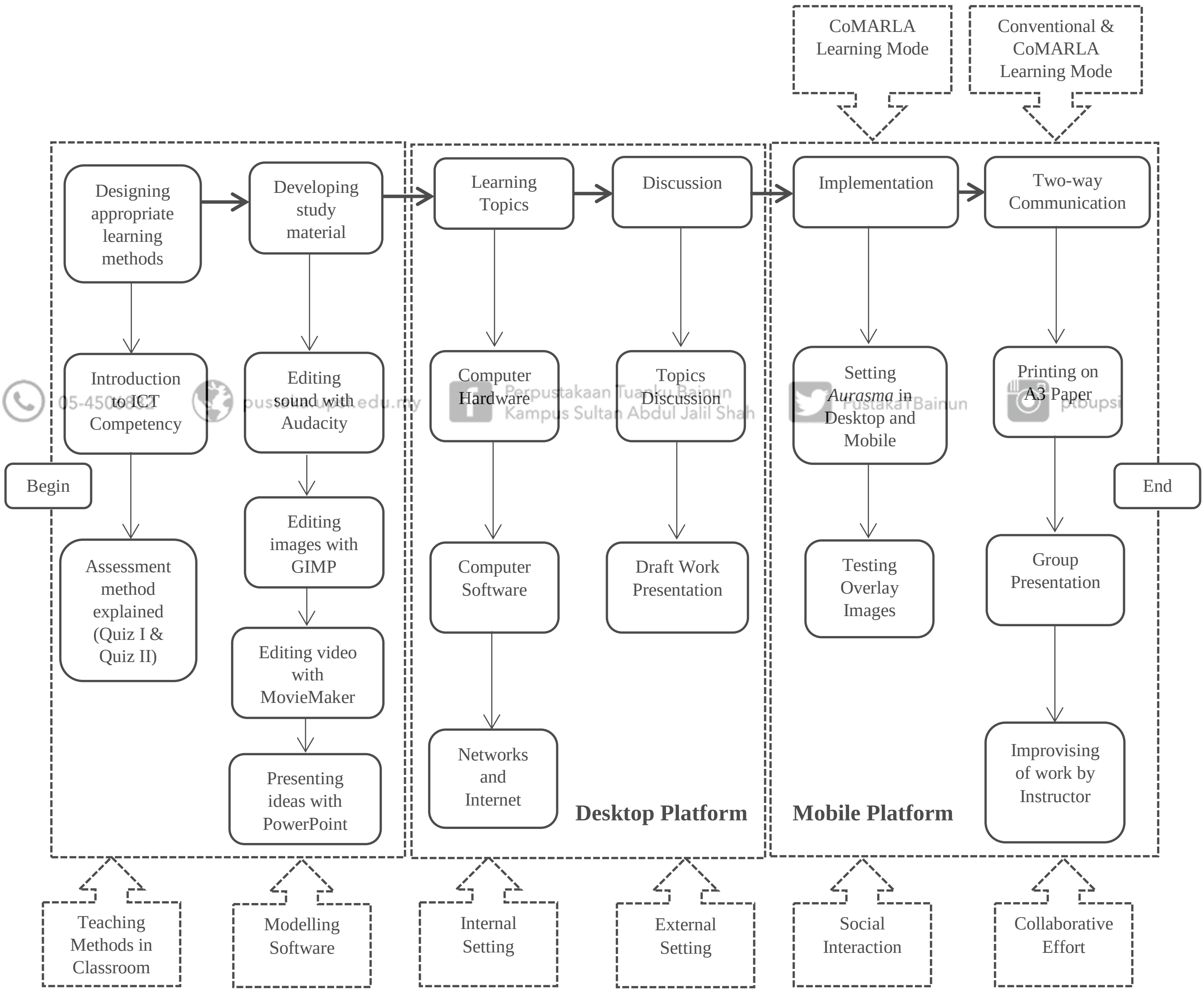

Figure 4.4.3. The Learning Process Performed using CoMARLA

In carrying out their learning activities, the participants were instructed to use the instructions and learning materials provided. Specifically, they were asked to read all the instructions carefully before attempting to carry out all the learning activities pertaining to the given group assignment. In performing the activities, they were guided by the researcher in using the cognitive tools using either the desktop or the mobile phone.

Each group carried out the learning activities collaboratively, albeit in different modes. For the experimental group, the participants used the online communication tools to discuss relevant matters, share their thoughts, and exchange their ideas using CoMARLA on their mobile phones. Meanwhile, for the control group, such discussions transpired in a physical setting, with the participants discussing face-to-face with one another. The researcher closely monitored each group's progress throughout the learning process.

For the experimental group, the output of their collaborative work consisted of several appropriate overlays that could be viewed using CoMARLA on the mobile phones. For the control group, such output was consisted of printouts on A3 paper. At the end, these collaborative learning activities culminated in complete group reports, written accordingly to the guideline given by the researcher. In addition, each group was required to make a presentation of their work using the presentation application using the desktop in the assigned computer laboratory. Clearly, all the learning activities that had been carried out collaboratively entailed a high level of social interaction between all group members, which led to the better knowledge acquisition.

4.4.1 The Instructional Design of CoMARLA

This research involved the development and implementation of CoMARLA in learning. This novel learning application consists of augmented reality elements, computer- generated images, and multimedia elements to help create a mobile learning environment. Specifically, the researcher used the Analysis Design Development Implementation Evaluation (ADDIE) model in developing CoMARLA. This application development model is widely used in developing a wide range of educational applications (Colpaert, 2006; Jeuring *et al.*, 2013) and computer systems (Caws, 2013). As such, the ADDIE model, which comprises five phases of development, helped the researcher to develop a prototype of the mobile augmented reality application that was used in this quasi-experimental study. Table 4.4.1.1 depicts the detail of each phase of the application development performed by the researcher in this study.

Table 4.4.1.1

The Development Phases of CoMARLA Based on ADDIE Model

Phases	**Task for CoMARLA**
A (Analyze)	a) Analyzing and determining the learning goals b) Analyzing the learning materials for students and also for the background of the study c) Analyzing the mobile learning and desktop learning methods d) Analyzing the appropriate learning environment or setting in a classroom

(*continued*)

Table 4.4.1.1 (*continued*)

Phases	Task for CoMARLA
D (Design)	a) Designing the learning task using four main multimedia elements, namely text, graphic, audio, and video b) Sequencing the task of the control and experimental group c) Setting the performance objective for the control and experimental group d) Designing the supporting information of the software, namely Aurasma e) Designing the challenges and levels of learning using Aurasma
D (Develop)	a) Creating the contents consisting of multimedia elements using Aurasma b) Programming the contents of overlay images c) Programming the contents of trigger images d) Setting the multimedia elements of CoMARLA
I (Implementation)	a) Implementing CoMARLA on mobile platform and similar application on desktop platform b) Implementing the learning environment in the classroom
E (Evaluation)	a) Testing the performance of CoMARLA b) Gathering feedback on user acceptance of CoMARLA from users through a test questionnaire

4.5 The Development of Collaborative Mobile Augmented Reality Learning Application (Desktop Computer Version)

The development of the Collaborative Mobile Augmented Reality Learning Application (CoMARLA) was carried out by using the web-based augmented reality

(AR) development system, *Aurasma Studio*, which also hosts a diverse array of AR contents online. When accessing Aurasma's website, users can use the various features available to develop AR contents using various templates. The developed AR contents can be uploaded to the system's server as cloud contents, which can be downloaded to users' device. These AR contents can be quickly accessed, shared, and distributed among users with some of the novel features, such as popular hashtags based on trend or sharing templates, as depicted in Figure 4.5.1. Having this quick search and precise search of relevant contents helps students in their learning process as it can proceed without any delays or interruptions (Fischer *et al.*, 2016). Interestingly, such AR contents can be accessed by any devices that have internet connectivity, such as the mobile phone, thus expanding the learning envelope that makes learning more pervasive and all encompassing (Dalle Mura *et al.*, 2016).

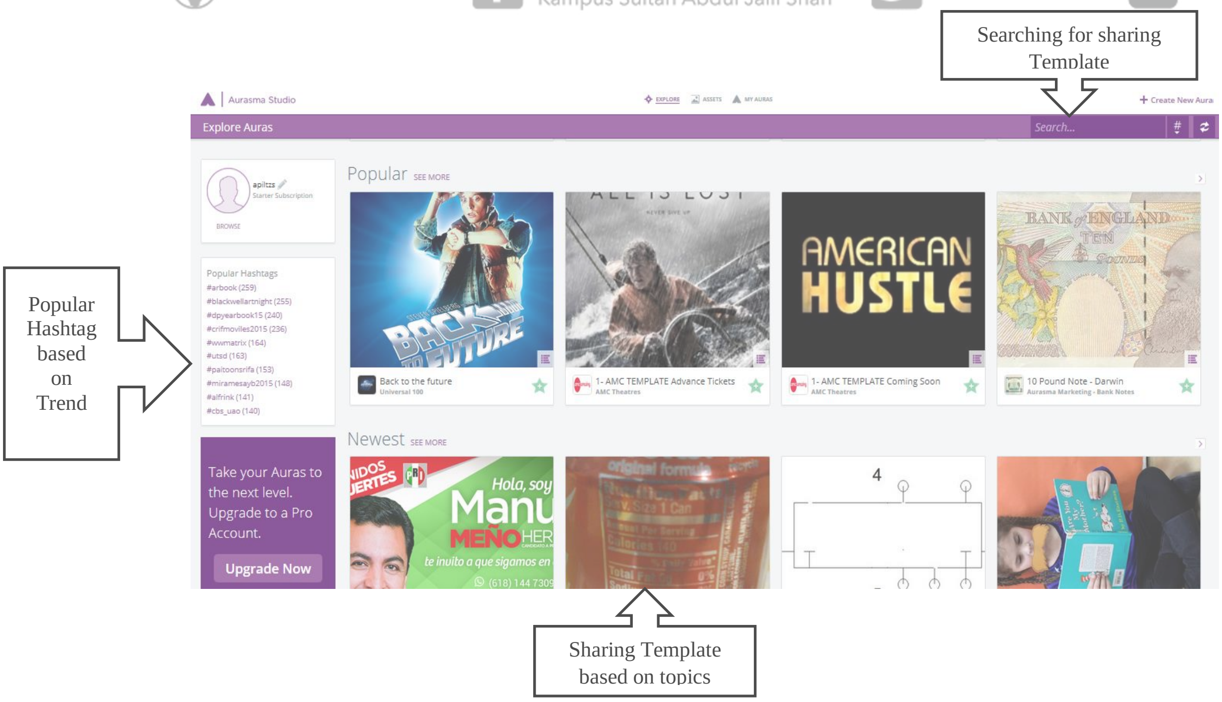

Figure 4.5.1. The Aurasma's Web Page Depicting Brief Introduction about Sharing Templates and Popular Hashtags

To use Aurasma Studio, students are needed to create an account to gain access to its repository. Once registered, they can readily log in into the system anywhere, anytime, making this process an educational as well as an entertaining experience. Figure 4.5.2 shows the sign-in interface of the Aurasma's web portal.

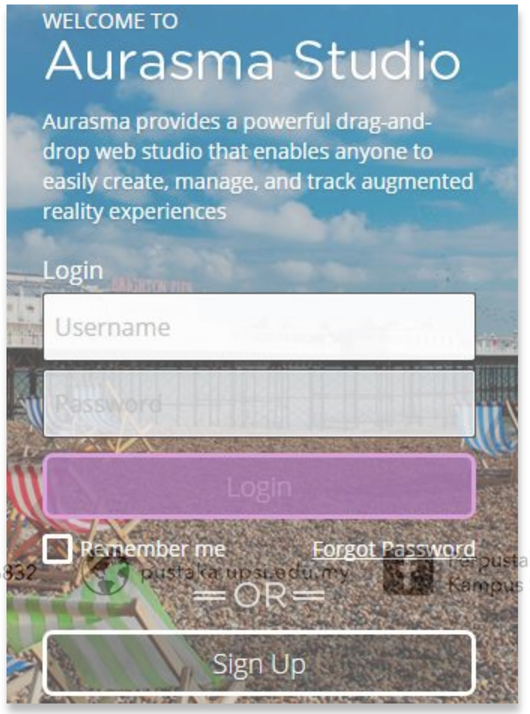

Figure 4.5.2. Aurasma's Web Portal

Furthermore, once logged-in, students can start developing their own AR contents using the "Getting Started" interface. With this interface, students can almost quickly and easily learn how to explore the AR contents development process, share such contents, upload trigger images, upload overlays, and utilize hashtags. To expedite such a learning process as above, students can load and play appropriate demonstration videos. Using such videos on *YouTube*, which contain a rich mixture of multimedia elements, students can clearly learn more efficiently. In addition, such online videos are easily shared by all members of the digital community, including agencies and developers, thus improving the process of knowledge acquisition on a global scale (Lee & Lehto, 2013). Figure 4.5.3 demonstrates the interface to help students get started with the development process of AR contents in Aurasma Studio.

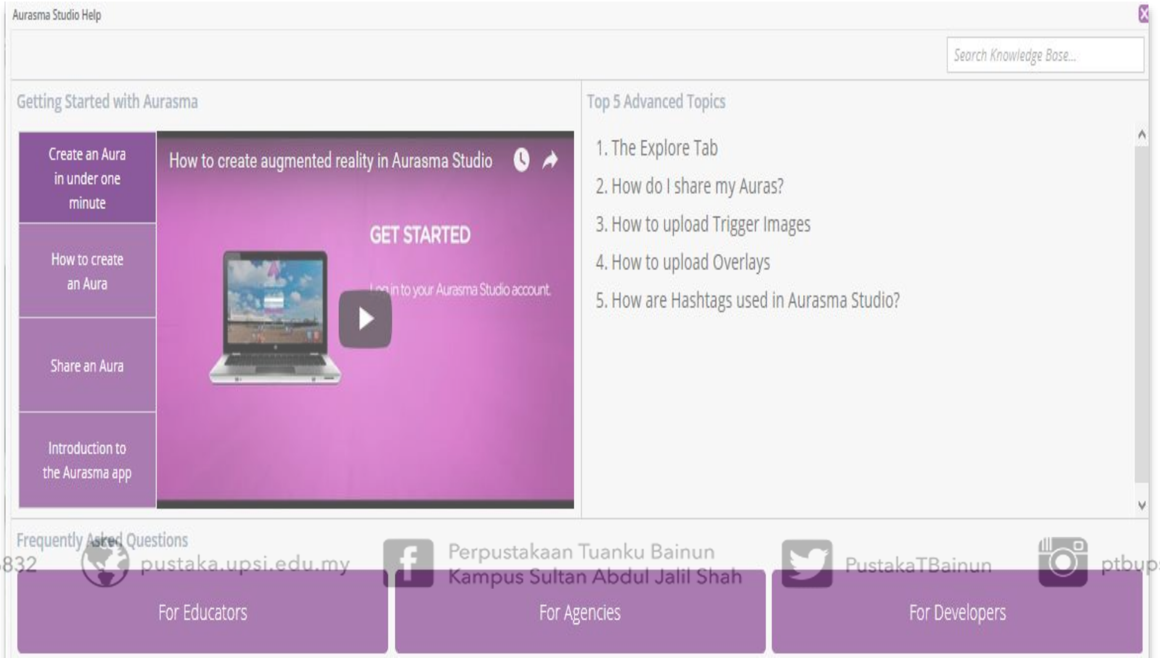

Figure 4.5.3. The Aurasma Studio's Interface for the Development of Contents

The process of developing AR contents starts out with a step called *Trigger Creation*, as shown in Figure 4.5.4. Essentially a trigger is created based a specific subject or topic, such as in this study the trigger was based on ICT Competency subject. Later, several trigger images are uploaded accordingly. This step is then followed by the step called *Overlay Creation* (see Figure 4.5.4). This step involves establishing the dynamic behaviour of the AR contents, which typically comprise multimedia elements, such as images, sound, and videos). Finally, the step called *Augmented Reality Scene* is performed, in which an AR scene is created, as in this study the CoMARLA learning environment was set up at this stage. Figure 4.5.4 depicts the above steps to create such an AR scene or an AR environment.

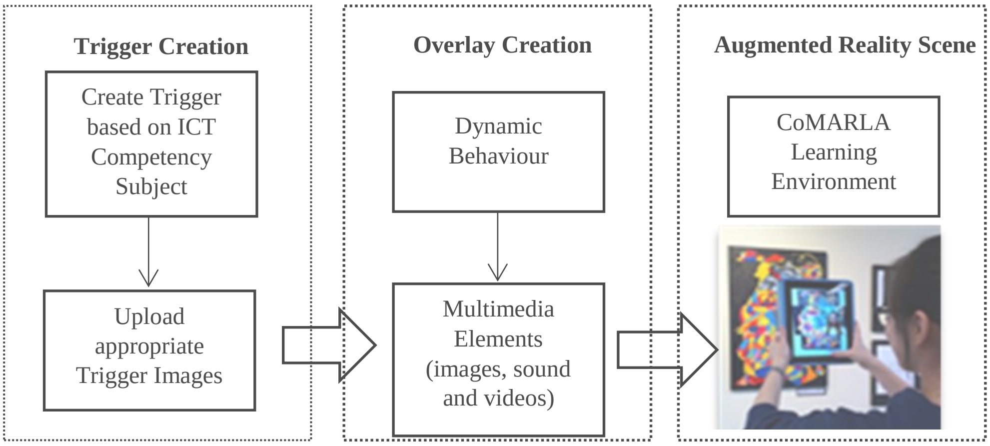

Figure 4.5.4. The Creation of an Augmented Reality Scene Based on the ICT Competency Course

For this study, the three steps used in Aurasma Studio to model the required of the augmented reality scene of the CoMARLA learning application were the trigger creation, overlay creation, and the creation of the augmented reality environment. Figure 4.5.5 shows the step involved in setting up the triggers using appropriate images, the elements that will be triggered when being scanned by a camera. Figure 4.5.6 depicts the step-by-step approach to create the AR scene.

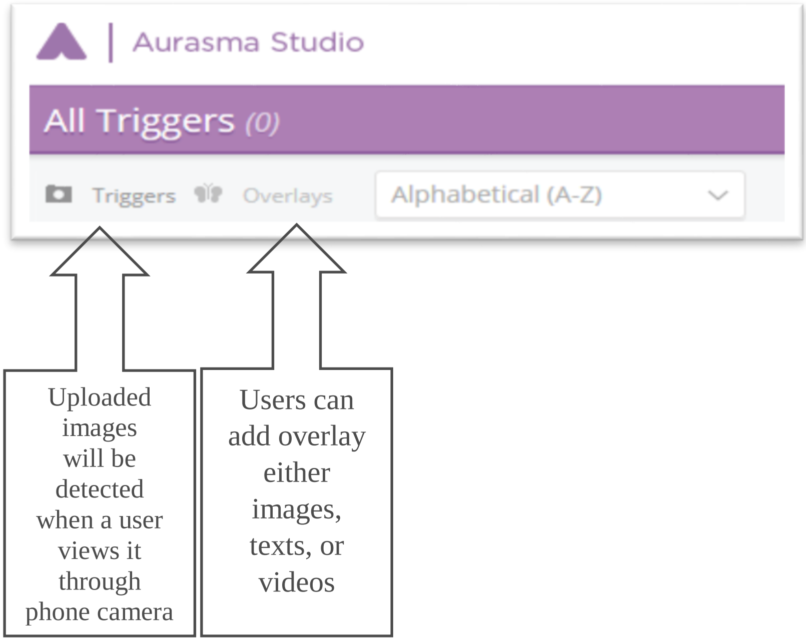

Figure 4.5.5. Setting up the Trigger

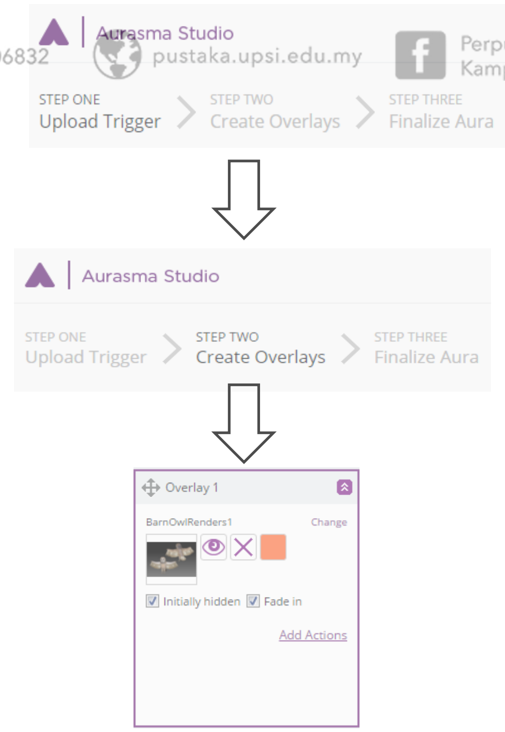

Figure 4.5.6. Setting up the Overlays

There is some flexibility in triggering elements in an AR scene, depending on the preferences of the students. For example, there are seven predefined overlay actions that students can choose from in this AR contents development system. Each overlay action has its own unique behaviour that makes triggering of events interactive and dynamic. Such interactivity in the AR environment can engender a learning milieu that is both exciting and meaningful (Moyer, 2016). Figure 4.5.7 shows the available predefined overlay actions, from which students can select.

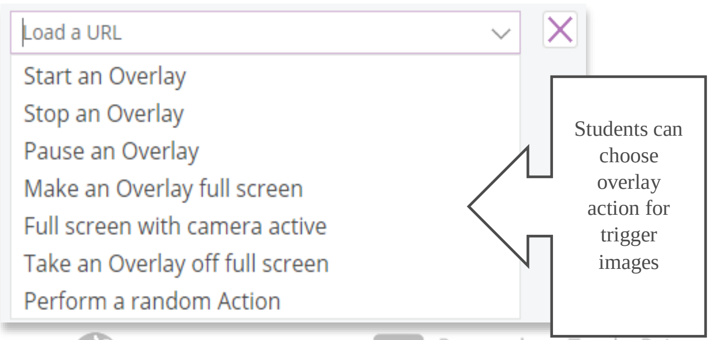

Figure 4.5.7. The Predefined Overlay Actions

Finally, the overlay images uploaded need to be tested such that the intended actions of behaviours can be invoked without any problems. Such testing can be easily carried out with any computer devices, including the android mobile phone or the Apple’s smart phone, provided they have an AR client browser installed accordingly. Figure 4.5.8 depicts such a preview of the testing of the overlay images.

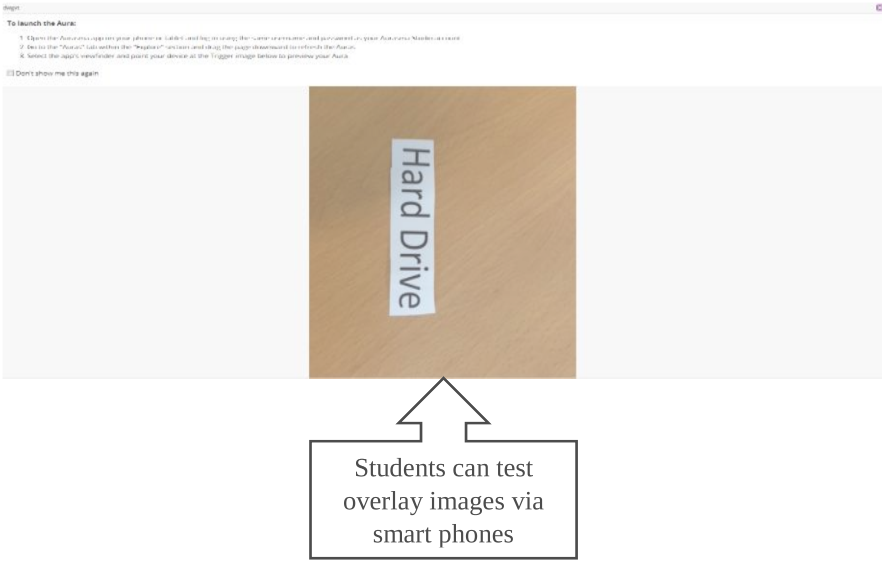

Figure 4.5.8. Previewing of an Overlay Action Based on a Trigger Image

As in this study, using the CoMARLA application entailed the participants to upload their aura or work that had been completed after working collaboratively in the classroom. There were two ways of uploading students' work or aura, namely by the social media sites or google documentation. Once uploaded, others could share their work by performing a few steps to allow such an access. Figure 4.5.9 shows the pop-out interface by which students could allow others the access to their work through twitter, email, or Facebook. Having shared information when working closely in a group could not only ease efforts in solving a problem, simply also forge a strong bonding among them, the impact of which could make them feel more comfortable and convinced into making comments or suggestions (Nebel *et al*., 2016).

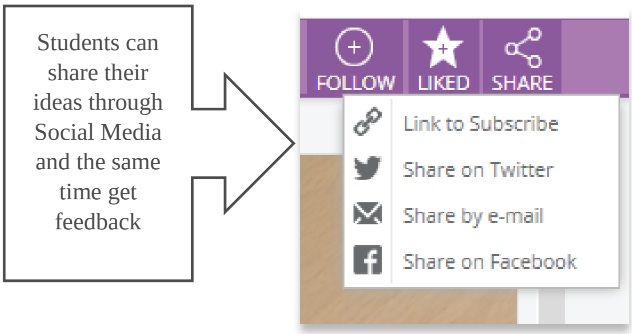

Figure 4.5.9. Sharing of and Linking to AR Contents

Alternatively, students could provide a link for others to gain access to the former's work. For example, a link to relevant Google Documentation material enables other students to subscribe directly to a specific material or content, as highlighted in Figure 4.5.10. In possession of this shared material (document), students can partake in a learning process collaboratively and actively as they can discuss or elaborate online with the aid of such document.

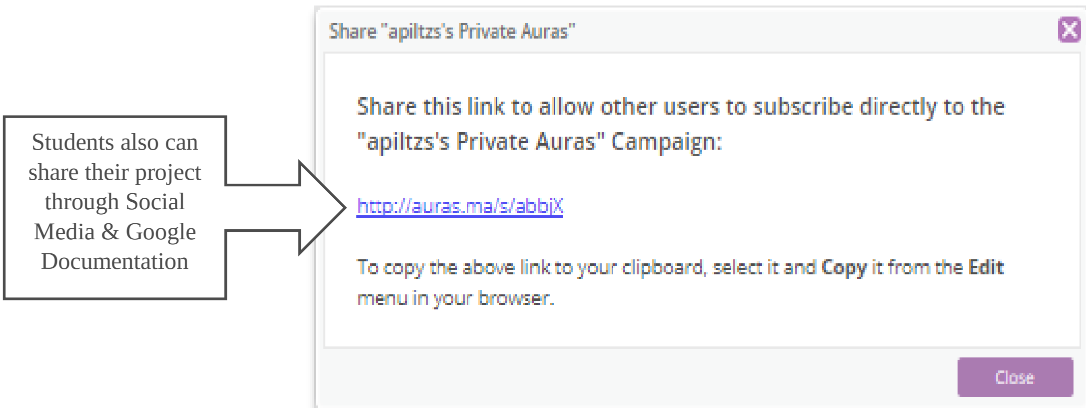

Figure 4.5.10. Link to a Designated Material

In this regard, the sharing of learning materials over the social media by means of the mobile device widens the scope of cooperation among students as they can gain access to such materials without being impeded by geographical or temporal barriers (Kwahk & Park, 2016). Having almost unlimited access to such information further fuels the discussion among students when they are collaborating on solving their assignments or projects (Balakrishnan & Gan, 2016).

In addition, this AR contents development tool can also manage contents that are deemed irrelevant to a certain segment of the student community. Some contents may be appropriate for a particular group, whilst the same contents may be inappropriate to another group. Materials that are not relevant to a certain group of students can be flagged as such. These flagged materials will not be displayed to such students when they launch the AR application. In essence, this flagging of materials as appropriate or otherwise can help *lecturer*s or instructors to customize learning materials based on their student profiles. Figure 4.5.11 shows the interface to flag such materials.

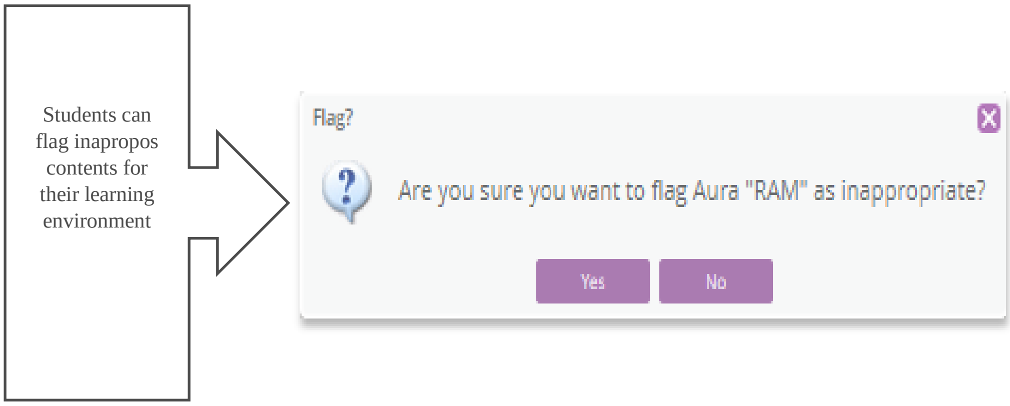

Figure 4.5.11. Flagging of Inappropriate Contents

Personalizing learning materials or contents according to a particular group of students provides lecturers with some control over the learning process. Specifically, lecturers can provide certain students with only relevant materials concerning a particular topic, which helps expedite the learning process (Schneider *et al*., 2015). Without such control, students will be overwhelmed with unrelated or superfluous information that can complicate the learning process (Ginns *et al*., 2013). Thus, such personalization capability can help create a personalized learning, which benefits students in learning a specific topic of the subject matter (Wanner & Palmer, 2015).

4.5.1 The Sharing Collaboration Tools of Aurasma on Smart Phones

The Aurasma image recognition technology uses the smartphone camera to recognize images that had been collected by students, which were then overlaid by relevant media in the form of animations, videos, 3D models, and web pages. The following subsection discusses the collaborative modes by which students shared and discussed their work collaboratively.

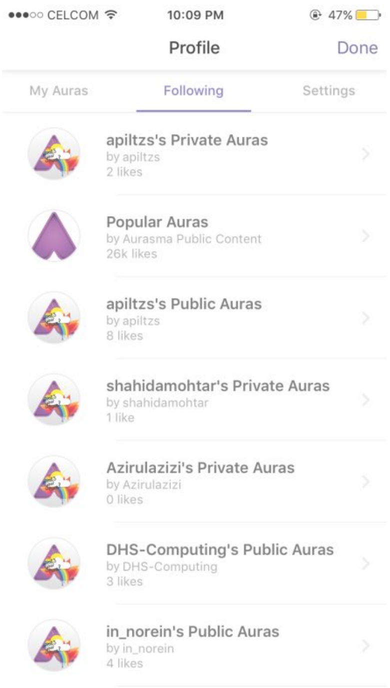

Figure 4.5.1.1. A Channel Showing the Student Profile

Figure 4.5.1.1 shows the channel in which the students must follow the student’s profile, which can be in the form of either public or private channel. In this study, the students were instructed to create a public channel in which all students could find and log on to initiate discussion pertaining to their work. Once logged on, the students could access all the learning materials on the mobile devices.

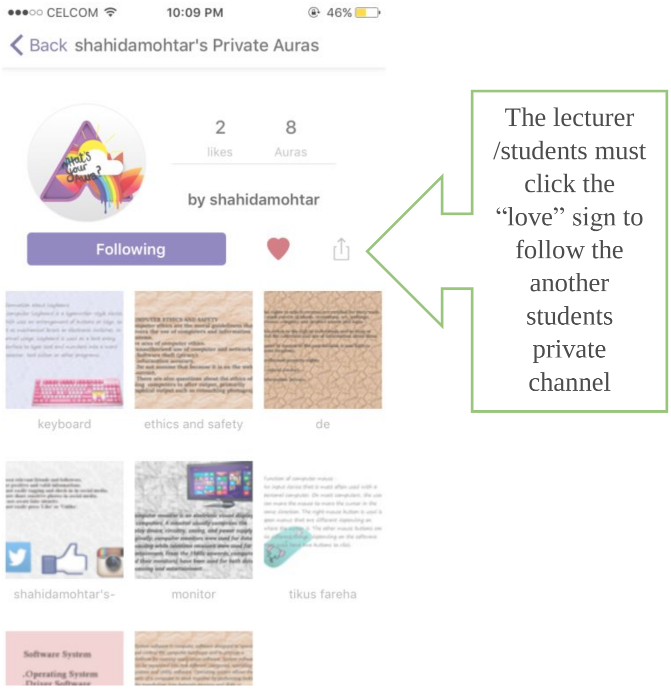

Figure 4.5.1.2. The Private Auras

A student could select a particular channel by clicking the appropriate "channel" icon and then clicking the "Link to Subscribe" button, as shown in Figure 4.5.1.2. Then, to enable other students to see his or her work, this student had to select and copy the link that had been generated to an email. With the link in their email, other students could readily edit, add, or delete any work in the Aurasma environment without any complicated procedure. Figure 4.5.1.3 depicts the sharing tools that enabled a group of students to share materials and give feedback to other groups, as needed, using their mobile devices.

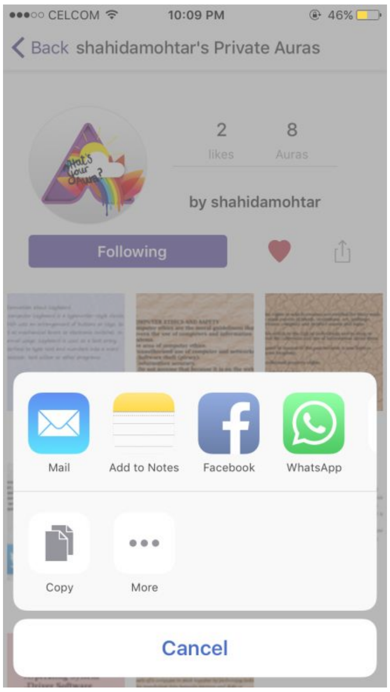

Figure 4.5.1.3. An Array of Collaborative Tools in Aurasma Environment

Such an environment allowed the students to select the various types of online communication tools that they preferred when discussing their work (see figure 4.5.1.1, 4.5.1.2, and 4.5.1.3) using a simple procedure. First, the students must use their mobile devices to log in to the Aurasma system. Then, the lecturer or instructor had to click the channel that had been selected by the students, as depicted in Figure 4.5.1.2. Finally, the lecturer or students or both had to click the “love” sign in order to start following the students' work. Once accessed, the lecturer could examine and subsequently grade the students’ work (see Figure 4.5.1.3).

4.6 The Instructional Design of the Computer-assisted Group Based Learning

In this study, the research subjects carried out their work in part through collaboration using the social media platform, such as Facebook. Even though this social network sites are commonly designed for social interaction of users, these communication sites can be tailored for learning or training purposes (Mao, 2014). In all likelihood, the participants were presumed to have some level of experience or expertise in using such communication sites; but they might not be familiar with the educational use of such sites. Thus, the onus on the researcher to provide the appropriate instructional design by which the learning activities performed by the participants would take place systematically, not spuriously (Strijbos *et al.*, 2004). Emphatically, such an instructional design would help the participants to communicate with one another effectively and efficiently, which led to improved learning performance.

The instructional design conceptualized was such that it can ease the learning process by which the participants could undertake without too much an effort. In other words, the learning process had to transpire smoothly, not haphazardly (Vössing *et al.*, 2016). Given that CoMARLA utilized rich learning contents in the multimedia form, care had to be taken such that their use would accelerate learning. Thus, in this study, the learning activities carried out by the participants were designed in such a way that the progression of learning started from the low level of difficulty, then to moderate level, and finally to a complex level. This seamless progression of learning activities helped the participants to carry out their learning activities with greater ease and some sense of control (Entwistle & Ramsden, 2015). In essence, using this kind of instructional approach, participants who were at a previous learning stage would have enough skills or knowledge to proceed to and learn in the following learning stage.

From the collaborative perspective, the online discussion of the participants had to purely focus on learning. Thus, this entailed the role of a facilitator by the researcher to closely monitor their discussion so that it concentrated on a particular learning issue. In any collaborative learning, it is important that discussion among students does not digress from the main learning issue (Meskill & Anthony, 2014). Without close monitoring of such online discussion, it would be naturally easy for the participants to indulge in tangential conversation, thus putting their efforts to attain the learning objectives at a risk (Hodge *et al*., 2010).

Another important aspect in online communication is the each member of a discussion group needs to be responsible in their comments, sensitive to others' feelings, and accommodative in accepting others' opinions or suggestions (Zhan, *et al*., 2015). Just like in face-to-face communication, such online communication also needs these positive attributes so much so that their discussion would result in consensual agreement or common understanding, which could help solve a given problem. Essentially, a facilitator is needed to moderate their discussions in a timely fashion, the result of which would make each student more willing to work in a team and display a high level of collaborative responsibilities (Hämäläinen & Häkkinen, 2010).

In this study, the participants used multimedia materials or contents for their learning activities. Specifically, these materials consisted of texts, images, audio narration, and video relating to the specific topic of ICT Competency course, namely the Computer System. Therefore, learning activities using these materials needed to be structured to allow smooth progression of learning. These materials needed to be developed and used according to a logical flow as depicted in Figure 4.6.1.

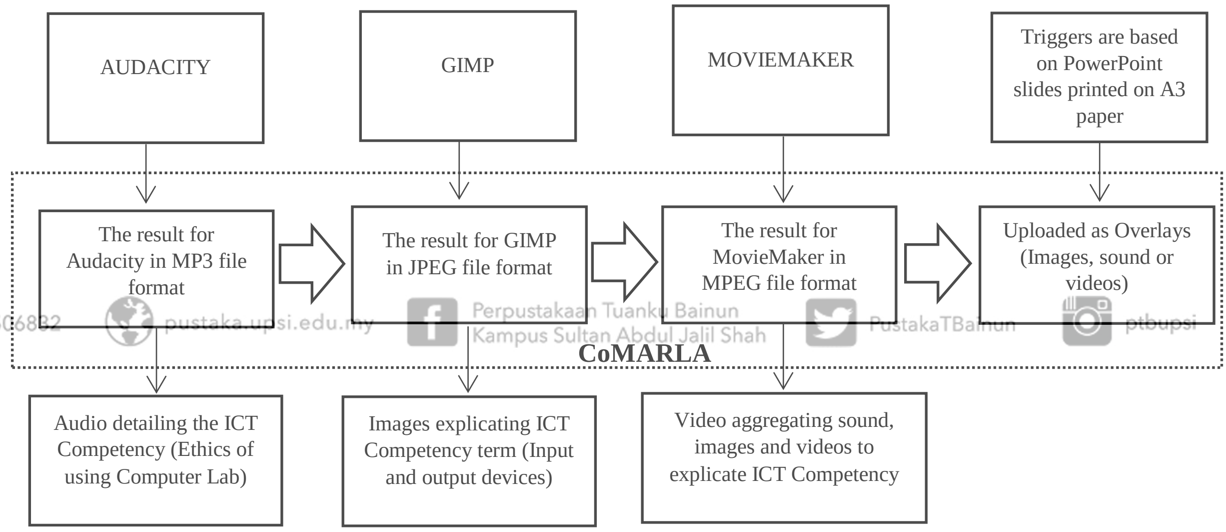

Figure 4.6.1. The Logical Flow of the Construction of Multimedia Learning Materials

In essence, the development of these learning materials consisted of relevant audio, graphic, and video elements. The audio element, which was produced using Audacity software, narrates relevant information on the selected topic of learning. The graphic element comprising appropriate images, which were produced using GIMP, provides vivid visual information pertaining to important concepts of the learning topic. The video element, which was produced using MovieMaker, facilitates explain in detail the important elements of the learning topic. These materials could be accessed by the participants when overlay images were created accordingly based on trigger images, which were printed on A3-sized paper. To implement such learning materials, the participants used their mobile phone camera to scan the trigger images. Once scanned, relevant learning materials would be downloaded on their mobile devices using the CoMARLA learning application. Thereof, the participants used these materials in their learning activities, in which relevant discussions took place over the online communication site. The outputs of such discussions were later saved as documents that made available to all group members using the online documentation, namely google documents.

4.7 Learning Activities in Mobile Augmented Reality Learning Application

In learning the topic of Computer System about the ICT Competency course, the participants were required to carry out a series of tasks using the Mobile Augmented Reality Learning Application (CoMARLA). These activities entailed the participants to use cognitive tools to help them perform their tasks, and in doing so, they learned the principles, concepts, and learning facts about the topic. Using the cognitive tools, they produced their final work using an array of elements, namely text, audio, graphics, and videos. In partaking in such activities using these multimedia elements, they were able to acquire the knowledge and skills pertaining the subject matter with a sense of accomplishment and motivation, which are two aspects of learning that are important in any academic endeavour (Adesope & Nesbit, 2013).

One of the important elements in learning is the audio element by which learners can listen to in understanding relevant concepts, issues, or factors of a learning topic. For example, an audio file can be played on the computer to help learners learn the basic hardware of the computer system. Obviously, such an audio file needs to be developed in such a way that it can deliver the messages clearly to the listeners. This smoother delivery of audio narration can be achieved using appropriate software, such as Audacity software. Using this software, spoken words by students, *lecturer*s, or instructors can be recorded and saved as audio files using several formats, but the MP3 file format is normally used because of its small memory size, allowing faster downloading. (Dascălu *et al*., 2014). Figure 4.7.1 shows the interface of the audio-editing software in recording and editing such a sound source.

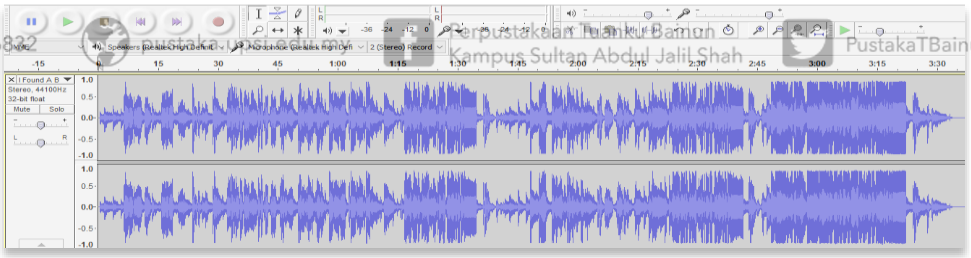

Figure 4.7.1. The Interface of Audacity Software for Sound Editing

The audio-editing software can be downloaded from the relevant website as follows: http://www.audacityteam.org/download/. To make use of such audio files in the learning process, they can be embedded in presentation slides or videos. With this editing software, students can perform numerous activities, such as extracting the vocal from a song or adding sound narrative to a blank audio file. Figure 4.7.2 and Figure 4.7.3 depict the process of removing the vocal from an MP3 song. In undertaking these activities, students can develop relevant technical skills that help them become more articulate in exploring the digital realm.

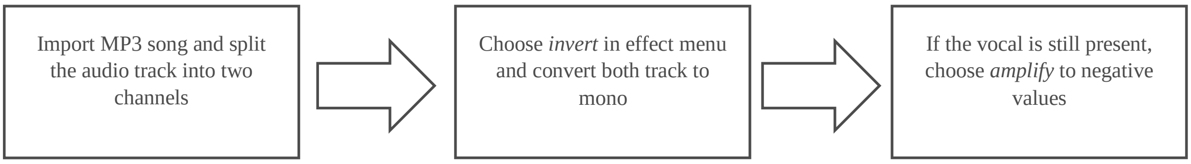

Figure 4.7.2. The Process of Removing Vocal from an MP3 song

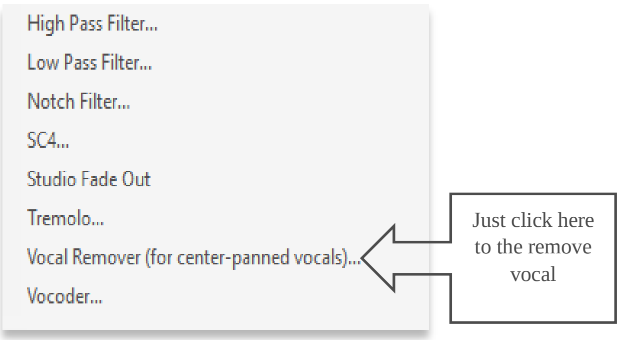

Figure 4.7.3. The Predefined Effect of Removing Vocal

Using the Aurasma software, overlay images are needed to trigger events in the AR learning environment. These images can be developed and edited using the image-editing software, namely GIMP software. This editing software can be obtained freely by downloading the installation file from the website as follows: www.gimp.org. Such images can be printed on A3-sized paper, which can serve as a poster containing trigger images. Using a mobile device (that has been installed with CoMARLA), pointing the camera of the device toward these images will trigger events that download relevant multimedia elements on the device. Figure 4.7.4 demonstrates the interface of GIMP software to edit an image.

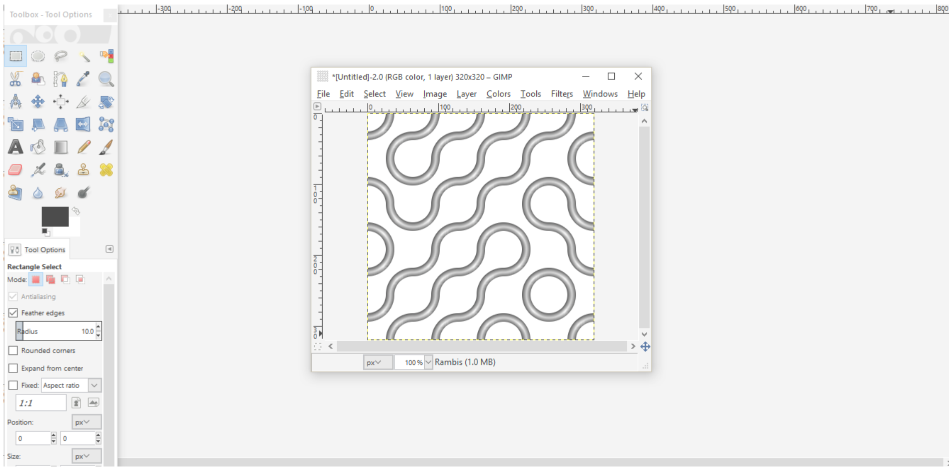

Figure 4.7.4. The Interface of GIMP Software to Edit Images as Trigger Images

Stimulatingly, images produced by GIMP can later be edited using Aurasma such that they can be viewed as three-dimensional (3D) objects as depicted in Figure 4.7.5. Essentially, a 3D object is defined based on three dimensions, namely width, height, and depth. These dimensions are represented in a three-coordinate system, in which width, height, and depth are measured along the *x*, *y* and *z*, respectively.

Figure 4.7.5. The 3D Viewing Option in Aurasma

Furthermore, rendering and transforming such objects can be performed using the Aurasma software. Transformation can be achieved by scaling, rotation, and translation to produce any particular objects deemed relevant for learning purposes. For this software, the transformation of objects is based on anchor points that determine the direction and curvature of objects. More importantly, these points need to be delineated conscientiously by users to ensure the resultant objects or overlay images will have the correct precision. Figure 4.7.6 shows the anchor points for the scaling, rotation, and translation of objects.

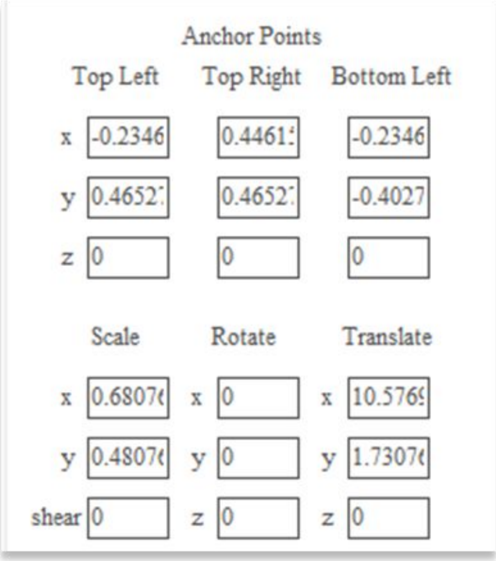

Figure 4.7.6. The Anchor Points for the Scaling, Rotation, and Translation of an Object

In addition, all of the movements of an object are linked with the position of anchor points only that controls its behaviour. For example, if the anchor points are defined far away from the object or overlay images, the resultant model will rotate in a peculiar direction, not in the anticipated direction. Alternatively, if the anchor points are defined with the object, the resultant model will spin about its centroid. This kind of behaviour will be useful in modelling objects representing mechanical components, such as car wheels or helicopter rotors.

Using video presentation on learning is a compelling, attractive method to help students learn. With appropriate videos, students can learn certain learning topics, especially involving procedural knowledge, more forceful compared with learning that relies of text only. In today's digital realm, not only *lecturer*s can develop learning videos, but students too can perform such a feat using user-friendly video editing software (Umar & Hassan, 2015). Later, such videos can be uploaded to several online-video hosting platforms, notably YouTube, enabling others to use these materials for learning purposes (Orús *et al.*, 2016). Students can access such online videos freely and readily so much so that these materials can be shared among themselves. This intimate sharing of learning materials helps create a strong community of students, in which collaborative learning can take place with ease. One of the popular video-editing software used for producing educational videos is Moviemaker, the interface of which is shown in Figure 4.7.7.

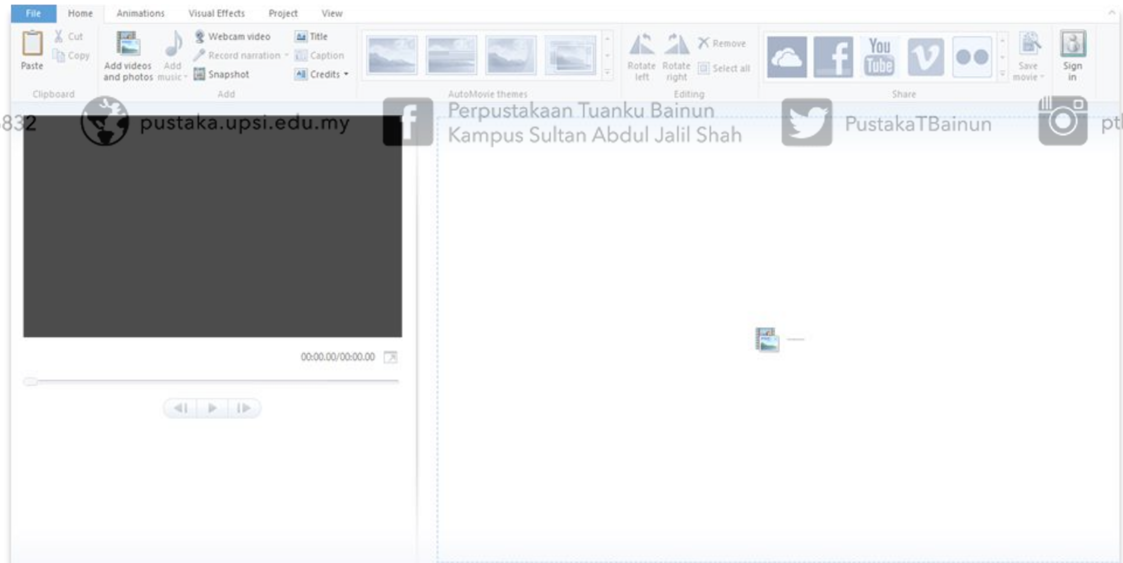

Figure 4.7.7. The Interface of Movie Maker

Videos developed specifically for learning or training purposes are an important cognitive tool that help students learn constructively. More importantly, concepts that are perplexing to learn can be explained more clearly using well-crafted video that can highlight their underlying principles through some special effects (Kon *et al*., 2015). In addition, demonstration videos are highly effective in learning that focuses on procedural knowledge, such as learning to assemble or dissemble parts, in which visual and audio information can be blended harmoniously to highlight such steps (Merkt *et al*., 2011). By utilizing Aurasma software, such videos can be developed and played with ease. Furthermore, these videos can be expended on mobile devices to augment a particular learning process.

4.8 Summary

The development of the collaborative mobile augmented learning application, CoMARLA, was guided by the conceptual framework of constructivist learning based on three principles namely as endogenous, exogenous, and dialectical elements. These elements assure that learners can learn in an environment that promotes a constructivist learning - learning that is student-focused - in which students can learn actively and collaboratively. Furthermore, the learning materials, contents, and structure were developed using Aurasma software, which is an augmented reality content development tool. All of these elements and materials were then harmoniously coalesced and packaged as a mobile learning application running on a mobile phone. In order to assure learning takes place efficaciously, the learning activities were structured and appropriate cognitive tools, such as image-, audio-, and video-editing tools, were materialize to assist students accomplish their learning tasks using such a novel learning tool.

CHAPTER 5

RESEARCH FINDINGS

5.1 Introduction

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This chapter provides a detailed account of the findings of the analyses of data encompassing the pre-testing and post-testing of participants' learning performance and motivation, testing of analysis of covariance (ANCOVA) assumptions, analysis of paired t-test and ANCOVA, testing of research hypotheses, and measurement of user acceptance of the mobile learning application. The detailed account of each analysis and finding are discussed in the following sections:

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5.2 Measurements of Learning Performance and Motivation Before and After Treatment

The measurements of learning performance and motivation before and after treatment of all the participants were carried out using the set of a multiple choice question and Intrinsic Motivation Iventory(IMI), respectively (see Chapter 3 for details). Learning performance was calculated based on the percentage of correct answers out of 50 questions, and motivation was calculated based on the mean score of item responses. Table 5.2.1 summarizes the mean percentage of learning performance and a mean score of motivation before and after treatment.

Table 5.2.1

Learning Performance and Motivation Before and After Treatment

Measure	Pre-test			Post-test		
	n	Mean	*SD*	*n*	Mean	*SD*
Learning Performance	120	62.37	3.52	120	77.39	6.30
Motivation	120	3.77	.49	120	4.07	.40

The table shows that the participants had a mean percentage of 62.37 (*SD* = 3.52) before treatment and 77.39 (*SD* = 6.30) after treatment for the learning performance measure. For motivation measure, they had a mean score of 3.77 (*SD* = .49) before treatment and 4.07 (*SD* = .40) after treatment.

5.3 Measurements Learning Performance and Motivation After Treatment by Learning Method

The descriptive statistics of learning performance and motivation after treatment by learning method (mobile learning using CoMARLA vs. desktop learning using similar application) are shown in Table 5.3.1.

Table 5.3.1

Learning Performance and Motivation After Treatment by Learning Method

Learning method	Measure					
	Learning Performance			Motivation		
	n	Mean	*SD*	*n*	Mean	*SD*
Mobile Learning (using CoMARLA)	60	81.79	5.71	60	4.08	.54
Desktop Learning (using similar application)	60	73.00	2.85	60	4.06	.21

For learning performance measure, participants who used mobile learning (using CoMARLA) had a mean percentage of 81.79 (*SD* = 5.71) after treatment, whereas those participants who used desktop learning (using similar application) had a mean percentage of 73.00 (*SD* = 2.85) after treatment. Evidently, participants who received mobile learning treatment attained higher learning performance compared to those who received desktop learning treatment, as highlighted in Figure 5.3.1.

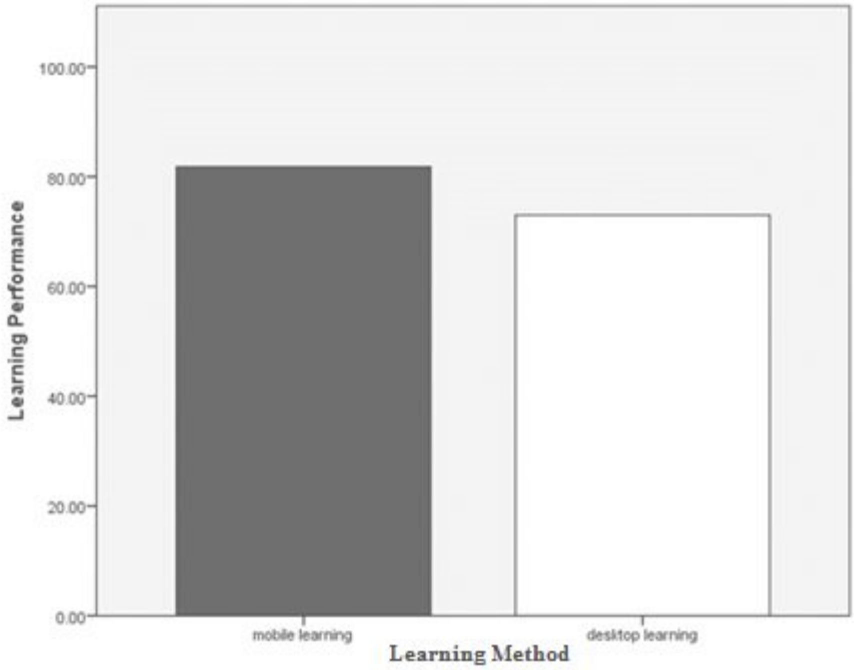

Figure 5.3.1. Learning Performances Based on Learning Method

For motivation measure, participants who used mobile learning (using CoMARLA) had a mean score of 4.08 (*SD* = .54) after treatment, whereas those participants who used desktop learning (using similar application) had a mean score of 4.06 (*SD* = .21) after treatment. Clearly, participants who received mobile learning treatment and those who received desktop learning treatment attained equivalent motivation, as highlighted in Figure 5.3.2.

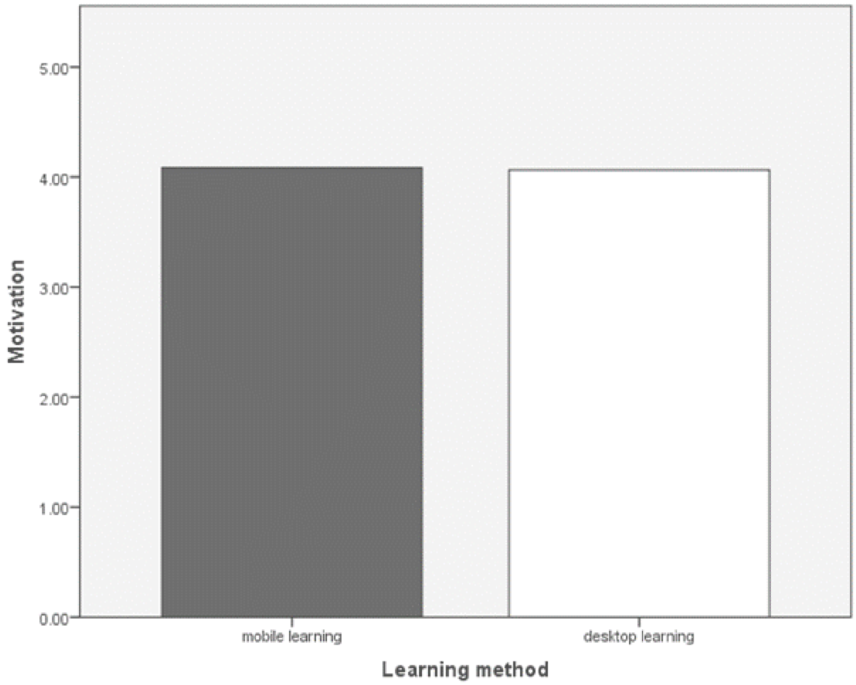

Figure 5.3.2. Motivation Based on Learning Method

5.4 Measurements Learning Performance and Motivation After Treatment by Gender

The descriptive statistics of learning performance and motivation after treatment by gender (female participants vs. male participants) is shown in Table 5.4.1.

Table 5.4.1

Learning Performance and Motivation After Treatment by Gender

Gender	Measure					
	Learning Performance			Motivation		
	n	Mean	*SD*	*n*	Mean	*SD*
Female	75	76.21	4.98	75	4.23	.24
Male	45	79.37	7.70	45	3.80	.46

For learning performance measure, female participants had a mean percentage of 76.21 (*SD* = 4.98) after treatment, whereas male participants had a mean percentage of 79.37 (*SD* = 7.70) after treatment. Evidently, the latter achieved higher learning performance compared to the former, as highlighted in Figure 5.4.1.

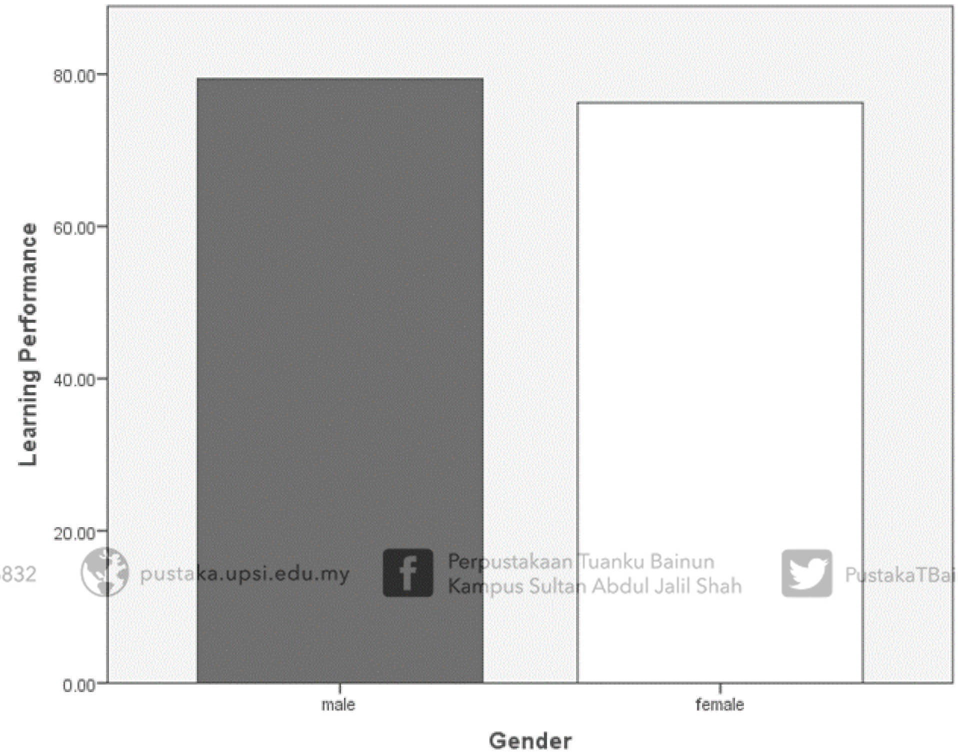

Figure 5.4.1. Learning Performances Based on Gender

For motivation measure, female participants had a mean score of 4.23 (*SD* = .24) after treatment. Whereas male participants had a mean percentage of 3.80 (*SD* = .46) after treatment. Clearly, female participants seemed more motivated than male participants. Figure 5.4.2 depicts the mean scores of motivation of female and participants after they completed the learning sessions.

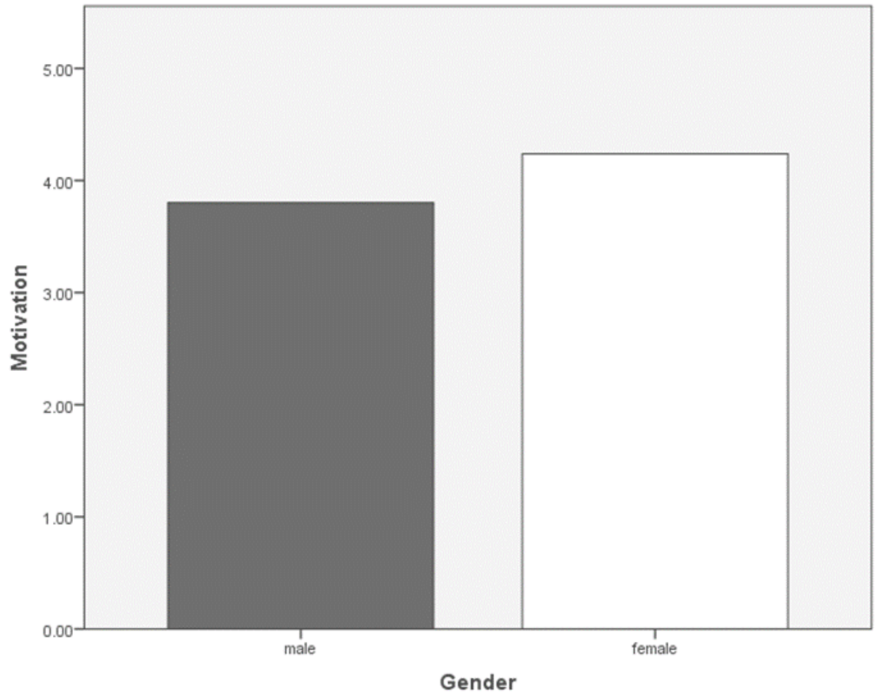

Figure 5.4.2. Motivation Based on Gender

5.5 Testing of the assumptions of ANCOVA

There are several assumptions that must be analyzed before attempting to use ANCOVA. These assumptions are described as follows:

a) *Normality*: For each group, each dependent variable must represent a normal distribution of scores. Furthermore, any linear combination of dependent variables must be normally distributed. Transformation or removal of outliers can help ensure this assumption is met. Violation of this assumption may lead to an increase in Type I error rates (Meyers *et al*., 2013).

b) *Independence of observations*: Each observation must be independent of all other observations; this assumption can be met by employing random sampling techniques. Violation of this assumption may lead to an increase in Type I error rates (Meyers *et al*., 2013).

c) *Homogeneity of variances*: Each dependent variable must demonstrate similar levels of variance across each independent variable. Violation of this assumption can be conceptualised as a correlation existing between the variances and the Mean of dependent variables. This violation is often called *homoscedasticity* and can be tested for using the Levene's test.

d) *Homogeneity of covariance*: The intercorrelation matrix between dependent variables must be equal across all levels of the independent variable. Violation of this assumption may lead to an increase in Type I error rates as well as decreased statistical power (Meyers *et al*., 2013).

e) *Moderate correlations of the dependent variables*: The correlations among the dependent variables should be significant with moderate strengths, with coefficient correlations *r* ranging from .2 to .6. (Meyers *et al*., 2013).

5.5.1 Testing of Normality

To test the normality assumption, graphs based on *Normal Q-Q Plot* were plotted to observe if the data were normally plotted or not. As shown in Figure 5.5.1.1 and

Figure 5.5.1.2, the data on learning performance were normally distributed for both the control and experimental groups, indicating that the assumption of normality was not violated (Zimmerman, 1998; Osborne & Waters, 2002; Finch, 2005; Gibbons *et al.*, 2011).

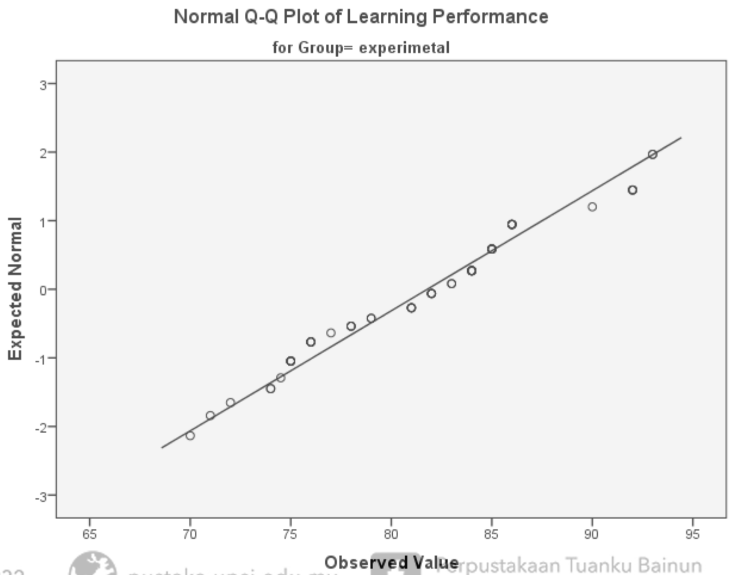

Figure 5.5.1.1. Normal Q-Q Plot of Learning Performance of Participants using CoMARLA on a Mobile Phone

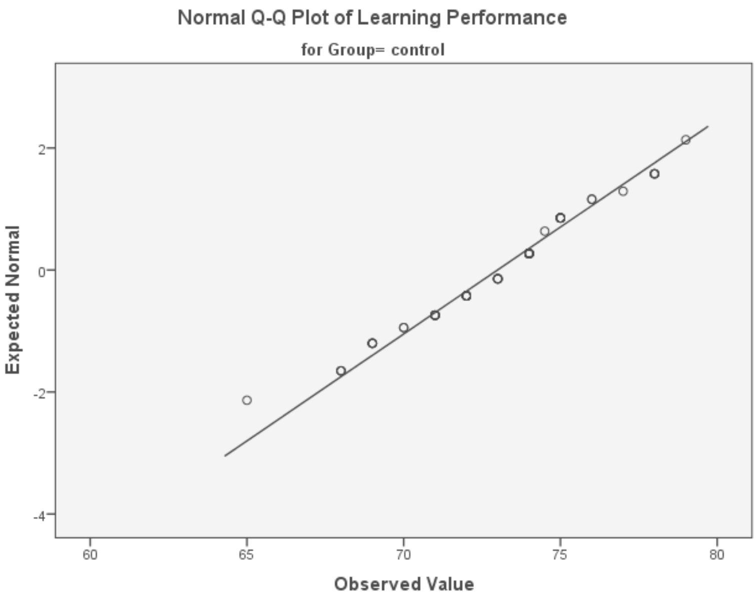

Figure 5.5.1.2. Normal Q-Q Plot of Learning Performance of Participants using a Similar Application on a Desktop Computer

Similarly, the same type of graphs was plotted for the motivation construct as shown in Figure 5.5.1.3 and Figure 5.5.1.4. Once more, the plotted graphs show that the assumption of normality for motivation was not violated.

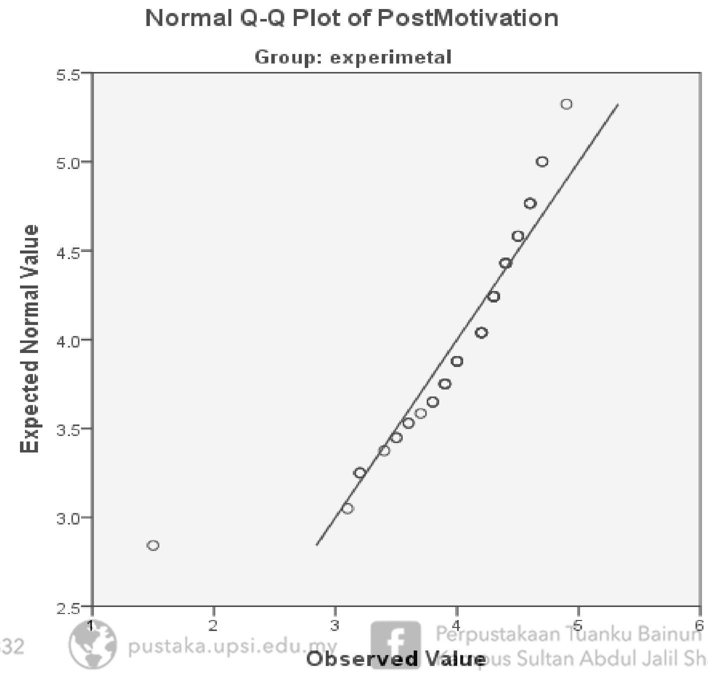

Figure 5.5.1.3 Normal Q-Q Plot of Motivation of Participants using CoMARLA on a Mobile Phone

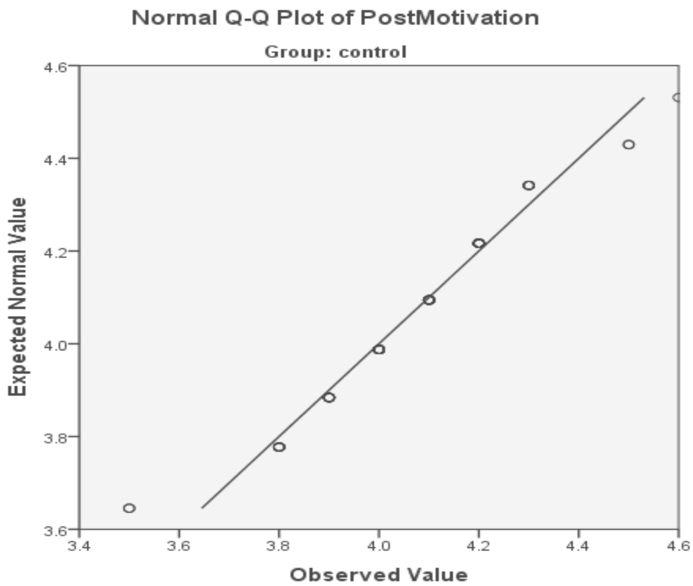

Figure 5.5.1.4. Normal Q-Q Plot of Motivation of Participants using a Similar Application on a Desktop Computer

The Shapiro-Wilk Test was then performed to verify the above finding. This test showed that the learning performances of participants who used CoMARLA on mobile phone (*p* > .06) and those who used similar application on a desktop computer (*p* > .07) were normally distributed (Filliben, 1975; D'agostino *et al*., 1990; Mudholkar, 1995; Razali & Wah, 2011).

5.5.2 Testing of Correlations between Dependent Variables

Bivariate correlation analysis was performed on the dependent variables, namely learning performance and motivation, to examine whether there was a reasonable correlation between the two variables (Pintrich & De Groot, 1990; Ragasa, 2008). For MANCOVA, the assumption is that these two variables must be moderately correlated with one another, with correlation coefficients ranging from .20 to .60 (Meyers *et al.*, pp. 212, 2013). In this study, the Pearson Correlation procedure was carried out to examine such a relation. Table 5.5.2.1 summarizes the result of the correlation analysis performed.

Table 5.5.2.1

Pearson Correlation Matrix for the Dependent and Independent Variables

Measure	1	2	3	4
1. Learning Performance	-			
2. Motivation	.14*	-		
3. Learning Method	.70**	.02	-	
4. Gender	.24**	.52**	.02	-

*p < .05, **p < 0.01

The computed coefficient for the correlation between learning performance and motivation was .14. Clearly, the correlation between these two dependent variable was weak in magnitude. Thus, the assumption of MANCOVA for dependant variables to be moderately correlated did not hold true, indicating that ANCOVA should be expended instead on MANCOVA.

5.5.3 Testing of Homogeneity of Variances

Boxplots were generated to provide visual highlights of the distributional spread of the dependent variables across groups or levels (McGill *et al*., 1978; Hoaglin *et al*., 1983; Massart *et al*., 2005) . Nevertheless, boxplots are the ideal way of comparing distributions when two or more data sets are being compared peculiarly on motivation and learning performance. Figure 5.5.3.1 and Figure 5.5.3.2 depict the Boxplots of learning performance and motivation of the experimental and control group, respectively.

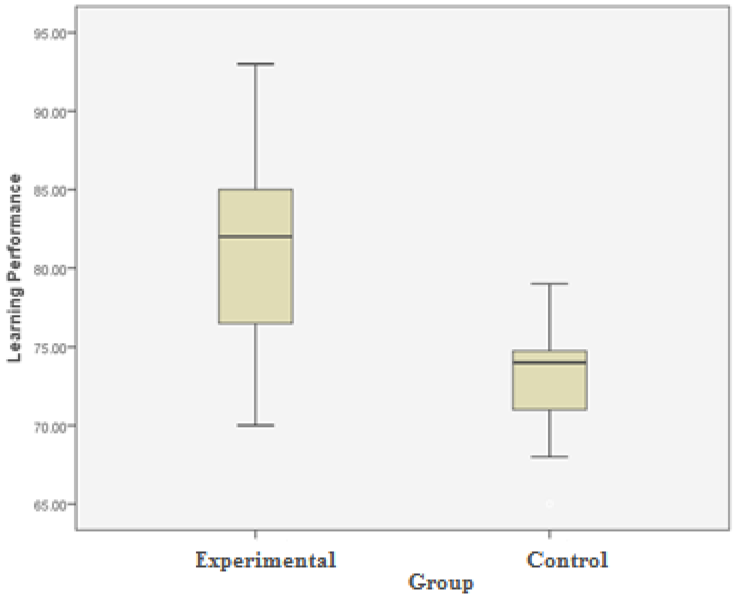

Figure 5.5.3.1. The Boxplot of Learning Performance Based on the Group

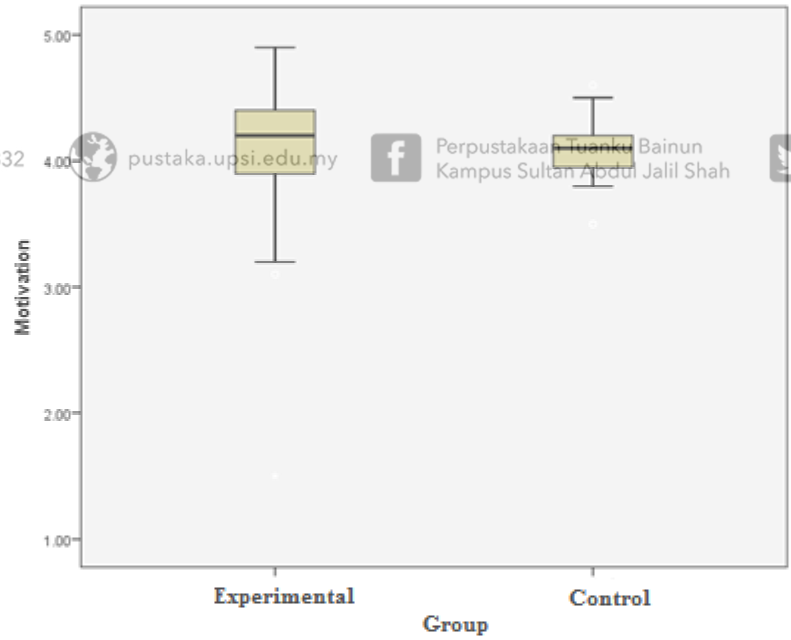

Figure 5.5.3.2. The Boxplot of Motivation Based on the Group

From the plots, the total length of the boxplots were not exactly the same for both groups. Distinctly, the spread of observations of the experimental group was greater than the spread of observations for the control. This visual inspection showed that the variances of these two groups were quite different. To test the assumption of variance, the Levene's Test of Equality of Variance was performed on the data using the General Linear Model (GLM) procedure. The findings confirmed that the variances of both measures (dependent variables) were significantly different across all levels of the independent variable, suggesting that the use of ANCOVA might not be appropriate. Table 5.5.3.1 summarizes the findings of this analysis.

Table 5.5.3.1

Levene's Test for Equality of Variances

	F	df1	df2	Sig.
Learning Performance	9.01	3	116	.000**
Motivation	8.80	3	116	.000**

** $p < .001$

5.5.4 Testing of Homogeneity of Covariance

Prior to testing the assumption of homogeneity of covariance, scatterplots of the pre-tested measures (the covariates) against the post-tested measure (the dependent variables) was plotted with regression slopes. Essentially, the lines of the regression slopes indicate the relations between the variables for each group. Figure 5.5.4.1 and Figure 5.5.4.2 depict the scatterplots of the learning performance and motivation before and after the learning sessions, respectively.

Based on the regression slope as shown in Figure 5.5.4.1, the relations between learning performances before and after the learning sessions were quite the same for both groups, indicating that the assumption of homogeneity of covariance was not violated (Glass *et al*., 1972; Pintrich & De Groot, 1990; Gabrielle, 2016).

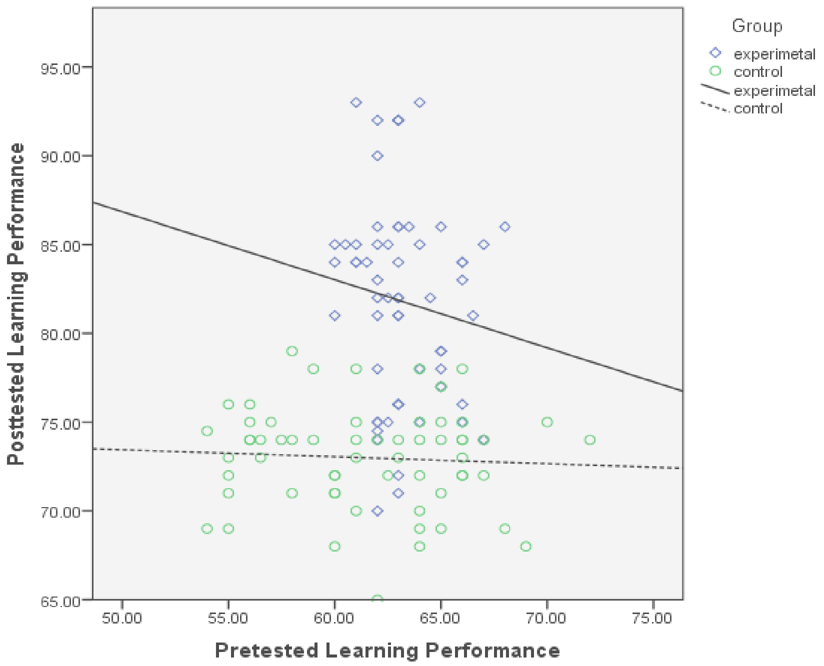

Figure 5.5.4.1. Scatter Plot of Learning Performances Before and After Learning

Nonetheless, the relations between motivation before and after the learning sessions, as shown in Figure 5.5.4.2, were not quite the same for both groups. In addition, the two regression slopes differed, suggesting that the assumption of homogeneity of covariance might have been violated. To confirm, the Box's test of equality of covariance matrices was performed on the data using the General Linear Model (GLM) procedure to determine whether such violation did occur or not (Nelder & Baker, 1972; Freund & Littell, 1981). Table 5.5.4.1 summarizes the finding of this analysis.

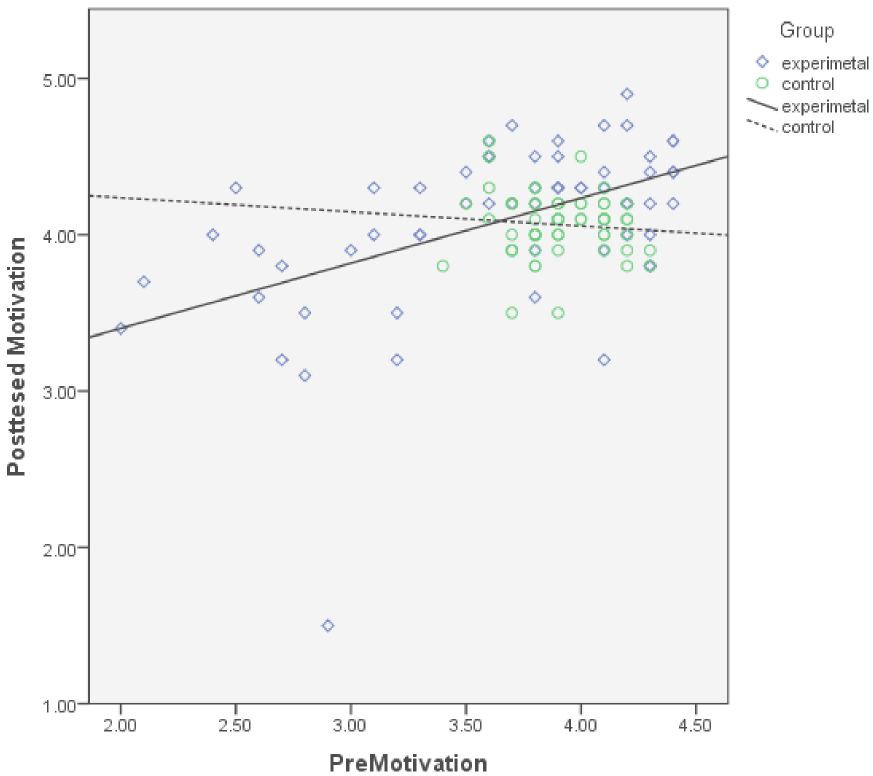

Figure 5.5.4.2. Scatter Plot of Motivation Before and After Learning

From Table 5.5.4.3, the Box's M value of 76.15 was associated with a *p* value of .001, which was interpreted as significant based on Huberty and Petoskey's guideline (Grise & Iwasaki, 2007; Warren, 2016). Thus, the covariance matrices between the groups were not equivalent, which violated the assumption of homogeneity of covariance.

Table 5.5.4.3

Box's Test of Equality of Covariance

Box's M	76.15
F	8.18
df1	9
df2	70335
Sig.	.000**

** $p < .001$

Based on the above results of the testing of assumptions, the use of MANCOVA might not be suitable, particularly when the correlation between the independent variables (learning performance and motivation) was found to be low ($r = .14$) , which is below the recommended range of .2 to .6 (Meyers *et al*., 2013). In light of this finding, the researcher opted for conducting analysis based on two separate ANCOVAs, one for learning performance and the other for motivation.

Even though the equality of variances was not established, the use of ANCOVA is nonetheless robust to such violations (Rogan & Keselman, 1977; Pituch *et al*., 2015). This is particularly true for the case in which the sample size is sufficiently large and the numbers of subjects in all groups of treatments are almost equal (Grise & Iwasaki, 2007; Campbell & Stanley, 2015), which was exactly the case for this study.

5.6 The Testing of the Research Hypotheses

Altogether, this study has six (6) research hypotheses that assisted the researcher to address the research objectives. Accordingly, these research hypotheses were tested through appropriate statistical procedures, namely the paired *t*-test and analysis of covariance (ANCOVA), the results of which determined whether such hypotheses were accepted or not accepted. The detailed accounts of such testing are as follows:

5.6.1 The Testing of the First and Second Research Hypotheses

The first research hypotheses states that the learning performance of participants after treatment would differ significantly from their learning performance before treatment. The second research hypotheses states that the motivation of participants after treatment would differ significantly from their motivation before treatment. Testing these two hypotheses entailed the use of paired t-test procedure. Table 5.6.1.1 summarizes the results of such analysis.

Table 5.6.1.1

The Differences Between Learning Performance and Motivation Before and After Learning For All Participants

Measure	Before		After		Difference		Significance
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	
Learning Performance	62.37	3.52	77.39	6.30	15.02	6.84	.000**
Motivation	3.77	4.93	4.08	.40	.31	.49	.000**

** $p < .001$

Immediately after learning, the paired t-test was performed to examine if the difference between the participants' learning performances before and after learning was significant or otherwise. The test indicated that the participants achieved a significant gain in learning performance, t (119) = 24.05, p = .001. Specifically, the participants gained a mean percentage of 15.02 (*SD* = 6.84) in learning performance measure (see Table 5.5). Thus, this finding provided strong evidence to support the first research hypothesis.

The same analysis indicated that the participants achieved a significant gain in motivation, t (119) = 6.81, p = .001. In fact, the participants gained a mean score of .31 (*SD* = .49) in the motivation measure (see Table 5.6.1.1). As such, this significant finding provided evidence to support the second research hypothesis of the study.

5.6.2 The Testing of the Third and Fourth Research Hypotheses

The third research hypothesis states that the learning performance of participants who used CoMARLA on a mobile phone would differ significantly from the learning performance of participants who used similar application on a desktop computer. The forth research hypothesis states that the learning performance of female participants would differ significantly from the learning performance of male participants. Testing these two hypotheses entailed the use of Analysis of Covariance (ANCOVA). Table 5.6.2.1 summarizes the results of the analysis.

Table 5.6.2.1

Tests of Between-Subjects Effects(Learning Method)

Source	Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Corrected Model	2935.70	4	733.92	47.04	.000
Intercept	2033.15	1	2033.15	130.30	.000
Pretested Learning Performance	.466	1	.46	.03	.863
Learning Method	2475.07	1	2475.07	158.62	.000**
Gender	245.59	1	245.59	15.74	.000**
Learning Method * Gender	358.01	1	358.01	22.94	.000**
Error	1794.39	115	15.60		
Total	723466.50	120			
Corrected Total	4730.09	119			

** $p < .001$

The analysis of learning performance was based on learning method (mobile learning vs desktop learning) and gender (female vs male) as between-subjects factors. The analysis revealed a significant main effect attributed to learning method, F (1,115) = 158.62, p = .001), where the group that used mobile learning attained a mean percentage of 81.79 compared to the group that used desktop learning that attained a mean percentage of 73.00. Evidently, the former significantly outperformed the latter in learning performance, thus providing evidence to support the third research hypothesis.

Similarly, the same analysis revealed a significant main effect attributed to gender, F (1,115) = 15.74, p = .001, where male participants attained a mean percentage of 79.37 compared to female participants who attained a mean percentage of 76.21. Clearly, the former significant outperformed the latter in learning performance, thus providing evidence to support the forth research hypothesis.

5.6.3 The Testing of the Fifth and Sixth Research Hypotheses

The fifth research hypothesis states that the motivation of participants who used CoMARLA on a mobile phone would differ significantly from the motivation of participants who used similar application on a desktop computer. The sixth research hypothesis states that the motivation of female participants would differ significantly from the motivation of male participants. Again, testing these two hypotheses entailed the use of Analysis of Covariance (ANCOVA). Table 5.6.3.1 summarizes the results of such analysis.

Table 5.6.3.1

Tests of Between-Subjects Effects (Motivation)

Source	Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	7.41	4	1.85	17.78	.000
Intercept	14.36	1	14.36	137.8	.000
Covariate	.08	1	.08	.73	.396
Learning Method	.003	1	.003	.03	.859
Gender	3.54	1	3.53	33.95	.000**
Learning Method * Gender	.91	1	.91	8.77	.004*
Error	11.98	115	.10		
Total	2011.25	120			
Corrected Total	19.39	119			

*$p < .05$, ** $p < .001$

The analysis of motivation was based on learning method (mobile learning vs desktop learning) and gender (female vs male) as between-subjects factors. The analysis showed that the main effect attributed to learning method was not significant, F (1,115) = .03, $p > .05$, where the group that used mobile learning attained a mean score of 4.08 compared to the group that used desktop learning that attained a mean percentage of 4.06. Obviously, both groups attained equivalent gains in motivation after treatment. As such, there was no evidence to support the fifth research hypothesis of the study.

However, the same analysis indicated that the main effect attributed to gender was significant, F (1,115) = 33.95, p < .001, where male participants attained a mean score of 4.23 compared to female participants who attained a mean score of 3.80. Clearly, the former were more motivated than the latter during the learning process, thus providing evidence to support the sixth research hypothesis. Table 5.6.3.2 summarizes the findings of all the research hypotheses of the study.

Table 5.6.3.2

Statistical Procedures for Testing the Research Hypotheses

Research Hypothesis	Statistical Procedure	Finding
a) The learning performance of participants after treatment would differ significantly from their learning performance before treatment.	Paired *t*-test	Supported
b) The motivation of participants after treatment would differ significantly from their motivation before treatment.	Paired *t*-test	Supported
c) The learning performance of participants who used CoMARLA on a mobile phone would differ significantly from the learning performance of participants who used similar application on a desktop computer.	ANCOVA	Supported
d) The learning performance of female participants would differ significantly from the learning performance of male participants.	ANCOVA	Supported
e) The motivation of participants who used CoMARLA on a mobile phone would differ significantly from the motivation of participants who used similar application on a desktop computer.	ANCOVA	Not supported
f) The motivation of female participants would differ significantly from the motivation of male participants.	ANCOVA	Supported

5.7 User Acceptance of the Mobile Augmented Learning Application

Questionnaire based on Venkatesh *et al.*'s (2003) model of the Unified Theory of Acceptance and Use of Technology (UTAUT) was used to measure the user acceptance of the mobile augmented learning application (CoMARLA). This research instrument assisted measure the relevant construct such as performance expectancy, effort expectancy, social influence, facilitating conditions, behavioural intention, and use behaviour. The questionnaire comprised of 21 items, each of which was rated along a 5-point Likert-type scale. Table 5.7.1 summarizes the mean score of the six constructs.

Table 5.7.1

The Mean Score of Constructs of User Acceptance of CoMARLA

Construct	Mean	SD
Performance expectancy	4.42	.671
Effort expectancy	4.47	.812
Social influence	4.35	.860
Facilitating conditions	4.18	.930
Behavioural intention	4.55	.594
Use behaviour	4.32	.513

The analysis showed that the mean scores of performance expectancy and effort expectancy were 4.42 and 4.47, respectively, which were clearly high. Similarly, the participants rated social influence and facilitating conditions high, as evidenced by their high mean scores of 4.35 and 4.18, respectively. Likewise, behavioural intention and use behaviour were rated highly by the participants, as indicative of the higher mean scores of 4.55 and 4.32, respectively.

5.8 Summary

Overall, the testing of the research hypotheses showed that the participants made significant gains in learning performance and motivation after learning sessions. Moreover, participants who applied CoMARLA for mobile phone and male participants significantly outperformed those who used similar application on the desktop and female participants, respectively. Interestingly, both groups were found to be equally motivated in learning the sub-topics of the ICT Competency course; nevertheless, male participants presented higher motivation than female participants in learning. In addition, the user acceptance of CoMARLA was highly rated by the participants, underscoring its usefulness and utility.

CHAPTER 6

DISCUSSIONS AND CONCLUSION

6.1 Introduction

The final chapter of this dissertation provides a detailed discourse of the impact of the use of a collaborative mobile augmented learning application on undergraduates' learning performance and motivation in learning a topic of the ICT Competency course. More importantly, the research findings are discussed in light of their practical implications to the current teaching and learning practice in Malaysian public universities. In addition, the discussion is also directed toward the development of such novel learning tools using the proposed development framework, as derived from this study. Finally, the discussion highlights the recommendations for future research and the conclusion of the chapter.

6.2 The Impact of Learning Treatments on Undergraduates' Learning performance and Motivation

The first research hypothesis states that the learning performance of participants after treatment would differ significantly from their learning performance before treatment. The result of the paired t-test carried out showed that participants' learning performance after treatment was significantly higher than their learning performance before treatment (see Table 5.3.1, Chapter 5). As such, this significant finding provides evidence to support the first hypothesis, indicating that the learning treatments underwent for several sessions by the participants managed to improve their learning performance.

The second research hypothesis states that the motivation of participants after treatment would differ significantly from their motivation before treatment. The same test performed indicated that participants' motivation after treatment was significantly higher than their motivation before treatment (see Table 5.3.1, Chapter 5). Again, this similar significant finding provides evidence to support the second hypothesis, indicating that the learning treatments underwent for several sessions by the participants managed to improve their motivation in learning the subject matter.

Given the above promising, positive findings, it would be reasonable to assert that social sciences undergraduates may, and can, achieve better learning performance and become more motivated in learning the mandatory course by undergoing specific learning methods that facilitate collaboration. From the social-constructivist standpoint, such a learning approach helps students of various cognitive abilities to learn more efficaciously (Overbaugh & Casiello, 2008).

Moreover, through online social negotiation, the less able students will be given appropriate scaffolds (from peers and instructor) and close supervision (from the instructor) to guide their learning. In contrast, for the more able students, they can become more articulate, creative, and acute through such collaboration, as their social skills and content knowledge are further enhanced more profoundly (Gehlbach *et al.*, 2015).

These interesting, promising findings provide hope and assurance to practitioners (especially lecturers and instructors) to adopt such a learning approach in which their students can engage in collaborative learning using novel learning tools, such CoMARLA, on either mobile devices or desktop computers. Using such tools, their students can deeply engage in discussion pertaining to assigned tasks or projects with a greater sense of motivation, thus resulting in higher commitment and conviction. Therefore, learning is enhanced through improved social negotiation, resulting in better learning performance and motivation (Lee *et al.*, 2016).

6.3 The Impact of Mobile Augmented Learning Application on Learning Performance of Undergraduates Based on Learning Method and Gender

The third research hypothesis states that the learning performance of participants who used CoMARLA on a mobile phone would differ significantly from the learning performance of participants who used similar application on a desktop computer. The results of the ANCOVA showed that the former's learning performance was significantly higher than the latter's learning performance (see Table 5.6.2.1, Chapter 5).

Hence, this significant finding provides evidence to support this hypothesis, indicating that different learning methods would result in different learning performance, which tends to favour students who use novel technology. This finding is consistent with other research findings that show student learning can be enhanced with the use of new technology, such as mobile technology (Aesaert *et al.*, 2017; Mohammad *et al.*, 2016). Arguably, students, in general, will try to use new, novel technology with greater enthusiasm, thus consequently help stimulate their interest in learning (Sung *et al.*, 2016). Immersed in such a state, students will strive to do well in learning, as their stimulated minds will encourage them to take an interest and thus learn about a particular subject (Shankar *et al.*, 2004).

Clearly, mobile learning using CoMARLA was more efficacious than desktop learning using similar application. This finding suggests that there are unique features of mobile devices that can enhance the essential functionalities of certain specific teaching methods (e.g., collaborative learning), and thus promote positive educational outcomes (Sung *et al.*, 2016). As students have their own mobile devices, such "individuality" combined with wireless communication enable more accessible self-paced and self-directed learning (Sung *et al.*, 2016).

Moreover, another feature that empowers collaborative mobile learning process is the portability and context awareness of mobile devices. Together, these two features permit students to exploit the information in the collaborative environment in which they are situated, and to retrieve, record, and react to the data needed to resolve their learning issues by traversing multiple learning settings more efficiently (Liu *et al.*, 2009). Arguably, collaborative learning tasks in this study, when coupled with mobile phone, might be helpful for increasing the interactive behaviours and social cohesions among team members, as opposed to learning using a desktop computer. As such, the increased social cohesion was powerful enough to enhance learning performance (Zurita & Nussbaum, 2007).

The forth research hypothesis states that the learning performance of female participants would differ significantly from the learning performance of male participants. Similarly, the same analysis showed that male participants significantly outperformed female participants (see Table 5.6.2.1, Chapter 5). As such, this significant finding provides evidence to support the fourth hypothesis of the study.

Such findings are not surprising given that many empirical studies of the use of technologies in learning have produced consistent results, showing greatest ability of male students, as compared to female students, to perform well in various technology-enhanced learning environments (Goswami & Dutta, 2016; Grimus, 2014; Michalak *et al.,* 2017; Samsudin & Rafi, 2010). One plausible reason for this gender disparity is due to experiential factor, of which boys are usually more exposed to playing digital games (which are more masculine in nature) at an early age than girls, thus giving the former a huge head start in developing and gaining technology-related skills. In contrast, the latter are exposed to different types of feminine plays that entail a different set of skills, notably social skills (Mitchell & Savill-Smith, 2004).

Such revelations pose some concerns to practitioners in adopting novel mobile learning tools, such as CoMARLA, in the teaching and learning process. Arguably, the use of mobile learning will entail instructors, teachers, or lecturers to closely monitor students' engagement and efforts in the learning process, especially involving online collaboration, to help determine those who may have problems from the onset of such collaborative learning using mobile devices (Rashid & Asghar, 2016). In all probability, this potential problem may materialize among female students, as compared to male students, given the former's moderate enthusiasm in using such a mobile learning tool (Jackson *et al.*, 2010). The same may not transpire among the latter, as male students tend to embrace technology with a greater level of enthusiasm (Karwowski *et al.*, 2016).

6.4 The Impact of Mobile Augmented Learning Application on Motivation Undergraduates based on Learning Method and Gender

The fifth research hypothesis states that the difference in motivation between participants who used CoMARLA application on the mobile platform and those who used similar applications on the PC platform is not significant. The results of the ANCOVA showed that the difference in motivation between participants who used the two learning methods was not significant (see Table 5.6.3.1), thus failing to provide evidence to support the fifth hypothesis. In fact, both learning methods were equally effective in improving the participants' motivation.

This finding thus suggests that using such a mobile augmented reality (MAR) learning tool will have a positive impact on students' motivation, irrespective of the platforms of communication used (i.e., mobile platform or desktop platform). One possible reason for the equivalent gains in motivation is that both learning methods used the same MAR technology, albeit on different platforms, which was new to almost all the participants. As such, it might arouse their curiosity and, ultimately, their motivation to explore the tool. Additionally, the diverse learning contents and modes of learning (using audio, video, and graphics) might be equally compelling to motivate them, which mighty offset any perceived advantages of using one

communication platform over the other in delivering the learning material in the classroom (Low, 2009).

The sixth research hypothesis states the motivation of female participants would differ significantly from the motivation of male participants. Unlike the above previous finding, the results of the Analysis of Covariance (ANCOVA) demonstrated that the difference in motivation between the two genders was significant, which favoured male participants over their opposite counterparts (see Table 5.6.3.1, Chapter 5).

In general, male participants were found to be more motivated than female participants. In fact, this particular finding is consistent with other research findings, which show higher motivation of male students, as compared to female students, in technology-assisted learning (Hu & Hui, 2011; Valderrama-Bahamondez *et al.*, 2011; Zamani, 2014). In light of the above revelation, using novel mobile augmented reality learning tools in the teaching and learning process will probably attract male students more than female students, which would lead to different levels of motivation to learn between male and female students.

Again, these revelations highlight potential problems that the teaching practitioners may encounter when adopting novel mobile learning tools, such as CoMARLA, in the teaching and learning process. As demonstrated, different motivation among male and female students in using new, novel technology may result in one particular gender outperforming the other in learning. Therefore, it becomes the imperative of lecturers or instructors to provide sufficient assistance and guidelines to students, especially female students, in helping them to quickly familiarize with the technology-assisted learning environment.

6.5 The Undergraduates' User Acceptance of the Mobile Augmented Learning Application

Determining the user acceptance or perceived usefulness of any learning applications or tools is extremely important as it provides a measure of the willingness of users, especially students, to continue using such applications on a continual basis, rather than on a sporadic basis (Lee & Osman, 2012). Of course, such perception of user acceptance is influenced by the overall capability or utility of the application to add value to the students' learning process (Pimmer *et al.*, 2016). In this regard, testing the user acceptance of educational applications can be carried out through survey questionnaires, one of which is based on the UTAUT model that has been widely used in many studies that focused on user acceptance of educational technology (Cheng & Mitomo, 2017).

In this study, the participants' perception of user acceptance of the mobile augmented reality learning application was measured using the UTAUT questionnaire, consisting of several items to measure six constructs of user acceptance, namely performance expectancy, effort expectancy, social influence, facilitating conditions, behavioural intention, and use behaviour. Descriptive analysis revealed that all the constructs attained high mean scores, ranging from 4.18 (for facilitating conditions) to 4.55 (for behavioural intention) (see Table 5.71, Chapter 5).

Furthermore, the correlation analysis performed showed that all the above constructs, together a moderating factor (gender), were significantly correlated with moderate strengths (see Table 5.7.2, Chapter 5). As predicted, gender moderated the relations among performance expectancy, effort expectancy, and social influence with behavioural intention, especially for male participants. Hence, this particular finding suggests that gender is a critical factor that may have a strong influence on such perception with regard to the usefulness of novel learning applications (Alsabawy *et al.*, 2016).

The finding of the moderating effect of gender on behavioural intention to use CoMARLA is hardly surprising, given that the ANCOVA analysis showed male participants performed better and were more motivated in learning using the mobile augmented reality application compared to female participants. Arguably, male participants might have regarded or perceived such a novel learning application as extremely indispensable to and highly essential for their learning compared to female participants. Hence, such male participants' perception resulted in significantly higher behavioural intention to use CoMARLA, as opposed to their opposite counterparts' intention.

Several reasons have been put forward to explain such a deferential perception of usefulness of technology applications in the educational context, but they seem to stem from gender socialization, which favours male students (Scherer *et al.*, 2015). Through such socialization, male students become more agile and articulate in using technology devices, notably mobile devices. Male students can learn more and acquire greater skills in using advanced multimedia features of their mobile devices, thus empowering them to learn with higher efficacy (Kühl *et al.*, 2014). Thus, this finding emphasizes the importance of paying more attention to the needs of female students in using mobile devices as the learning tool by which learning takes place (Du & Xu, 2016).

6.6 Implications for the Learning and Teaching Practice

Surely, the research findings of this study will have some implications on the current learning practice of ICT Competency among social science undergraduates in many public universities in Malaysia. As demonstrated in this study, learning applications based on mobile augmented reality (MAR) have a huge potential to help these non-technical students to improve their learning performance and motivation. Specifically, the use of such MAR application is more educationally forceful and efficacious when implemented on mobile platform than on the desktop platform in helping students to engage in collaborative learning activities.

As such, university educators (i.e., lecturers and instructors) should undertake to explore and implement this technology in their current teaching practices. As acknowledged, the teaching and learning of the subject matter fall short of the desired quality, given the prevailing and persistent problems faced by educators, such as the lack of teaching and learning tools, short lecture hours, and lack of opportunity for collaborative learning. Together, these problems have resulted in less than conducive teaching and learning environment that resulted in poor learning performance and motivation among such students.

Given the existing limited teaching resources and time, all concerned, especially lecturers and instructors, should seriously consider using a collaborative mobile learning approach to help improve their teaching practices. In fact, this method has been proven effective in many studies involving self-regulated and independent learning (Sung *et al*., 2016; Tan *et al.*, 2007; Zurita & Nussbaum, 2007). As such, by adopting such an approach, educators could assign their students to group works or assignments, which have to be carried out outside the formal teaching and learning hours.

Nonetheless, implementing this collaborative mobile learning approach in actual practice will not be easy as it was in this experimental study, as many factors would come into play in a real-world setting. As highlighted in this study, gender will certainly play a crucial role in ensuring the success of such a mobile learning approach using MAR technology. Arguably, male students will probably utilize MAR learning applications more enthusiastically and efficiently than female students. In the extreme, the latter may even be initially intimidated or threatened if they are forced to use of untried or unfamiliar applications in their learning activities. This kind of learning setting may be counterproductive, which could negatively affect their psychological wellbeing (Granito & Chernobilsky, 2012).

Hence, such a potential problem needs to be factored in when educators decide to use such MAR learning applications in their teaching practice. Obviously, some sort of familiarization training should be carried out, especially for female students, to help them learn to use such a learning tool prior to performing learning assignments or tasks. With sufficient exposure to or training of such a tool, students will certainly gain the enough confidence and courage to partake in collaborative learning activities. It is therefore turning the imperative of educators to plan and implement appropriate training sessions to help mitigate any disparities in terms of technological experience or skills, which may disadvantage students of a particular gender (Grimus, 2014).

More importantly, in using such MAR applications for collaborative learning, educators need to formulate an effective plan to guide and monitor students' online discourse. Put simply, a wholesale use of such technology in teaching and learning must be avoided at all costs — thus, the needs for planning. Educators must select appropriate topics that are appropriate for such use of technology, as learning topics have varying degrees of depths and breaths. Arguably, some topics may be better taught without the use of such a technology, while some really need it for better delivery and explanation of the contents.

Once a particular topic is selected, educators need to prepare all the essential instructions and guidelines to which students would refer before they start using the mobile application to learn in groups. Specifically, these instructions and guidelines should be prepared in advance to inform students the correct method to access learning resources, to use the application's unique features appropriately, and efficiently conduct collaborative activities using a diverse array of communication platforms (e.g., Facebook and Google Document). In short, students should be carefully guided on how constructing the use of the learning application efficiently and effectively from the very beginning.

In such a collaborative learning setting, students become the active participant, assuming the central role in the learning process. Consequently, this kind of learning shifts educators' role to that of a facilitator (Sormunen, Alamettälä, & Heinström, 2013). In assuming this facilitating role in the collaborative mobile learning, lecturers and instructors should always keep a close watch on their students' activities online. Such close monitoring is needed to help educators to guide, control, and moderate discussions of students' online such as to produce fruitful, meaningful collaborative learning engagement.

In addition, as the facilitator of learning, educators can serve as a mentor to motivate students who show signs of frustration or disinterest in learning. Moreover, as facilitator, educators can serve as a moderator to a learning situation in which there

are conflicting and contentious issues that require immediate resolution. Furthermore, students who collaborate in solving a task might not really understand what they are actually doing at a certain point. As such, educators demand to be able to track this and put students back to a meaningful solution process. All the above scenarios underscore the important role that educators need to undertake if collaborative mobile learning is being implemented in the learning of the ICT Competency in public universities in Malaysia.

6.7 Research Contributions

From the undertaking of this study, several important, promising findings were revealed to assist the researcher to propose and argue the practical significance that they may have on the current practices, both on the learning practices and learning application development practices. The following are the contributions of the research that may further improve the current practices.

6.7.1 Contribution to the Teaching and Learning Practice

This study revealed several interesting, promising results. First, participants were able to improve their learning performance significantly after treatment. Second, they were also able to improve their motivation significantly after treatment. Third, participants who used mobile learning using CoMARLA on mobile phone outperformed those who used desktop learning using a similar application on a desktop computer. Forth, male participants significantly outperformed female participants. Fifth, both learning methods produced equivalent gains in motivation. Sixth, male participants attained significant higher motivation than female participants. Seventh, male participants showed greater behavioural intentions to use such a novel learning application.

From the teaching perspective, the use of such mobile augmented reality application can help improve student learning by engendering an effective environment that fosters collaborative learning. Students can use their mobile devices with greater flexibility and mobility to communicate and discuss with their peers, as well as with their instructor. This improved mobility can enrich students' learning experience as they can gain access to and make use of relevant learning materials or contents anywhere, anytime. Thus, such a mobile application can be effectively used in independent (informal) learning contexts, in which students on the go will be able to practice and rehearse learning activities no matter where they are. Given that such application supports a diverse range of multimedia contents, learning can become more intense and entertaining, which appeals to students from a wide spectrum of educational background. Obviously, such mobile application can be a potent tool to help learning both in the formal and informal setting.

As found in this study, differential attainments of learning performance and motivation between the two genders (which favoured males), highlight their dissimilar orientations toward technology use. Arguably, male students may have a strong inclination to use technology in learning more than their opposite counterparts. Arguably, male students tend to use and embrace technology with more confidence than female students (Yau & Chen, 2012). In a sense, the former can be viewed to be "technology-oriented", whereas the latter "technology-neutral". This finding is consistent with other findings, which in general show male superiority in various learning situations that used an array of technology tools. Many researchers assert that such superiority is not due to biological factors but social factors. More importantly, this particular finding may have some serious implications on the teaching practice, affecting both students and instructor. In today's realm, technology is practically everywhere and peoples, particularly the youth, are so accustomed to using technological devices.

Naturally, students will expect that they can use appropriate tools or applications in their learning activities. Failing to fulfil this high expectation can result in low morale among students, thus forfeiting their rights to have a meaningful learning experience. For instructors, they will face many challenges in adopting such a mobile learning tool in their classes. Apparently, it can be argued that female students, as compared to male students, tend to be cautious in using an unfamiliar learning method at the beginning. In other words, they may not be as highly excited as their opposite counterparts to try new technology in their learning. Such an attitude needs to be corrected to ensure female students too can capitalize on novel learning using appropriate technological learning applications. Thus, the onus is on instructors to guide and motivate students, especially female students, to use such new learning tools.

Arguably, the use of such MAR learning application can help create an effective learning environment in which students can work together more intensely compared to working in a computer laboratory in the group. In the former setting, students can use their mobile devices with greater flexibility and mobility to communicate and discuss with their peers and instructor or mentor. With such greater mobility, they can engage in an exciting learning experience as access to relevant learning materials or contents is always available anywhere, anytime — in short, time and geographical barriers are virtually "a thing of the past". Additionally, such a mobile learning application can be readily used in independent or informal learning contexts, in which students will be able to practice and rehearse learning activities outside the formal learning hours. Furthermore, such mobile learning application, which supports a wide range of multimedia contents, can help deal with the different learning demands of students who come from diverse educational backgrounds

(Majid *et al.*, 2015). Naturally, with this capability, the learning application will have a strong appeal to attract students to partake in learning activities with a higher level of enthusiasm and motivation, which leads to better learning experience. As such, such mobile learning application can become a potent learning tool to help informal learning.

As demonstrated, male students tend to become highly motivated in learning in environments that use novel, innovative tools or applications. By contrast, such orientation may not transpire for female students, suggesting that they may have some reservations to utilize such tools at the beginning. Most probably, they may use such tools with some cautions, or they may not be too excessively excited compared to male students. Thus, this particular finding underscores the needs to pay greater attention to female students when employing new, unfamiliar learning tools. They should be given more time to get acquainted with the tools and, if required, be provided with special training. The above finding is consistent with previous findings that indicate male students gaining greater advantages in various learning situations that employed a wide range of technological tools. Of course, such findings are open for debates, but many scholars agree that such male advantages are not due to biological factors but social ones.

Clearly, this particular finding may have some serious implications on the teaching practice, affecting the morale of students and instructors alike. Undisputedly, all sorts of technologies, especially communication technology, have reached every corner of the world, pervading almost every facet of the peoples' lives. In particular, the younger generation is so accustomed to using new, innovative technological devices. As such, today's students will naturally develop high expectation with regard to learning or training, anticipating eagerly that their learning will involve some sort of exciting, new learning tools or applications. If such high expectation is not fulfilled, their morale or motivation to learn would suffer, thus forgoing their inalienable rights for effective, meaningful learning experience.

For instructors, they will encounter many challenges in adopting such a mobile learning tool in their classes. As learned from this study, female students (compared to male students) may not be highly motivated in using new, innovative learning method. In short, they may view or perceive such new learning method as something equally on par with the conventional one. In doing so, they may miss the opportunity to explore the attractive features of the learning tools. Given their heavy psychological inertia at the beginning, they may not catch up with male students in the computer-mediated learning activities, which could lead to poor learning motivation and performance. Thus, it becomes the imperative of the instructors to correct such a misplaced perception such that female students too can capitalize on new, innovative learning applications. In this regard, the responsibility is on the lecturers or instructors to guide and motivate students.

6.7.2 Contribution to the Application Development Practice

The research findings and the lessons learned from the study helped the researcher to formulate and propose a set of development guidelines to which designers and developers of mobile augmented reality application for learning purposes can refer. Using such a guideline can help contribute to the ongoing efforts in enhancing the current practice of the development of learning applications. The detailed discussion of this section is dealt with in the subsections as follows:

6.7.2.1 Design Process Guidelines for Collaborative Mobile Augmented Reality Learning Application

The lessons learned from this experimental research using an augmented reality learning application running on mobiles devise are very informative and useful that can help inform designers and developers regarding important rationales, aspects, and steps needed to develop such learning application or tool. It has been demonstrated that such a novel application can bring benefits to both students and lecturers in collaborative learning, but they are several factors, such as students' demographic, that can impel its effectiveness. The philosophy of having a novel tool or application to help students learn collaboratively using their mobile has been established to be well justified in this study as participants made huge gains in learning performance and motivation.

Even though the use of such application for learning activities is highly recommended, nonetheless factors related to the training of the tool, development time, and deployment cost need to be factored in; otherwise, it will be difficult to justify its implementation. Thus, a well-designed mobile augmented learning application is entailed to ensure such investment will pay off, with students having access to efficacious and conducive learning environment. Failing to develop such a well-designed application may result in learning that is as effective as the conventional method, thus wasting all the time and energy in developing the tool.

Therefore, the design and development of such an application will have to strictly follow a set of rules or guidelines that can help build an effective application or program in collaborative learning. There are some existing instructional guidelines for developing tools in many areas of learning; however, most of them are applied to the desktop platform. As such, the researcher proposes some direction to assist developers build mobile augmented reality application based on the synthesis of the current literature and the research findings.

6.7.2.2 Determining the Level of Learning in a Particular Topic of a Course

The first step involves identifying the specific problem–solving skills, knowledge, or reasoning ability that is to be imparted to students based on specific objectives or aims of a particular topic. Obviously, some of the objectives may be generic, while some may be specific. From such examination, the type of learning objects (e.g., graphics, video, or 3D objects) and their implementation on mobile devices can only be determined, thus allowing students to use such mobile learning application efficaciously. Moreover, using appropriate learning objects is vital to empower students to use the mobile application with ease and confidence; otherwise, students may find learning using such a tool formidable at best or menacing at worst.

Thus, the focus on determining the level of learning helps pave the way for instructional designers to search appropriate learning or training objects to be used by students as required in the ensuing steps. As demonstrated in this study, learning the Computer System topic of the ICT Competency course entailed specific learning objects that helped students learn efficaciously by engaging them in collaborative learning on mobile devices such that their learning performance and motivation learning had improved significantly.

6.7.2.3 Selecting Appropriate Learning Objects for the Learning of a Particular Learning Topic

In this experimental research, the selection of learning objects for the learning of the particular learning topic involved examining the contents of the topic in detail. From such examination, important facts, elements, or concepts that are deemed highly important for learning the topic can be accurately determined. For example, in learning the Computer System topic, the basic components of computer hardware, such as the microprocessor or the system memory, are important elements that students need to know in terms of their physical appearance, functions, as well as their spatial interrelations with other components. Thus, such components can be digitally model as learning objects in the mobile application, the modelling which can be carried out in many three-dimensional (3D) modelling development tools. Students can interact with the 3D models to better understand their shapes or sizes. To learn their functions, videos can be developed accordingly by which students can listen to and watch, thus enhancing their understanding. Likewise, graphics can be prepared to highlight the layout of the components to function as a unit. In essence, all these objects (i.e., 3D models, graphics, and videos) can serve as learning objects that students use in their learning.

Clearly, the effectiveness of the mobile application will rely on using well-designed learning objects to enable students to use them effectively by capitalizing on the cognitive affordances inherent in them. Using such learning objects through observation, interaction, discussion, or manipulation in the learning process will engage appropriate communication and cognitive processes by which students can become more knowledgeable of the subject matter and proficient in social negotiation. Thus, selecting appropriate objects for learning is vital to ensure students can utilize them effectively as these objects will serve as learning tools to invoke and strengthen appropriate cognition processes during training or learning.

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6.7.2.4 Developing Appropriate Instructional Approach for Learning

The third step in developing the spatial trainer is a very critical stage in determining the appropriate instructional and pedagogical approach to be employed in learning. Identifying the proper instructional learning setting at this stage will require an

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understanding of current theory of learning. There are several learning theories having numerous variants, but essentially they can be categorized along a continuum of two opposite poles namely instructivist and constructivist perspectives. Experience gained from the research, suggests using a mix of the two paradigms where the former can help develop focused learning activities through clear learning goals and instructions while the latter can help learners in knowledge construction through active participation in the learning process. The researcher proposes the steps to be followed at this stage involving the development of instructions, organization of learning units and sequence of learning tasks as follows:

a) Developing clear and precise instructions to be followed by the students prior to engaging in learning activities will entail communicating and explaining the learning objectives such that the students should be primed both mentally and physically. Having a clear understanding of what they are expected to achieve after learning will help them concentrate on the learning activities more objectively.

b) Organizing the learning objects into learning units with appropriate instructions that are structured and ordered will need careful analysis of the learning tasks that when carried out successfully will help attain the learning objectives. For collaborative learning, such learning objects must be made accessible to all students in real time by which they can share and exchange comments, ideas, or feedback on a particular topic of discussion based on their observation and interpretation of the learning objects. In addition, the lecturer should pose questions pertinent to a topic being discussed at the right time such that students will be always be alert and focused.

c) Sequencing the learning tasks systematically such that students will perform the simple tasks first. Then, they can proceed learning with the moderate task, and finally they can focus on the complex tasks. For example, in the case of learning the computer system, students must learn to identify the basic computer components first. Then, they need to learn the functions of such components in detail. Finally, students have to learn the interconnections of the components in an assembly that represents a functioning computer system. Such a progression of learning activities will help students learn naturally and confidently as the knowledge or skills acquired from the earlier tasks can be transferred to the next tasks.

6.7.2.5 Developing the Appropriate Mobile Learning Environment

The fifth step in the design process of the mobile augmented learning application entails the creation of an environment in which all the learning objects can be delivered and used on an efficacious and convenient platform that engenders collaboration. There are important technological and financial considerations at this stage as developing a particular learning environment needs to carefully strike a balance between these two factors, especially when the number of students is high. The level of sophistication of the mobile learning application will invariably rely on the costs of procurement and ownership that can be prohibitive for implementation in some colleges or universities. Nonetheless, the empirical findings of this study demonstrate that even a low-cost mobile learning application running on a mobile platform can be more effective than the desktop platform to improve students' performance and motivation. Arguably, the effectiveness of any learning application relies more on the instructional strategy or method than the sophistication of the technology.

Experience from the experimental research suggests that the use of marker-based mobile augmented reality using a variety of learning objects is within the reach of many institutions of learning given its low-cost of ownership. The development time to develop the training objects and environment will not be too laborious due to the simple system architecture for such implementation. In addition, training or learning curve to use such an application is not steep as students are already conversant with the use of mobile devices, notably mobile phones, thus eliminating any specialized training that will be expensive and time-consuming.

6.7 Recommendations for Future Research

Further research is entailed to examine the impact of mobile augmented reality learning application of student learning performance and motivation is required as there are a number of factors that have not been dealt with in this and other studies. In addition, the methodological approach in conducting such research can be further improved. In light of such factors and methodological considerations, the researcher proposes a number of recommendations to help future undertakings as follows:

a) Future studies should focus on other demographic factors, notably students' mobile computer skills or students' age, which may have mediation effects on learning performance and motivation during interventions or treatments. The former is certainly an appropriate factor to focus on given the pervasive use of mobile devices, especially mobile phones, in today's societies, in particular among students. Age is also an important factor to investigate as students will have different experiences in and perspectives of mobile learning. With difference experiences, naturally students will develop different orientations in using technological tools. Thus, focusing on this factor is deemed appropriate in this information era.

b) From the methodological approach, the mixed-mode method using both quantitative and qualitative approaches can be used to conduct similar research. Such research can help examine the subtle nuances of students' opinions on the use of mobile augmented reality learning applications in finer details. To help conduct the mixed-method approach, learning treatments can be first carried out and then followed by in-depth interviews. The first helps collect the quantitative data and the latter provides the quantitative data. Using triangulation techniques, the research findings of both data can help provide greater insights into the understanding of the critical roles played by relevant factors that may have an impact on the use of such novel tools in improving student learning performance and motivation.

c) Detailed investigation and analysis of the depth of collaboration among students can be carried out in future research using qualitative approach. More specifically, a narrative analysis can be performed to qualitatively analyse the communication threads of students as they engage in online collaboration. This analysis can help researchers to detect the fine nuances of conceptual and technological contents being discussed by students as they try to solve a given task or an assignment. Additionally, this method can help researchers to determine the quality of discussions carried out by students in terms of its depth. Such revelations provide insights into the thinking process of students in more detail than the findings of an analysis based on the quantitative method of investigation. With such detailed analysis, researchers will be able to make a more informed decision and strong recommendations to further improve current teaching and learning practice. With such recommendations, future researchers, notably doctoral students, can do a follow-up study to examine the impact of mobile learning using augmented reality on student learning and motivation.

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6.9 Conclusion and Discussion

Overall, the findings of this study help illuminate the potential benefits and challenges of using mobile augmented reality learning tools in the learning process to help improve students' learning performance and motivation. The mobile augmented reality learning application has been demonstrated to be more effective than desktop learning tools in terms of both measures – learning performance and motivation. With this novel mobile application, students will be able to learn to collaborate more efficiently, as opposed to using a similar application on a desktop platform.

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Surely, this finding augurs good news to practitioners as future learning is expected to be dominated with mobile learning using a range of mobile devices, such as mobile phones, tablets, or personal data assistants (PDAs). Thus, this finding should encourage more efforts to utilize mobile technology in the teaching and learning process, thus spurring the growth of mobile learning. More specifically, mobile augmented reality can be used to help students learn concepts that are difficult to discern, especially in technical- and computer-related courses.

From the view of practicality, these findings are promising given that the mobile application used in this study was developed based on the marker-based augmented reality technology, which is affordable compared to the expensive markerless augmented reality technology. Thus, such findings suggest feasible and practical applications of the former in learning activities in many universities, which have a huge number of students. In addition, developers can use a marker-based augmented reality technology in developing learning applications that are not only effective, merely also appealing, thus enticing students to use them with greater motivation.

In addition, the use of the mobile augmented reality learning application inevitably to consider gender as an important factor as female users will probably require more coaching or training than male users. Furthermore, the development of such a learning tool may entail the use of sound theoretical frameworks to help mould a strong foundation, onto which formidable learning tools can be designed and developed. In addition, more studies are entailed to investigate the impact of this technology on students' learning performance and motivation by taking into account other critical factors.

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APPENDIX I

Final Questionnaire for CoMARLA (Actual Study)

The Consent Form for the Survey Research of CoMARLA

Dear Students,

This set of questionnaire is cogitated to interrogate the students' background, acceptance, learning process, motivation and the user acceptance of CoMARLA for learning intendment. It is the combination of learning by using Augmented Reality software, namely as Aurasma with ICT Competency Subject (MTE3012). Augmented Reality is an interactive three dimensional free software that can be downloaded via Playstore and Apple Store. The questionnaire consists of five major parts constructed as follows:

Part A: Students Background Information

Part B: Learning Process of CoMARLA

Part C: Motivation of using CoMARLA (Pre)

Part D: Motivation of using CoMARLA (Post)

Part E: Acceptance of CoMARLA

The students can decide either participate or not to participate at any time. As a result, all information that gathered in this survey research are treated as confidential and only the researcher has access to the information and personal data that have been given. I understand my participation in this questionnaire are solely voluntary.

Student Signature Date

________________ ________________

Part A: Students Background Information

This portion is aimed to gather a basic background information about participant knowledge.

Please select and tick (√) only one appropriate answer for each following question.

Male ☐

Female ☐

Do you have a personal computer at college/home? Yes ☐ No ☐

Do you have a mobile phone/ smart phone? Yes ☐ No ☐

How often you are using a computer at college/home? ______________________________

How often you are using a mobile phone / smart phone at college/home? ______________

In what way do you use computer at college/home? ________________________________

Did you have a Facebook Account? Yes ☐ No ☐

Do you know about "Augmented Reality" before taking this ICT Competency Subject? Yes ☐ No ☐

Would you like to use Augmented Reality in this subject? Yes ☐ No ☐

Part B: Learning Process of CoMARLA

1. I enjoyed learning CoMARLA program very much

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. Learning with this type of CoMARLA was a pleasure

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. I have been able to ponder on how I learned in a classroom

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. After utilizing this type of CoMARLA I felt very competent

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I felt frustrated while learning this type of CoMARLA environments

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. I put a lot of exertion in learning this CoMARLA based learning environment

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

7. I was able to reflect on my own learning based on the exercises given by lecturers

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

8. I was satisfied with my academic performance in this type of CoMARLA learning environments

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

9. This type of CoMARLA feeds me more time to collaborate with peers in social media

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

10. I was able to associate my new knowledge with early knowledge and experiences with CoMARLA

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Part C: Motivation of using CoMARLA-Pre (MSLQ)

1. When is study ICT Competency subject, I outline the material to help me organize my thought

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. I usually study in a place where I can concentrate on my Course Work

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. I often so lazy or bored when I study for this class that I quit before I finish what I planned to do

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. When I study for this class, I always practice visualizing the material concerning ICT Competency

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I ask the Lecturer to clarify the concept that I don't understand well

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. When reading the ICT Competency topics, I try to relate the material to what I really know

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

7. I attend this class regularly

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

8. I try to apply an idea from this course in other class activities relating the ICT Competency Skills

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

9. I make sure that I keep up with the weekly readings and assignments for this ICT Competency Course

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

10. I try to play around with ideas of my own related to what I am learning in this ICT Competency Course

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Part D: Motivation of using CoMARLA-Post (MSLQ)

1. Whether the computer content is difficult or easy, I am sure that I can understand it.

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. When learning new computer concepts, I attempt to understand them.

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. When I do not understand a computer concept, I find pertinent resources that will help me

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. During CoMARLA learning processes, I attempt to make connections between the concepts that I learn

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I think that learning computer is important because I can use it in my daily life

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. I am willing to take part in this ICT Competency course, because the content is exciting

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

7. During an ICT Competency course, I feel more delighted when the lecturer accepts my ideas

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

8. During an ICT Competency course, I feel more delighted when other students accept my ideas

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

9. I am willing to participate in this computer course with an Augmented Reality element because it is challenging.

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

10. I am willing to participate in this ICT Competency course, because the students are involved in peer discussions.

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Part E: Acceptance of CoMARLA

1. I find it easy of use of ICT provided by FSKIK

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. I was satisfied with this type of learning environments (Augmented Reality)

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. I use the ICT Competency skills when learning in another class

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. I use the ICTs Competency skills for accessing and gathering learning materials

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I intend to use Augmented Reality in other subjects provided in the next semester

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. The content provided by lecturers is encouraging and practicable

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

7. Using ICT Competency provided by FSKIK improve my productivity in learning

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

8. I find an ICT Competency subject provided by FSKIK useful to my study

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

9. It is comfortable for me to become proficient with using the ICTs provided by FSKIK

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

10. People who are significant to me believe I ought utilize the ICTs provided by FSKIK

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Suggestions and Comments

1. In what ways do you conceives this type of Augmented Reality (Aurasma) is efficacious as an educational tool to assist students in visualization especially in learning ICT Competency?

____

____

2. Do you have any suggestion and recommendation on the use of Augmented Reality for Learning ICT Competency?

____

____

Thank you for your participation and contribution of this survey is deeply appreciated, if you have any suggestion that might be a significant way of learning Augmented Reality, don't be hesitate to contact me via email: via email: hafizul@fskik.upsi.edu.my or by Whatsapp 0122505531. Thanks

Final Questionnaire For Conventional Learning Mode (Actual Study)

The Consent Form for The Survey Research of Conventional Learning Modes

This set of questionnaire is cogitated to interrogate the students' background information, the conventional learning approach and finally the motivation of Conventional Learning Approach. The questionnaire comprises of three major parts constructed as follows:

Part A: Students Background Information

Part B: Learning Process with Conventional Learning Approach

Part C: Motivation of using Conventional (Pre)

Part D: Motivation of using Conventional (Post)

Part E: User Satisfaction of Conventional Learning Approach

The students can decide either participate or not to participate at any time. As a result, all information that gathered in this survey research are treated as confidential and only the researcher has access to the information and personal data that have been given. I understand my participation in this questionnaire are solely voluntary.

Student Signature　　　　　　　　　　　　　　　　　　　　Date

________________　　　　　　　　　　　　　　　　　　　　________________

Part A: Students Background Information

This portion is aimed to gather a basic background information about participant background information. Please select and tick (√) only one appropriate answer for each following question.

Male ☐

Female ☐

Do you have a personal computer at college/home? Yes ☐ No ☐

Do you have a mobile phone/ smart phone? Yes ☐ No ☐

How often you are using a computer at college/home? ____________________________

How often you are using a mobile phone / smart phone at college/home? _____________

In what way do you use computer at college/home? ______________________________

Did you have a Facebook Account? Yes ☐ No ☐

Part B: Learning Process with Conventional Learning Approach

1. I was interested to learn ICT Computer Topics

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. I have learned a lot of factual information on certain topics

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. I gained a good understanding of basic concepts of the material provided by lecturer

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. I managed to learn and identified an important topic of ICT Competency

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I was interested to learn more about the different teaching approach

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. I was able to summarize and conclude what I have learned

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

7. The learning activities are interesting and meaningful

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

8. I can associate what I have learned in real context

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

9. I always do my homework on the individual

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

10. I always do my homework and discuss with my peers on social media

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Part C: Motivation of using Conventional-Pre (MSLQ)

1. When is study ICT Competency subject, I outline the material to help me organize my thought

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. I usually study in a place where I can concentrate on my Course Work

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. I often so lazy or bored when I study for this class that I quit before I finish what I planned to do

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. When I study for this class, I always practice visualizing the material concerning ICT Competency

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I ask the Lecturer to clarify the concept that I don't understand well

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. When reading the ICT Competency topics, I try to relate the material to what I really know

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

7. I attend this class regularly

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

8. I try to apply an idea from this course in other class activities relating the ICT Competency Skills

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

9. I make sure that I keep up with the weekly readings and assignments for this ICT Competency Course

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

10. I try to play around with ideas of my own related to what I am learning in this ICT Competency Course

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Part D: Motivation of using Conventional-Post (MSLQ)

1. Whether the computer content is difficult or easy, I am sure that I can understand it.

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. When learning new computer concepts, I attempt to understand them.

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. When I do not understand a computer concept, I find pertinent resources that will help me

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. During learning processes, I attempt to make connections between the concepts that I learn

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I think that learning computer is important because I can use it in my daily life

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. I am willing to take part in this ICT Competency course, because the content is exciting

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

7. During an ICT Competency course, I feel more delighted when the lecturer accepts my ideas

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

8. During an ICT Competency course, I feel more delighted when other students accept my ideas

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

9. I am willing to participate in this computer course because it is challenging.

   ☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

10. I am willing to participate in this ICT Competency course, because the students are involved in peer discussions.

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Part E: User Satisfaction of Conventional Learning Approach

1. I was satisfied with this type of conventional learning experience in a classroom

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

2. A wide variety of learning materials were provided in this type of learning environments

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

3. I don't think this type of learning environment would benefit my learning

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

4. I was satisfied with the information given in this type of learning

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

5. I was satisfied with the teaching approach of this type of learning

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

6. I was satisfied with overall learning environments, especially the learning materials in a classroom

☐ Strongly Disagree ☐ Disagree ☐ Not Sure ☐ Agree ☐ Strongly Agree

Suggestions and Comments

1. In what ways do you conceives Conventional Learning is efficacious as an educational tool to assist students in visualization especially in learning ICT Competency? Do you feel motivated? If no state your reason why.

____

____

2. Do you have any suggestion and recommendation on Conventional Learning Environment in order to improve learning effectiveness, for instance freeware tools that might be useful in learning?

____

____

Thank you for your participation and contribution of this survey is deeply appreciated, if you have any suggestion that might be a significant way of learning, don't be hesitate to contact me via email: hafizul@fskik.upsi.edu.my or by Whatsapp 0122505531. Thanks.

APPENDIX H

SECTION A (10 marks)

Instruction: Answer **all** questions. Mark B for **TRUE** and D for **FALSE** on the OMR form provided.
***(Arahan:** Jawab **semua** soalan. Tandakan B untuk **BENAR** dan D untuk **SALAH** pada borang OMR yang telah disediakan.)*

1. The bus topology primarily is used for LAN.
(*Topologi bas biasanya digunakan untuk LAN.*)

B. True. *(Benar.)*
D. False. *(Salah.)*

2. Computer voice mail system converts an analog voice message into digital form.
(*Sistem pesanan suara komputer menterjemah pesanan suara analog kepada bentuk
digital.*)

B. True. *(Benar.)*
D. False. *(Salah.)*

3. Nearly the entire telephone network today uses analog technology.
(Hampir semua rangkaian telefon pada hari ini menggunakan teknologi analog.)

B. True. *(Benar.)*
D. False. *(Salah.)*

4. An essential feature in a multimedia application is user participation or interactivity.
(Satu ciri penting dalam aplikasi multimedia adalah penglibatan pengguna atau interaktiviti.)

B. True. *(Benar.)*
D. False. *(Salah.)*

5. The access time of memory is slow, compared with the access time of storage.
(Masa capaian ingatan adalah perlahan berbanding masa capaian storan.)

B. True. *(Benar.)*
D. False. *(Salah.)*

[See next page

6. There are three (3) basic categories of operating systems that exist today. Symbian OS is an example of a(n) network operating system.
(*Terdapat tiga (3) kategori asas sistem pengoperasian yang wujud pada hari ini. Symbian OS merupakan contoh sistem pengoperasian rangkaian.*)

B. True. *(Benar.)*
D. False. *(Salah.)*

7. A database uses characteristics such as field size and data type to define each field.
(*Pangkalan data menggunakan ciri-ciri seperti saiz medan dan jenis data bagi menakrifkan setiap medan.*)

B. True. *(Benar.)*
D. False. *(Salah.)*

8. A shorter password provides greater security than a longer password .
(*Kata laluan yang pendek menyediakan keselamatan yang lebih berbanding kata laluan yang panjang.*)

B. True. *(Benar.)*
D. False. *(Salah.)*

9. Most antivirus programs do not provide updated virus detection files for users.
(*Kebanyakan program anti virus tidak menyediakan fail pengesanan virus yang terkini kepada pengguna.*)

B. True. *(Benar.)*
D. False. *(Salah.)*

10. The term, unauthorized access, refers to the use of a computer or its data for unapproved or possibly illegal activities.
(Istilah capaian tidak sah merujuk kepada penggunaan komputer atau data-data untuk aktiviti-aktiviti yang tidak sah atau yang melanggar undang-undang.)

B. True. *(Benar.)*
D. False. *(Salah.)*

[See next page

SECTION B (15 marks)

Instruction: Answer **all** questions. Choose the right answer and mark it on the OMR form as provided.

Arahan: *Jawab* ***semua*** *soalan. Pilih jawapan yang tepat dan tandakan pada OMR yang disediakan.*

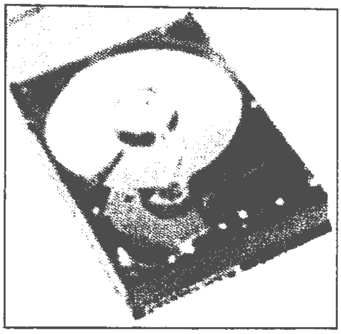

Figure 5.0
(Rajah 5.0)

11. Which of the following statements is **not** a characteristic of a hard disk as shown in Figure 5.0?
(Manakah antara pernyataan-pernyataan berikut ***bukan*** *merupakan ciri cakera keras seperti yang ditunjukkan pada Rajah 5.0?)*

A. Chip.
B. Track.
C. Platter.
D. Cylinder.

12. Nowadays, most web pages include more than formatted text and links. The more exciting web pages use multimedia. Multimedia refers to any application that combines ____________________.
(*Kini, kebanyakan laman web mengandungi lebih daripada teks yang diformat dan pautan. Laman web yang menarik menggunakan multimedia. Multimedia merujuk kepada aplikasi yang menggabungkan* ____________________.

A. text, graphics, audio and video
(*teks, grafik, audio dan video*)
B. text, graphics, audio, video and animation
(*teks, grafik, audio, video and animasi)*
C. text, graphics, audio, video, animation and virtual reality
(*teks, grafik, audio, video, animasi dan realiti maya*)
D. graphics, animation and virtual reality
(*grafik, animasi dan realiti maya)*

13. Presentation software is used to create ____________________.
(*Perisian pemsembahan digunakan untuk mencipta* ____________________.)

A. video (*video*)
B. photographs (*fotograf*)
C. virtual reality (*reality maya*)
D. on-screen media (*media paparan*)

14. The ___________ is the component of the processor that directs and coordinates most of the operations in the computer.
(_______________ *merupakan komponen pemproses yang mengarah dan mengkoordinasi kebanyakan operasi di dalam komputer*.)

A. register (*pendaftar*)
B. control unit (*unit kawalan*)
C. machine cycle (*kitaran mesin*)
D. arithmetic logic unit (*unit logik aritmetik*)

[See next page

15. You are working with ABC Company as an ICT Officer. You are required to connect multiple computers and transmit data to its correct destination on the network. You want the device to be used on any size of network at a high speed Internet connection. Which communication device is suitable for you?
(*Anda bekerja dengan Syarikat ABC sebagai Pegawai ICT. Anda dikehendaki untuk menyambungkan lebih dari satu komputer dan menghantar data ke destinasi yang betul atas rangkaian. Anda berkehendakan peranti yang boleh digunakan dalam pelbagai saiz rangkaian dengan kelajuan sambungan Internet yang tinggi. Manakah antara peranti komunikasi yang berikut yang sesuai dengan anda*?)

A. Router
B. Dialup modem
C. Wireless Access Points
D. ISDN and DSL Modem

16. Many of today's computer support ___________, which means the computer can automatically configure adapter cards and other peripherals as you install them.
(*Pada hari ini, kebanyakan komputer menyokong ___________, yang bermaksud komputer secara automatik dapat menkonfigurasikan kad adapter dan alatan lain yang di 'install'*.)

A. Plug and Play
B. Pack and Go
C. Park and Ride
D. Pick and Choose

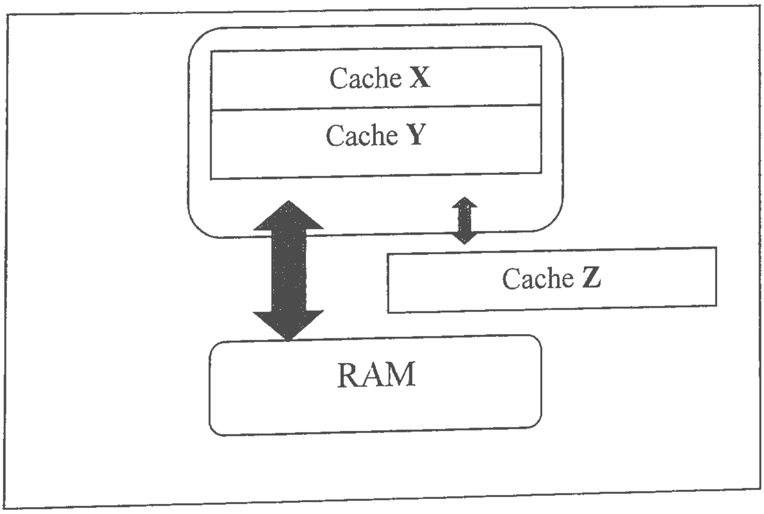

Figure 6.0 (*Rajah 6.0*)

[See next page

17. Two types of cache are memory cache and disk cache. Memory cache helps speed the processes of the computer because it stores frequently used instructions and data. Which of the following refers to cache **Z** in Figure 6.0?
*(Dua jenis 'cache' adalah 'cache' memori dan 'cache' cakera. 'Cache' memori membantu mencepatkan proses komputer kerana ia menyimpan arahan dan data yang sering digunakan. Manakah antara berikut merujuk kepada 'cache' **Z** dalam Rajah 6.0?)*

A. L1 cache
B. L2 cache
C. L3 cache
D. L2 advanced transfer cache

18. When 8 bits are grouped together as a unit, they form a byte. A byte provides enough different combinations of Os and 1s to represent 256 individual characters. These characters include ______________________.
(Apabila 8 bit digabungkan sebagai satu unit, satu bait akan terbentuk. Satu bait menyediakan kombinasi berbeza yang terdiri dari 0 dan 1 bagi mewakili 256 aksara. Aksara-aksara ini merangkumi ______________________.)

A. numbers (*nombor*)
B. punctuation marks (*tanda bacaan*)
C. uppercase and lowercase letters (*huruf besar dan kecil*)
D. all of the above (*semua di atas*)

19. Saving is the process of copying data, instructions and information from RAM to storage device such as a hard disk. These are three basic types of RAM chips **except** ____________________.
*(Penyimpanan/Penstoran merupakan proses menyalin data, arahan dan maklumat dari RAM ke peranti storan seperti cakera keras. Berikut adalah tiga jenis asas RAM **kecuali** ____________________.)*

A. Static RAM (SRAM)
B. Dynamic RAM (DRAM)
C. Magnetoresistive RAM (MRAM)
D. Complementary Metal Oxide Semiconductor (CMOS)

[See next page

20. A ____________________ also called a graphic card, converts computer output into a video signal that travels through a cable to the monitor, which displays an image on the screen.
(______________________ *juga dikenali sebagai kad grafik, menukar output komputer ke isyarat video yang melalui kabel kepada monitor bagi memaparkan imej di atas skrin.*)

A. video card (*kad video*)
B. sound card (*kad bunyi*)
C. internet card (*kad internet*)
D. memory card(*kad memori*)

21. Radio Frequency Identification (RFID) is a technology that uses _____________ to communicate with a tag placed in or attached to an object, an animal or a person.
(*RFID merupakan satu teknologi yang menggunakan ____________ untuk berkomunikasi dengan 'tag' yang diletakkan pada objek, binatang atau manusia.)*

A. pixels (*piksel*)
B. a thin wire (*wayar halus*)
C. radio signals (*isyarat radio*)
D. light waves (*gelombang cahaya*)

22. All of the following are tips on how to take care of an optical disc **except;**
(*Berikut merupakan tips tentang penjagaan cakera optik* ***kecuali;***)

A. Do hold the disc by its edges.
(Sila pegang cakera di bahagian tepi.)
B. You are encouraged to touch and clean up the underside of the disc.
(*Anda digalakkan menyentuh dan mencuci bahagian bawah cakera.*)
C. Do not expose the disc to high temperature of heat or sunlight.
(*Jangan mendedahkan cakera kepada haba pada suhu kepanasan yang tinggi atau cahaya matahari.*)
D. You are encouraged to store the disc in a jewel box when not in use.
(*Anda digalakkan menyimpan cakera di dalam kotak barang kemas apabila tidak digunakan.*)

[See next page

23. _______________ is a series of instructions that tells a computer what to do and how to do it.
(_______________ *merupakan arahan yang memberitahu komputer apa yang perlu dilakukan dan bagaimana untuk melakukannya.*)

A. Data
B. Command (*Arahan*)
C. Program (*Aturcara*)
D. Information (*Maklumat*)

24. The goal of ________ is to incorporate comfort, efficiency, and safety in the environment of the workplace.
(*Matlamat utama* ___________ *adalah untuk memasukkan keselesaan, ketepatan dan keselamatan dalam persekitaran tempat kerja.*)

A. network (*rangkaian*)
B. ergonomic (*ergonomik*)
C. Repetitive Strain Injury (RSI)
D. information technology (*teknologi maklumat*)

25. A(n) ____________ has a design that reduces the chance of wrist and hand injuries.
(____________ *mempunyai rekabentuk yang mengurangkan kecederaan pergelangan tangan dan tangan.*)

A. function key (*Kekunci fungsi*)
B. cordless mouse (*Tetikus tanpa wayar*)
C. gaming joystick (*Kayu ria permainan*)
D. ergonomic keyboard (*Papan kekunci ergonomik*)

SECTION C (5 marks)

Instruction: Answer **all** questions. Choose the best answer and mark it on the OMR form as provided.
(Arahan: *Jawab* ***semua*** *soalan. Pilih jawapan yang terbaik dan tandakan pada borang OMR yang telah disediakan.)*

26. The advantages of multifunction peripherals are that _______________.
(*Kebaikan peralatan pelbagai fungsi ialah* ___________________.)

I. if the multifunction peripheral breaks down, all functions are lost.
(*jika peralatan pelbagai fungsi rosak, semua fungsi tidak dapat digunakan.*)
II. they require more space than having separate devices.
(*ia memerlukan lebih banyak ruang berbanding peranti berasingan.*)
III. they are significantly more cheaper than purchasing each device separately.
(*ia lebih murah berbanding membeli peranti secara berasingan*)
IV. it is smaller in size than separate devices.
(*ia lebih bersaiz kecil berbanding peranti secara berasingan.*)

A. I and II only. *(I dan II sahaja.)*
B. III and IV only. *(II dan IV sahaja.)*
C. I, II and III only. *(I, II dan III sahaja.)*
D. All of the above. *(Semua di atas.)*

27. Choose the **correct** statements regarding word processing and spreadsheets.
(*Pilih pernyataan yang* ***betul*** *mengenai pemproses perkataan dan hamparan kerja.*)

I. Create a webpage with text and graphics.
(Membina laman web dengan menggunakan teks dan grafik).
II. Performs calculations and recalculates when data changes
(Membuat pengiraan dan pengiraan semula bila ada perubahan data).
III. Data can be copied from one area of the document to another.
(Data boleh disalin dari satu kawasan dokumen ke kawasan yang lain).
IV. Selected parts of the document can be formatted for different fonts.
(Bahagian yang dipilih dari dokumen boleh diformatkan ke bentuk fon yang lain).

A. I, II and III only *(I, II dan III sahaja)*
B. I, II and IV only *(I, II dan IV sahaja)*
C. I, III and IV only *(I, III dan IV sahaja)*
D. II, III and IV only *(II, III dan IV sahaja)*

SECTION A (10 marks)

Instruction: Answer **all** questions. Mark B for **TRUE** and D for **FALSE** on the OMR form provided.
(Arahan: *Jawab* ***semua*** *soalan. Tandakan B untuk* ***BENAR*** *dan D untuk* ***SALAH*** *pada borang OMR yang telah disediakan.)*

1. The bus topology primarily is used for LAN.
   (*Topologi bas biasanya digunakan untuk LAN.*)

   B. True. *(Benar.)*
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   (*Sistem pesanan suara komputer menterjemah pesanan suara analog kepada bentuk digital.*)

   B. True. *(Benar.)*
   D. False. *(Salah.)*

3. Nearly the entire telephone network today uses analog technology.
   (*Hampir semua rangkaian telefon pada hari ini menggunakan teknologi analog.*)

   B. True. *(Benar.)*
   D. False. *(Salah.)*

4. An essential feature in a multimedia application is user participation or interactivity.
   (*Satu ciri penting dalam aplikasi multimedia adalah penglibatan pengguna atau interaktiviti.)*

   B. True. *(Benar.)*
   D. False. *(Salah.)*

5. The access time of memory is slow, compared with the access time of storage.
   (Masa capaian ingatan adalah perlahan berbanding masa capaian storan.)

   B. True. *(Benar.)*
   D. False. *(Salah.)*

6. There are three (3) basic categories of operating systems that exist today. Symbian OS is an example of a(n) network operating system.

[See next page

(Terdapat tiga (3) kategori asas sistem pengoperasian yang wujud pada hari ini. Symbian OS merupakan contoh sistem pengoperasian rangkaian.)

B. True. *(Benar.)*
D. False. *(Salah.)*

7. A database uses characteristics such as field size and data type to define each field.
(Pangkalan data menggunakan ciri-ciri seperti saiz medan dan jenis data bagi menakrifkan setiap medan.)

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9. Most antivirus programs do not provide updated virus detection files for users.
(Kebanyakan program anti virus tidak menyediakan fail pengesanan virus yang terkini kepada pengguna.)

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10. The term, unauthorized access, refers to the use of a computer or its data for unapproved or possibly illegal activities.
(Istilah capaian tidak sah merujuk kepada penggunaan komputer atau data-data untuk aktiviti-aktiviti yang tidak sah atau yang melanggar undang-undang.)

B. True. *(Benar.)*
D. False. *(Salah.)*

[See next page

SECTION B (15 marks)

Instruction: Answer **all** questions. Choose the right answer and mark it on the OMR form as provided.

Arahan: *Jawab* ***semua*** *soalan. Pilih jawapan yang tepat dan tandakan pada OMR yang disediakan.*

11. Computer literacy, also known as digital literacy, involves having a current knowledge and understanding of_________________________.
(*Celik komputer, juga dikenali sebagai celik digital, melibatkan pengetahuan mengenai* ____________________ .)

    A. computer repair (*pembaikan komputer*)
    B. computer programming (*pengaturcaraan komputer*)
    C. computer and their uses (*komputer dan penggunaannya*)
    D. all of the above (*semua di atas*)

Figure 1.0
(*Rajah 1.0*)

12. The refresh rate of a CRT like the one in Figure 1.0 is measured in _________.
(*Kadar' refresh' paparan monitor CRT seperti Rajah 1.0 diukur dalam* ________).

    A. baud
    B. hertz
    C. pixels
    D. dot size

[See next page

13. This type of computer is a special purpose computer that functions as a component in large products such as a car, digital television and DVD players.
(*Komputer jenis ini adalah komputer khas yang berfungsi sebagai komponen di dalam produk-produk bersaiz besar seperti di dalam kereta, televisyen digital dan pemain DVD.*)

A. Server (*pelayan*)
B. Mainframes (*kerangka utama*)
C. Supercomputer (*superkomputer*)
D. Embedded computer (*komputer terbenam*)

14. Examples of the __________ category of computer users include engineers, scientists, architects, desktop publishers and graphic artists.
(*Contoh-contoh kategori __________ merangkumi jurutera, ahli saintis, arkitek, penerbit desktop dan artis grafik.*)

A. power user (*pengguna kuasa*)
B. mobile user (*pengguna mudah alih*)
C. large business user (*pengguna perniagaan besar*)
D. small office/home office (SOHO) user (*pengguna SOHO*)

15. A _____________ is recorded audio stored on a web site that can be downloaded to a computer or portable media player.

(__________ *adalah audio rakaman yang disimpan pada laman web yang boleh dimuat naik kepada sebuah komputer atau pemain media.*)

A. *blog*
B. *podcast*
C. speaker (*pembesar suara*)
D. social networking web site (*laman web rangkaian sosial*)

16. __________ consists of programs that control or maintain the operations of the computer and its devices.
(__________ *mengandungi aturcara yang mengawal atau mengekalkan operasi komputer dan perantinya*)

A. System software *(Perisian sistem)*
B. A communication device *(Peranti komunikasi)*
C. A graphical user interface (*Antaramuka grafik pengguna*)
D. Application software (*Perisian aplikasi*)

[See next page

Figure 2.0
(*Rajah 2.0*)

17. Which of the following refers to Y as shown in Figure 2.0?
(*Manakah antara berikut merujuk kepada Y seperti yang ditunjukkan pada Rajah 2.0?*)

A. Username
B. Domain Name
C. Top Level Domain (TLD)
D. File Transfer Protocol (FTP)

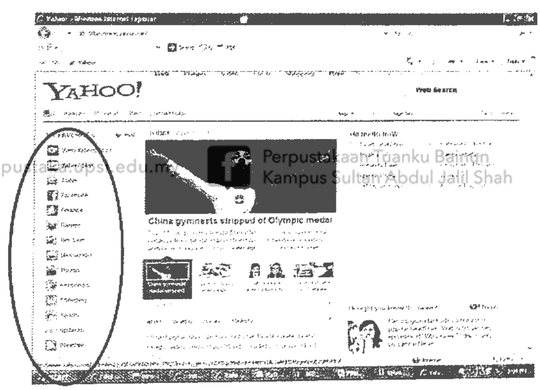

Figure 3.0 (*Rajah 3.0*)

18. This searching strategy in Figure 3.0, allows user to search the web by clicking at the lists provided which is known as ______________________.
(*Strategi carian ini dalam Rajah 3.0, membenarkan pengguna untuk mencari web dengan mengklik pada senarai yang disediakan yang dikenali sebagai ________________.*)

A. metacrawlers
B. keyword searches (*carian kata kunci*)
C. major search engines (*enjin carian utama*)
D. subject index searches (*carian indeks subjek*)

[See next page

19. Each computer on the Internet has a unique numeric address called as __________.
(Setiap komputer di Internet mempunyai alamat numerik yang unik yang dipanggil sebagai __________.)

A. IP address *(alamat IP)*
B. web address *(alamat web)*
C. domain address *(alamat domain)*
D. protocol address *(alamat protokol)*

20. Programs set up to block access of certain Internet sites are called ___________.
(*Program untuk menghalang capaian kepada laman web tertentu dikenali sebagai ________.*)

A. worms
B. avatars
C. cookies
D. firewalls

21. An unsolicited electronic mail (e-mail) message or newsgroup posting sent to multiple recipients or newsgroups at once is called ________________.
(*Mel elektronik atau "newsgroup posting" yang dihantar secara rawak kepada beberapa penerima pada satu masa yang sama dipanggil ________________.*)

A. spam
B. adware
C. cookies
D. spyware

22. Due to the ethical and legal issue, an illegal access can be blocked using techniques as follows, **except** ____________________________.
(*Berpandukan kepada isu etika dan kesahan, capaian yang tidak sah boleh dihalang menggunakan teknik-teknik berikut,* ***kecuali*** *_____________.*)

A. firewall software (*perisian 'firewall'*)
B. antivirus software (*perisian antivirus*)
C. application software (*perisian aplikasi*)
D. filtering software (*perisian penyaringan*)

[See next page

23.

"This software is used for **sharing, distributing and searching** through documents by **converting them into a format** that can be **viewed by any user**"

Figure 4.0 (*Rajah 4.0*)

The above statement in Figure 4.0 is best refer to ____________________)
(*Pernyataan dalam Rajah 4.0 merujuk kepada* ________________.)

A. database (*pangkalan data*)
B. portable document format (PDF)
C. word processing *(pemprosesan* perkataan)
D. document management (*pengurusan dokumen)*

24. Hani is using word processing software to finish up her report. She realizes that every time the cursor reaches the end of every line, it will automatically start at the beginning of the new line. This word processing feature is called ______________
(Hani menggunakan perisian pemprosesan perkataan untuk menyiapkan laporan beliau. Dia menyedari setiap kali penanda sampai di akhir barisan, ia akan bermula pada barisan yang baru. Ciri pemprosesan perkataan ini dipanggil _______________)

A. table.
B. justification.
C. lookup table.
D. word wrap.

25. _______________ is someone who accesses a computer or network illegally and has the intent of destroying data, stealing information, or other malicious action.
(_______________adalah seseorang yang mengakses komputer atau rangkaian tanpa kebenaran dan bertujuan untuk memusnahkan data, mencuri maklumat atau tindakan tidak bermoral yang lain.)

A. Cracker
B. Cyberstalker
C. Cyberterrorist
D. Cyberextortionist

[See next page

SECTION C (5 marks)

Instruction: Answer **all** questions. Choose the best answer and mark it on the OMR form as provided.
***(Arahan:** Jawab **semua** soalan. Pilih jawapan yang terbaik dan tandakan pada borang OMR yang telah disediakan.)*

26. Which of the following are types of miniature mobile storage media?
(*Manakah antara berikut merupakan media storan mudah alih mini*?)

    I. Smart cards
    II. DVD ROM
    III. USB flash drives
    IV. Flash memory cards

    A. I and II only. *(I dan II sahaja.)*
    B. II and III only. *(II dan III sahaja.)*
    C. I, III and IV only. *(I, III and IV sahaja.)*
    D. All of the above. *(Semua di atas.)*

27. Popular uses of electronic commerce by consumers include shopping, investing and banking.Three (3) different types of electronic commerce are Business-to-Consumer (B2C), Business-to-Business (B2B) and Consumer-to-Consumer (C2C). Which of the following statements are **true** about Consumer-to-Consumer (C2C)?
*(Penggunaaan elektronik dagang yang popular oleh pengguna termasuk membeli belah, melabur dan perbankan. Tiga (3) jenis elektronik dagang yang berbeza adalah Perniagaan-kepada-Perniagaan (B2B), Perniagaan-kepada-Pengguna (B2C) dan Pengguna-kepada-Pengguna (C2C). Manakah antara pernyataan-pernyataan berikut adalah **benar** mengenai Pengguna-kepada-Pengguna (C2C)?)*

    I. Purchase products from other consumer.
    (*Membeli produk daripada pengguna lain.*)
    II. Method of payment is made through secure Internet connection.
    (*Kaedah pembayaran dibuat melalui sambungan Internet yang selamat.)*
    III. Often provides products and services to other business.
    (*Sering menyediakan produk-produk dan servis kepada perniagaan yang lain*).
    IV. Contains product description, images and a shopping cart.
    (*Mengandungi penerangan produk, gambar dan kereta sorong membeli belah.*)

    A. I, II and III only. *(I, II dan III sahaja.)*
    B. I, II and IV only. *(I, II dan IV sahaja.)*
    C. I, III and IV only. *(I, III dan IV sahaja.)*
    D. All of the above. *(Semua di atas.)*

[See next page

28. A disk controller consists of a special-purpose chip and electronic circuits that control the transfer of data, instructions and information. Which of the following are types of disk controller?
(*Pengawal cakera mengandungi cip dan litar elektornik yang mengawal penghantaran data, arahan dan maklumat. Manakah antara berikut merupakan jenis pengawal cakera?*)

I. SATA
II. EIDE
III. SCSI
IV. SAS

A. I and II only. *(I dan II sahaja.)*
B. II and III only. *(II dan III sahaja.)*
C. I, II and III only. *(I, II and III sahaja.)*
D. All of the above. *(Semua di atas.)*

29. Network architecture describes how a network is arranged. The arrangement is called topology. There are three (3) types of network topology. Which of the following is **true**?
(*Senibina rangkaian menerangkan bagaimana rangkaian disusun. Susunan ini dipanggil topologi. Terdapat tiga (3) jenis topologi rangkaian. Manakah di antara berikut* ***benar?***)

I. Bus network consists of single central cable.
(*Rangkaian bas terdiri daripada satu kabel pusat.*)
II. Ring network has a central file server or computer.
(*Rangkaian cincin mempunyai pelayan fail pusat atau komputer.*)
III. In star and bus network, nodes can be added and removed without disturbing the rest of the network.
(*Dalam rangkaian bintang dan bas, nod boleh ditambah dan dibuang tanpa sebarang gangguan terhadap keseluruhan rangkaian.*)
IV. Star network consists of computers linked to a central device.
(*Rangkaian bintang terdiri daripada computer-komputer disambungkan kepada peranti pusat.*)

A. I , II, and III only. (*I, II dan III sahaja.*)
B. I , II, and IV only. (*I, II dan IV sahaja.*)
C. I, III, and IV only. (*I, III dan IV sahaja.*)
D. All of the above. *(Semua di atas.)*

[See next page

30. Below are types of websites and their description. Which of the following matches are **true**?
(*Berikut adalah jenis-jenis laman web dan huraian mengenainya. Manakah antara padanan berikut adalah* ***benar****?*)

	Types of Web Sites (*Jenis Laman Web*)	Description (*Penerangan*)
I.	Blog	Contains video clips called video blog. (*Mengandungi klip-klip video dikenali sebagai blog video.*)
II.	News (*Berita*)	Informational web site providing information such as tax codes and census data. (*Laman web maklumat menyediakan maklumat seperti kod cukai dan data bancian.*)
III.	Advocacy (*Pembelaan*)	Contains a cause, opinion, idea and present views of a particular group or association. (*Mengandungi tujuan, pendapat, idea dan menyatakan pandangan daripada kumpulan atau organisasi tertentu.*)
IV.	Wiki	Collaborative web site that allows users to create, add to, modify or delete the web site content via their web browser. (*Gabungan laman web yang membenarkan pengguna-pengguna untuk mencipta, menambah, mengubah atau memadam kandungan web melalui pelayar pengguna.*)

A. I, II and III only. *(I, II dan III sahaja.)*
B. I, II and IV only. *(I, II dan IV sahaja.)*
C. I, III and IV only. *(I, III dan IV sahaja.)*
D. I, II, III and IV. *(I, II, III dan IV)*

END OF QUESTIONS
(SOALAN TAMAT)

28. Examples of text-based documents are ________________.
(*Contoh dokumen berasaskan teks adalah* ________________.)

I. letter (*surat*)
II. e-mail (*emel*)
III. drawing (*lukisan*)
IV. speeches (*ucapan*)

A. I and II only. *(I dan II sahaja.)*
B. II and IV only. *(II dan IV sahaja.)*
C. I, II and III only. *(I, II dan III sahaja.)*
D. All of the above. *(Semua di atas.)*

29. To make information system valuable, the information must be accurate, organized, useful and cost effective to produce. Generating information from a computer requires the following five (5) elements. Part of the elements involved are:
(*Bagi menjadikan sistem maklumat berkualiti, maklumat perlulah tepat, tersusun, berguna dan efektif dari segi kos dalam menyediakannya. Menjana maklumat daripada sebuah komputer memerlukan lima (5) elemen. Antara elemen yang terlibat adalah:*)

I. people. *(manusia.)*
II. software. *(perisian.)*
III. hardware. *(perkakasan.)*
IV. environment. *(persekitaran.)*

A. I, II and IV only. *(I, II dan IV sahaja.)*
B. I, II and III only. *(I, II dan III sahaja.)*
C. I, III and IV only. *(I, III, dan IV sahaja.)*
D. II, III and IV only. *(II, III dan IV sahaja.)*

[See next page

30. Which of the following are rewritable DVD formats?
(*Manakah antara berikut merupakan format DVD 'rewritable'* ?)

I. DVD-ROM
II. DVD-RW
III. DVD-RAM
IV. DVD+RW

A. I and II only. *(I dan II sahaja.)*
B. II and III only. *(II dan III sahaja.)*
C. II, III and IV only. *(II, III and IV sahaja.)*
D. All of the above. *(Semua di atas.)*

END OF QUESTIONS
(SOALAN TAMAT)