Interactivity Oriented System Architecture for the 21st Century Classroom: the New Smart Classroom

Thesis By

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In Partial Fulfilment of the Requirements

For the Degree of Doctor of Philosophy in Computer System

Submitted to the Graduate School of the

University of Technology, Sydney.

2017

University of Technology, Sydney

New South Wales, Australia

CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Student:

Date:

Dedication

To those who have been by my side during this long and challenging work, offering me guidance and support with every obstacle that appeared, they have never stopped with their support, prayers and love.

Humbly, I dedicate this work with gratitude to my

Father & Mother

Also with deep appreciation to

My Wife

who has been a constant inspiration.

And to my dear daughter

Ghazl

for her future –may it be bright and happy.

And most importantly my praise and thanks to

Almighty Allah

Always.

Acknowledgment

In my research field, I want to extend my personal thanks to Dr Zenon Chaczko for his supportive ideas, insights, advices and directions related to the research project and in helping me. Also, my gratitude to Dr Roman Danylak for his assistance particularly with document design and proof reading.

Moreover, I would to acknowledge and thanks Amy Tran and Cheuk Yan Chan who were capstone students at UTS for their collaboration in developing the experiment work as capstone projects under the supervision of Dr. Zenon Chaczko. They were successfully run and achieved based on the research modelling and design requirements.

I wish also to give special thanks to King Saud University, Saudi Arabia for their generous and ongoing scholarship support that made my research study in Australia possible.

Abstract

The Smart Classroom is now a typical feature in education emerging from Information Communications Technologies (ICT) and the constant introduction of new technologies into institutional learning. The aim of the Smart Classroom is that users develop skills, adapt and use technologies in a learning context that produces elevated learning outcomes. However, research has shown that the use of ICT in the classroom is often confused or poorly adapted to the learning setting. The main goal of this research is to design Smart Classroom solutions particularly modelling, that address key limitations of system architecture design, technologies and practice. Applications of very recent technologies, such as AR, Haptics, Cloud and IoT/WSNs are investigated. The expected outcomes involve: improving the design of systems architecture; an improved selection and use of devices; improved teaching skills deployment. An extended model of the Smart Classroom is developed. A quality measurement tool for the validation of the system architecture is constructed to evaluate the model and its assumptions. Devices are also assessed measuring interactivity, usability and performance attributes, as well as, an assessment of teaching skills used in the ICT context. Finally, an innovative model of the Smart Classroom architecture that integrates an effective and practical pedagogic approach is proposed.

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Glossary

Acceptability

The system architecture quality factor that influences user preferences, acceptance and tolerance for a given solution.

Archimate Modelling Tool

A UML based modelling architecture language tool that supports the description, analysis and visualisation of system design architecture within and across system domains in an obvious way.

Augmented Reality - AR

Augmented Reality is a mixture of both the virtual and real worlds. It is characterised here by the superimposition or projection of computer-generated images or virtual reality onto real-world elements. AR enhances the real image using digitised content and information by creating a virtual overlay scene. It may also have three-dimensional expressions.

Extended Technology Acceptance - ETAM

ETAM plays a key role in the introduction of the advanced ICT tools and a specific training program to accept the use of advance technology for higher ICT tools acceptance. A key research contribution.

Haptics

It refers to a technology that uses touch to control and interact with peripherals.

Human Machine Interaction - HMI

The interaction behaviour between the user and the machine occurring in two directions.

Information Communications Technologies - ICT

Tools and resources that establish and create communication, disseminating, storing and managing information.

Interactivity

The communication process that involves users / machines in certain established channels for obtaining or exchanging data/commands between the internal and external objects.

Internet of Things - IoT

Refers to the network of physically embedded technologies that work to communicate, sense or interact with their internal or the external environment based on IP address.

Machine to Machine Interaction - MMI
It refers to the communication between machines (devices) by using ad hoc channels, such as wired and wireless communication; and thus can be executed via IoT, WSN and middleware.

Smart teaching and learning pedagogy
An approach that represents a cooperative teaching and learning method(s) using ICT advanced equipment among learners.

System architecture
Applies to the software that processes information between system users. Moreover, it also defines a conceptual model that represents the structure, behaviour and views of the proposed system.

Smart Classroom
A physically built room equipped with audio-visual Information Communications Technologies (ICT), tools that may capture human motion, utterance and gesture. The equipment allows the teacher to instruct both local and remote students.

Teaching and learning pedagogy
The teacher-student realtionship forming a direct flow of information the teacher is a sender of information to the student; the student is the receiver of that information. It also involves the pre-setting of the teaching and learning environment that incubate pedagogical materials, tools and resources.

Technology Acceptance Model - TAM
It refers to the information system theory, developed by Davis (1986) that consists elements lead to model how users derive to accept technology. These elements involve: perceived usefulness; perceived ease of use; attitude toward using technology; and behavioural intention.

The Open Group Architecture Framework - TOGAF
An enterprise architecture framework offering a high level approach to introduce system architecture design. Moreover, the TOGAF framework is used for designing, planning, implementing, and governing the information technology architecture enterprise.

Unify Modelling Language – UML
A general modelling language that provides a reflected visual design of the system.

Usability
The system architecture quality factor that determines user perception of a given solution fitness for the designated role or purpose.

Wireless Sensor Network - WSN

A wireless network system consists of spatially distributed autonomous devices using sensors for monitoring and distributed data in a particular network environment.

Related Publications

During the investigation progression, there are several research achievements have been approved reflected the research outcomes. Therefore, papers had been developed and participated in various publish areas involve the following:

Book Chapters

Alenazy, W. & Chaczko, Z. 2015, 'Augmented Reality and the Adapted of Smart Grid Monitoring for Educational Enhancement', G. Borowik, W. Jacak, Z. Chaczko & F. Gaol L (eds), Studies in Computational Intelligence, Springer International Publishing, Page(s) 353-370, Heidelberg, Germany, ISSN: 1860-949X.

International Journal Papers

Alenazy, W.,, Chaczko, Z. and Chan C.Y. (2016), “Middleware-based Software Architecture for Interactions in the Smart Learning Environment”, Communications of the IBIMA, Vol. 2016 (2016), Article ID 979834, DOI: 10.5171/2016.979834.

Alenazy, W. and Chaczko Z. (2016), "Modelling Gesture Recognition Systems", Journal of Software & Systems Development, Vol. 2016 (2016), Article ID 557104, DOI: 10.5171/2016.557104.

Conference Papers

Alenazy, W., Chaczko, Z., Chan, C.Y. & Carrion, L. (2015), 'Haptic Middleware Based Software Architecture for Smart Learning', Computer Aided System Engineering (APCASE), 2015 Asia-Pacific Conference on, pp. 257-63.

Alenazy, W., Chaczko, Z., Tran, A. & Carrion, L. (2014), 'Augmented Reality Based Remote-Lab for Monitoring', paper presented to the ITHET, IEEE Xplore, York, England, 11 -13 September.

Alenazy, W., Chaczko, Z., Carrion, L. & Mu, M. (2014), 'Development of an Expert System to Assist in Resource Management', ITHET, IEEE Xplore, York, England, 11-13 September.

Alenazy, W. & Chaczko, Z. (2014), 'The extended technology acceptance model and the design of the 21 century classroom', Computer Aided System Engineering (APCASE), Asia-Pacific Conference, IEEE Xplore, South Kuta, Indonesia, pp. 117-21, ISBN: 978-1-4799-4570-2.

Extended Abstract

Alenazy, W. & Chaczko, Z. (2014), ’The Extended Technology Acceptance Model and the Design of the 21 Century Classroom’, In Proceedings of the 2nd Asia - Pacific Conference on Computer Aided System Engineering, APCASE (2014) Extended Abstracts, 10th -12th February 2014, South Kuta, Bali, Indonesia, page(s) 102-103, APCASE Foundation, ISBN: 978-0-9924518-0-6.

PART 1:

Research Proposition

Vision, Scope, Solutions, Requirements and Nominated Approaches.

Chapter 1

Introduction

Chapter 1 is an overview of the research investigation and the nominated approaches to achieve research objectives. The chapter is divided into four main areas: *Motivation*; *Problem*; *Method*; and *Solution*.

The research hypothesis, question, aim and objectives are presented. Further, the chapter shows the research contribution and concludes with an outline of the thesis structure.

1.1 Motivation and Overview:

The Role of the Smart Classroom in Education

A classroom is a physical environment that is used in the implementation of education curricula (Fraser 2015). At the current stage of the ethnological development, a new form of the classroom can be created which is not only useful for accessing educational resources and presenting effective teaching content, but it should also be able to promote interaction between the teacher and the learner with context awareness and environment management. In this regard, the classroom has been applying ICT to heighten the degree of education in learning teaching and process (Lee, Park & Cha 2013). The application of Information Communication Technology (ICT) does not only enhance interactivity, but it also introduces accessibility and usability of learning materials provided by the Smart Classroom's equipment (Clarke 2012). Since 1980 until now, the use of smart learning tools is steadily growing and now prevalent in most of education systems (Chaudhary, Agrawal & Jharia 2014). Smart classrooms introduce a new teaching and learning system into education, which creates an ultimate learning environment for long-term ICT skills development. The use of Smart Classroom tools provides a Human Machine Interaction enhancing the teaching and learning experience. Through such interactions, the coordinator is able to provide feedback to the learners that leads to an ideal teaching and learning model for future classes. The interaction between learners and coordinator can occur both locally and remotely.

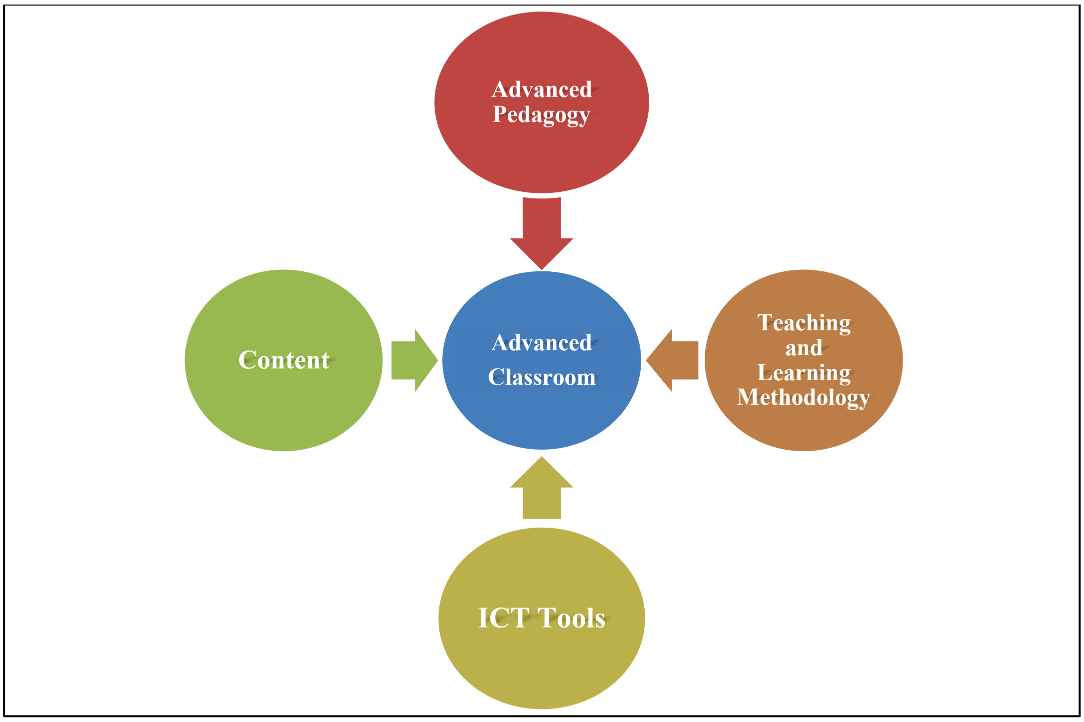

Figure 1. 1: Smart Learning Factors

Smart Classrooms have a positive impact on students, for example, they can maximise cognitive retention, and Smart Classrooms support various learning and teaching methods, such as student-centred learning method (Bouslama & Kalota 2013). Thus, the main objective of using smart technologies in classrooms is to assist students and to enable teachers to facilitate better achievement. Therefore, the primary approach is to increase the usability among users, teachers and students to support the learning and teaching process.

Smart Classrooms will continue to evolve due to the increasing number of technologies being developed. Therefore, it is important to understand what future generation classrooms might be like and how this may reformat the learning and teaching experience. This can be done by taking into consideration pedagogy and architecture to achieve the goal of further Smart Classroom development (Sobh & Elleithy 2013).

Smart Classrooms are not only useful for education purposes in a local environment, but they can also be used in remote learning, such as UTS-Remote-Lab (Alenazy, Chaczko & Tran 2015). In fact, they are suitable for application in users' experience, assisting in the learning process. For example, in Smart Classrooms, information can be communicated easily in a convenient way through real time media transmission. It also allows students to access a wealth of information that will help them understand the content of the lesson. In terms of rich learning environment, Smart Classrooms assist students to understand content better by enabling them to use various materials, and they also promote students' engagement and concentration (Jena 2013). Finally, this method is also very convenient.

Specifically in the study to follow, Augmented Reality (AR) is considered alongside with haptic devices to empower the Smart Classroom system by increasing interactivity among system's users. The augmented reality system allows students to discover and explore virtual materials as if they are real through the use of overlaid scenes (Freitas & Campos 2008); while haptic devices relate to the awareness and manipulation of objects using the senses of touch. The literature review points out that educators are increasingly finding AR suitable for implementing the teaching and learning process (Cuendet et al. 2013). This interest can be put down to the increasing scope of the benefits technology can provide to both educators and students. AR and the integration of state of art haptic technologies allow flexible, convenient and effective solutions that can enhance learning outcomes using its various forms and techniques. Therefore, the approach can lead to a real time interactive Smart Classroom (Chaudhary, Agrawal & Jharia 2014). However, most importantly, there is a need to tailor the technology and align it with the ever-changing requirements and capabilities of various users in order to improve interactive effectiveness (Chen et al. 2013).

Learners must not only be able to acquire knowledge but they must also remember and retain it for an extended period of time. Without the ability to retain knowledge, the learning process is essentially futile. Active ICT learning tools, such as AR and advanced haptic tools, may support students' ability to not only acquire knowledge but also to retain it more simply (Freeman et al. 2014; Yang & Huang 2015).

1.2 The Problem

The concept of Smart Classrooms will continue to evolve due to the rapid development and increasing popularity of various innovative ICT tools. Hence, it is vital to have a practical process to enable future classrooms changing the teaching and learning experience (Huang et al. 2015). The study here explores the potential of designing and developing Smart Classrooms that integrate new ICT advanced tools to form an improved smart teaching and learning interactive environment. The modern learning environment and pedagogical objectives and goals require teaching and learning resource that are not only interactive, but also flexible enough to meet the demands of new advanced ICT tools adoption (Chaudhary, Agrawal & Jharia 2014). The research investigation showed poorly designed and inefficient Smart Classroom system architecture that did not consider the utilisation of advanced ICT tools into the education process (Huang et al. 2015). There were some recent attempts to introduce such advanced technologies into classes (Huang et al. 2015). The effectiveness of these recent endeavours reduced ICT tools benefits as these worked in isolation from peripherals. The solution needs to resolve a key problem: the use of technology in the Smart Classroom is often congested and can be difficult to adopt significantly reducing educational goals (Zualkernan 2012). The problem of technical complexity is common and a partial solution would improve learning outcomes.

Moreover, alongside the demand of developing a new Smart Classroom system architecture and the collaboration of smart peripherals, it is important to convince users to adopt technology. Technology Acceptance Model (TAM) developed by Davis et al. (1989) set the fundamental factors of technology acceptance in education system. It represents the original pedagogical acceptance model which still used in design of education system (Teo 2011), however, the dimensions of acceptance is somehow limited due to the ICT evolution. TAM posits that three factors are at play in the acceptance or rejection of technology. These include: perceived usefulness (PU), perceived ease of use (PEU), and behavioural intentions (Teo 2011). It has been found that behavioural intention is directly influenced by both PU and PEU. Moreover, perceived ease of use also has a direct effect on usefulness (Teo 2011). TAM has recently been used by researchers to investigate a wide range of issues of user technology acceptance. A wide range of issues in educational settings involving students acceptance of online course, effective course website tools, online students communication for class, e-learning, teachers' perception of computer technology in relationship to their behavioural intentions have been investigated (Teo 2011).

In this regard, it has indicated that there is need for the extension of the TAM to encompass the external variables that influence the factors explored by the TAM including the introduction of advanced ICT tools into the teaching and learning process (Alenazy & Chaczko 2014). It should enhance user's acceptance.

TAM is the basic pedagogical acceptance model, which is currently used in many education systems. In the study, it was found that the TAM model contains serious limitations, as it does not consider the evolution of technology and its integration with the teaching and learning process. The proposed Extended Technology Acceptance Model (ETAM) underlines the need to consider these additional aspects to allow a higher acceptance level among education practitioners (Alenazy & Chaczko 2014). In this study, ETAM, as an introduced solution, went about introducing and designing the acceptable use of technologies that would detect movement and provide a gesture controller of the entire classroom system based on AR and Middleware Haptic controller techniques. So, the study made an equation: movement and controlling objects are equal to robust curiosity among the users. AR and the collaboration of haptics controller offer versatility that enables learners to learn a wide range of topics and subjects (Alenazy et al. 2015; Barfield 2010; Fraser 2015).

In the literature, the research shows that the deployment of ICT advanced tools in various the teaching and learning methods has benefits, like offering curriculum content in an alternative way, flexible scheduling, assessment of individual learner's requirements and strengths. However, realisation of effective interactive Smart Classroom has been met with various limitations in regard to the ICT tools adoption and adaptation.

1.2.1 Research Hypothesis

It is expected that architecture design will include a range of haptics, sensing and visualisation services for effective interactivity and connectivity aspects. Furthermore, building and integrating the computation model will involve AR and haptics to support the interactivity and visual modes. Consequently, the proposed model of the system will address aspects of usability and system performance in the context of technology constraints and educational needs. The hypothesis can then be best summarised as follows:

> ‘User acceptability, usability and interactivity performance qualities attitudes are closely related to system architecture. A dynamic teaching and learning environment requires specific and specialised system architecture to support selected teaching and learning tools. When the system architecture is properly designed and used in conjunction with dedicated teaching and learning ICT tools, classroom performance will be enhanced’.

Smart Classroom system architecture enhancement include: acceptability; usability; interactivity; and observability (classroom scene perception). These attributes support the multi-mode and ad hoc teaching and learning approaches. The performance measurement will be based on users’ acceptance that reflects a successfully proposed system.

Other related issues involve finding answers to the following questions:

- Should the proposed model of the user experiments include various haptics, sensing and visualisation services in order to improve interactivity and connectivity management of the system?
- Will the building and integration of AR based application and haptic components support dynamic modes of the interactivity and visualisation?
- Would the proposed model of the system architecture make a significant impact on usability and quality of user experience with the system?

The following will be performed in order to answer the main research question and also related issue involving several important activities.

The system architecture design leads to increased system interactivity by introducing new communication aspects between various interactive devices. The design of the system architecture includes three levels of connectivity, middleware and different technological aspects that support a wide range of connectivity. IOT/WSN and Cloud computing will play a key role to improve the interactivity and connectivity of the entire system. Moreover, the integration of AR based applications and haptics will have a dramatic impact by increasing interactions.

The study will focus on three domains:

- System design development to support ICT adoption choices
- The need for interactive devices
- User ability

1.2.1.1 Hypothesis Validation

In this study, there are several approaches applied to verify and validate the research hypothesis and related questions including:

- Best practices and application for modelling and designing by using modelling and designing tools addressing in Chapter 4.
- Experimentation using a testbed for building the nominated system that evaluates the performance and versatility addressing in Chapter 5.
- Conducting a survey to validate the system acceptance and usability by academics and ICT practitioners addressing in Chapter 6.

1.2.2 System Architecture Design Platform

Smart learning is comprised of smart pedagogies, smart content, learning methodology and smart equipment. This creates a complex system characterised by many connections and various sections. An interactive classroom design involves various complexities and the complete list of parts and connections may not be possible. Creating an innovative and active learning environment to achieve some goals requires concerted effort by the stakeholders, which can be achieved through proper planning and system design (Kossiakoff et al. 2011).

Therefore, there is a need to design build new Smart Classrooms which underline the demands of future equipment. In the design of a Smart Classroom, effectiveness and flexibility are essential; methods that involve spaces, student-centred cooperation and problem-based learning are desirable (Bouslama & Kalota 2013). To be able to implement a complex system, the designers need to design and choose proper tools that will enable them to empower a flexible system architecture design application in future; this includes the protocols, the infrastructure and artifacts.

1.2.3 Interactive Devices

The development of Human Machine Interaction (HMI) creates more possibilities for implementing new frameworks to improve the learning process. The computer interaction interfaces enable the instructor to teach and the students to learn or discuss with each other. Various projects are available for implementing the interaction process for e-learning which include wireless sensor networks (WSN); and actuator/sensor networks (SANET) (Kipper & Rampolla 2012).

Devices such as a smartphone, Google glasses, a smart projector, and a smart wall are currently available to the public. Various studies have shown that these devices can be used in interactive learning. For example, the smartphone can be used by the teachers to regulate slides and laptops are used by the students in the discussion (Singh, Bhargava & Kain 2006).

Interactive devices can be integrated into the architectural system following a general standard. The technology can provide a mechanism for integrating Human Machine Interaction in the Smart Classroom, as well as create a standard interface system for communication, which can accommodate the use of interactive devices (Singh, Bhargava & Kain 2006).

The current observed limitations of the Smart Classroom are summarised as follow:

- Haptic devices released in the current system require user intervention at close proximity, less than one meter to the interactive devices, such as a smart board, key board and mouse
- There is no single integration of communication services between haptic devices to increase functionality. That means the adapted peripherals are isolated.
- The interactive model requires physical observation from instructors. This aspect leads to limiting usability and reliability in a smart learning environment for smart interaction.
- Through the current system model layout, sensory objects are limited in functions individually that are insufficient to produce pervasive computing actions for a Smart Classroom environment.
- Limited range of individual haptic sensors which cause multiple out of range areas if implemented individually.

1.2.4 Users Skills

Technology acceptance is indeed one of the most important factors underpinning the integration of technology into education. To try to combat this reaction in the education sector, a number of programmes based on models have been developed. These models include: the Theory of Reasoned Action (TRA) (Ajzen & Fishbein 1980); and the Technology Acceptance Model (TAM) (Davis, Bagozzi & Warshaw 1989; Teo 2011).

Skills are required to install and operate the smart equipment, and manage complex information of higher order cognitive processes, and for self-directed lifelong learning, as well as the ability to organise, evaluate and monitor the progress of their own learning (Mingaine 2013). However, due to the advanced ICT tool mechanisms, computing skill is often low. A high level of users' acceptance is often related to the individual skills and capabilities of users; this is discussed in details in the literature review (see Chapter 2). According to Choo (2001), Smart Classroom by its nature requires basic skills as well as active engagement in learning activities and much control, discipline and motivation (Kossiakoff et al. 2011).

Consequently, the main aim of the study is to develop a system architecture that addresses the demands of technology users' interactions for future Smart Classrooms. The result of the investigation will add new value into the Smart Classroom that will lead to enhancing the experience and productivity of the teaching and learning process.

1.2.5 Research Aim and Objectives: Summary

The research area relates to developing the future generation classroom by designing smart system architecture in conjunction with selected teaching and learning ICT tools. The system will aim to introduce new techniques to partially fill the gap. Thus, the research aim and objectives will address the following issues:

- To develop a system architecture that is suitable for the future generation Smart Classroom, supporting interactive configurations, leading to a more dynamic teaching and learning environment, particularly through the adoption of new emerging technologies.

Specific objectives are:

- To design system architecture for effective interactivity and connectivity management. Various haptics, sensing, and visualisation services require smart access and a key objective is for these devices to work in conjunction with the system architecture.

- To implement and validate an effective AR and haptic tools in conjunction with system architecture in order to support various interactivity and visual modes. The validation will focus on acceptability, usability, feasibility and viability.

- To model a system for advanced ICT tools acceptance and adaptation

1.3 Methodology

The study is based on action research (Candy 2006; Schön 1983) that progressively aims to solve predefined problems. It demonstrates how various strategic practices and teaching and learning environments can be improved. In this research, the approach also consists of several tests that examine in depth ICT tool adoption in the new Smart Classroom environment. The individual tests from which a teaching and learning acceptance model is developed include:

- In depth examination using single face application architecture tools
- Application of technologies.

The proposed system relies on system architecture design and development. It contains design and modelling, field experiment and verification and validation approaches. The study as mentioned is based on a problem-solving (Truyen 2006) technique taking into account:

- Model Driven Architecture (MDA)
- Architecture Development Method (ADM)

These approaches help to provide a systemic design and implementation.

In addition, Archimate's core layers have been considered because they provide a description of viewpoints and provide understandable representative language needed to design and build the referenced system precisely (Harrison 2013) (presented in detail, Chapter 3: Research Methodology). These layers include:

- Business
- Application
- Technology

Moreover, the research progress shows specific phases that reflect sequences of modelling and building of the referenced system. Each phase focuses on activities that can be followed for improved outcomes. In Chapter 5, a **quantitative** outcome of the experiment was recovered. Key indicators were:

- System performance
- Possible interactive nodes
- Peripherals.

Lastly, **a qualitative** survey was also undertaken at the end of implemented architecture solution validating usability and acceptability of the referenced system among stakeholders in a tertiary educational environment. The results of this survey are found in Chapter 6.

Figure 1.2 depicts the top down model of research investigation. The Tech-Pedagogy process involves consecutive stages and refinement of the applied methodology.

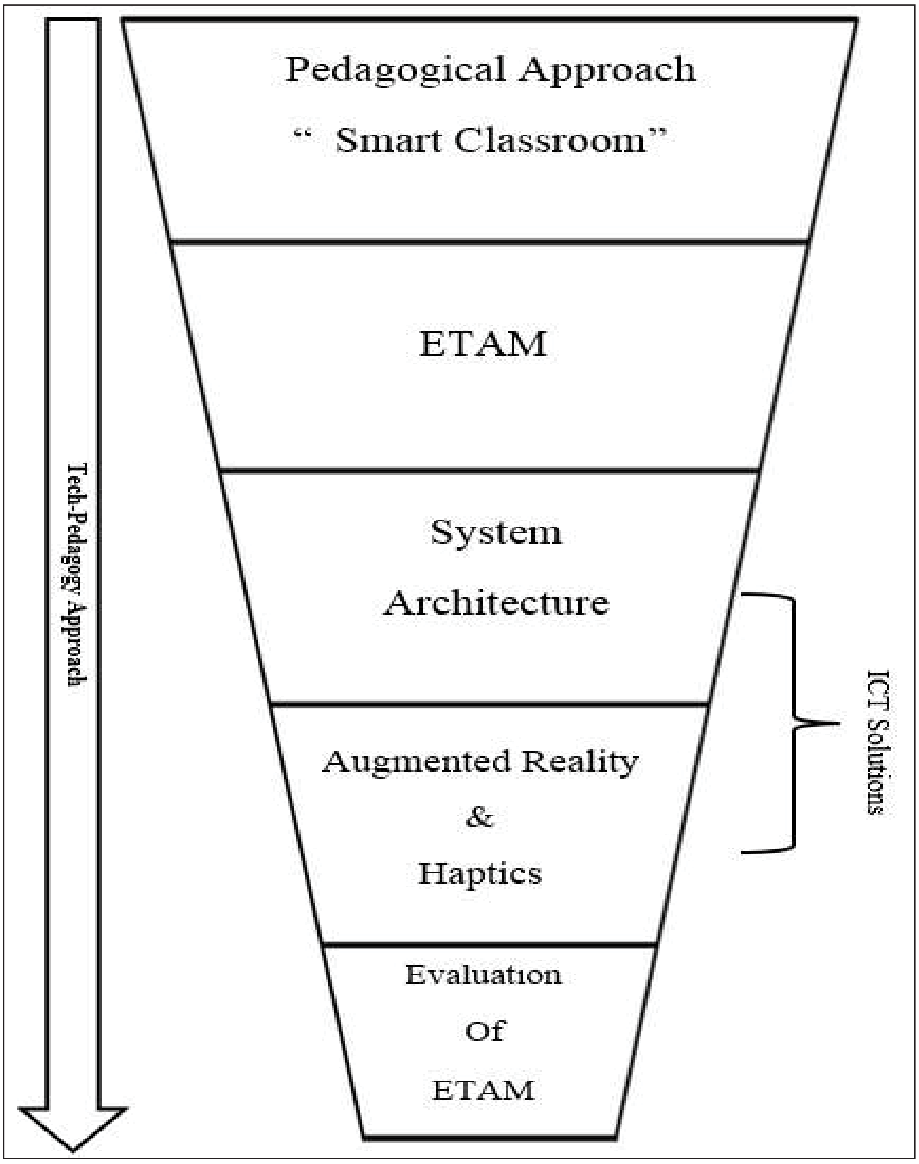

Figure 1. 2: Tech-Pedagogy Study Approach

1.4 Research Contributions

The research validates the ETAM model through system architecture design specific ICT tools selection creating a sensitive consideration for teaching and learning outcomes. These are a key focus of the research outcomes and directly address the problem of congestion and confusion in current Smart Classroom performance. The key contributions are as follows:

1.4.1 System Architecture Design

Based on the selection of the advanced technologies, the system architecture (as shown in Chapter 4.1.2) offers a platform that can orient visualisation services and haptic control through augmented techniques to enhance advanced user interactivity in Smart Classroom environment using a set of configurations for sensing, control and monitoring devices.

The goal is to build advanced computing and system architecture that will address the improvement needed for Smart Classroom. Hence, the proposed solution stated the initial conceptual design, which integrates the main aspects of selected recent ICT tools that included: haptics and augmented reality within the integration of cloud computing, Internet-of-Things (IOT) frameworks as well as Sensor and Actuator Networks (SANET) technologies in order to support interactive teaching and learning approach. The proposed framework offers a smart middleware that can unify and simplify through haptic gesture controls to enhance advanced user interactivity in classroom environment by using configurations of sensing, control and monitoring devices. Moreover, scenes mapping and partitioning (AR smart grid) were also explored for capturing, identifying and handling specific events. This work has been proved and published in journal and conference papers (see the Related Publications page).

1.4.2 Design of Interactive Learning Tools: Augmented Reality and Haptics

Based on the system architecture design and modelling to build a new Smart Classroom, a selection of advanced ICT tools were integrated into the proposed smart system environment. The study focused on two aspects: visualisation; and haptic nodes proving and validating the proposed system architecture (see Chapter 5).

One of the technology solutions introduced in this research project is Augmented Reality (AR). AR technology is currently gaining significant popularity among the public. This is attributed to new AR centric devices, such as Google Glass, and the capabilities of mobile devices that enable easy integration with the technology (Chun & Höllerer 2013; Dunleavy 2014). There are many possible applications of AR technology in education. The research utilises AR Smart Grid in monitoring independently and controlling of the environment's events. Currently, there are several sophisticated AR toolkits on the market, and by leveraging the existing framework, most of the work has focused on the development of a Smart Grid for monitoring and controlling visual events, visual cues or displayed contents.

Moreover, the majority of the Smart Classroom applications are still interacted using the traditional teaching and learning interaction tools, such as keyboard and mouse (Morrison & Kirby 2008; O'Malley, Lewis & Donehower 2013). These types of interactions restrict the users' mobility across different points inside the Smart Classroom system, utilising different haptic gesture devices such as an extension to control these peripherals in the Smart Classroom.

Based on the provided solutions, the teachers observe users activities held by objects movement doing things that can lead to notice that there is activity run/occurred in class. If movement increases, then it the measurement increases; gesture activity has increased. We assume here that increased gestures mean increased classroom interest. This assumption is tested with the developed experiments in chapter 5. Another advantage may be that teachers, can monitor gesture activity; this is a secondary outcome of the delivered project.

The advanced ICT tools techniques and solutions for the new Smart Classroom setting were developed as follows:

- Implementing multiple sensors, which give users the ability to interact with the system in a greater range.
- Creating communication between these interfaces would be handled by a high-level hardware service. A proposed system would implement hardware devices could share a common set of interface. This design allows AR and haptic objects to function and interact with the user in both individual and service connected states. This solution is scalable and it is possible to implement additional devices that promote a greater awareness of the system.
- Creation of system awareness. Awareness recognises the actors or objects within the environment.
- Creating the ability to handle and listen to multiple objects through services, the data acquired can be processed to formulate actions and interactions with the actors. It is possible to design a cross implementation advanced techniques to increase the level of Human Machine Interactions (HMI) via a mixture of sensory objects with augmented reality systems.
- Implementing multiple haptic sensors, the information obtained can be implemented to handle and cover the grey spots between devices.

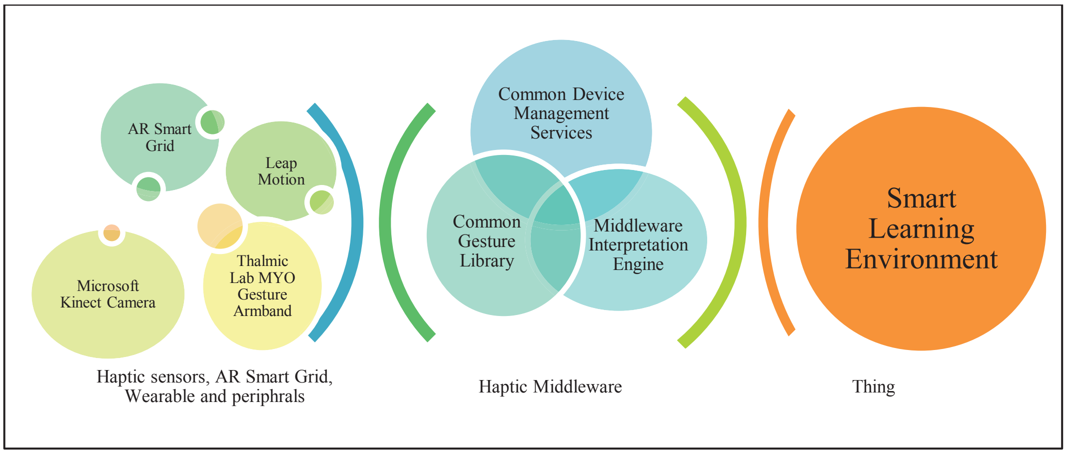

Figure 1. 3: Haptic Smart Middleware Vision for the New Smart Classroom

This work has been proved and published in journal and conference papers (see the Related Publications page).

1.4.3 Extended Technology Acceptance Model

Technology acceptance is an important factor underpinning the integration of technology into education. To try to combat this reaction in the education sector, a number of programmes based on models have been developed, these models including the Theory of Reasoned Action (TRA) (Ajzen & Fishbein 1980) and the Technology Acceptance Model (TAM) (Davis, Bagozzi & Warshaw 1989; Teo 2011) (see Chapter 2). Consequently, a key outcome of the investigation is the developed Extended Technology Acceptance Model (ETAM) by Alenazy and Chaczko (2014). The modified model seeks to increase the ability of individuals to operate efficiently in any current or future Smart Classroom; and thus improving the users' acceptance of advanced ICT tools in teaching and learning process as tested (see Chapter 6).

The solution should serve to increase the motivation level of teachers and students alike in the Smart Classroom. Moreover, the adjustments made should serve to bridge the gap between variables at play in ensuring users are receptive to using technology in classes. The end result of the implementation of ETAM should increase technology acceptance among educators and students alike (Alenazy & Chaczko 2014). Therefore, it is hoped that the teaching and learning process in the future will be easier, faster and more enjoyable for all educational stakeholders involved in Smart Classroom teaching and learning environment. The goal is to demonstrate an innovative outcome for teaching and learning in the new Smart Classroom. This work has been published in a conference paper (see the Related Publications page).

1.5 Document Structure

The structure of the thesis is demonstrated in the following table:

Thesis Outline			
Part 1	Research Proposition: Preliminary, Vision, Scope, Solution(s), Requirement(s) and Used Approaches		
	Introduction	Literature Review	Methodology
Chapter1	Start Introducing the motivation, justification of the thesis. Research hypothesis, aim and objectives. Expected outcomes/ solutions		
Chapter 2		Investigating and underlining the research scope by proposing some crucial research aspects: - Technology Acceptance models - Smart Classroom and AR in education process - System architecture design of the Smart classroom	
Chapter 3			Showing and elaborating the action research methodology that applies ADM and MDA TOGAF Frame work for modelling, design, and developing.

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Practice-Led</td><td colspan="3">- Introducing the conceptual system design of the New Smart Classroom System.
- Designing and Modelling the system architecture by using ArchiMate tool reflecting the core layers for system designing and modelling (Business Architecture, Information system Architecture and Technology Architecture).
- Introducing and defining the Extended Technology Acceptance Model (ETAM); encapsulating elements of the new smart learning environment and providing the teaching and learning scenario.</td></tr>
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Chapter 5 Practice-Based	<u>Empirical Contribution, B:</u> Testbeds Development and Qualitative Verification Experimental 1: AR Smart Grid for Monitoring and Detecting Events. Experimental 2: Haptics and Smart Middleware for Gesture Controlling.
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1.6 Conclusion

In this chapter, the purpose of the study was decribed: to design a system architecture solution for building an improved Smart Classroom in conjunction with a specific selection of user devices, in this case AR and Haptics. The approach, it is hoped, will empower technology-based teaching and learning activity. The integration of AR and Haptics with novel system architecture modelling it is hoped will have a positive impact on the teaching and learning processes. Qualitative survey and tests were used to establish the point.

The proposed solution builds an appropriate platform that coordinates interactivity among the peripherals and users. Therefore, the study considers these tools alongside designing and modelling of the new system architecture to boost the Smart Classroom ICT environment, offering a way forward in curriculum and pedagogical development.

Chapter 2
Literature Review

The chapter shows relevant works of ICT deployment for the Smart Classroom. Moreover, it consists of two parts: theoretical description and a survey of the research field and software.

The theoretical description underlines fundamentals aspects of technology acceptance theories that set crucial factors for ICT tools, adoption and satisfaction. Therefore, acceptance levels are highlighted as factors in teaching and learning while using ICT tools.

The description of the research field and software represent the technological design and development of the Smart Classroom. Furthermore, the discussion focuses on system architecture design and how it fulfils potentially optimum solutions of ICT tool in smart classes. Additionally, AR is surveyed as a base solution to the system architecture design, along with haptic. Therefore, the goal of literature review is to show the benefits and challenges of the existing methods and reflects the possible solutions for applying improved methods increasing interactivity in the Smart Classroom.

2.1 Technology Acceptance in Education

Technology acceptance or rejection is a function of several factors. These factors could be in their environment (external) or a function of the users' own pre-conceptions, beliefs, and attitudes (internal). Whether users accept or reject technology influences the outcomes of their lives. Owing to the radical advancement in technology in recent times, the way in which everyday life is conducted has changed due to the influence of technology. Because the way life is lived has changed, the ways in which information and communication are done has changed with it. This in turn influences every professional field the world over, education notwithstanding. Though technology is a part of most people's everyday life, it is ironically not well received in professional settings. This literature contains a review of studies that focus on strategies to prepare less confident users of Information and Communication Technologies (ICT) to support the incorporation of technology into the education sector. The Technology Acceptance Model (TAM) is designed to increase the tendency of users to accept technology. It particularly aims at those instructors who are considered pre-service. The TAM, however, does not take into consideration in-service instructors with little or no skill in the use of technology within the classroom setup.

The main idea of this investigation is, therefore, to modify the TAM using additional elements in order to enhance the learning and teaching experience of teachers and students alike within the education system, thus improving the acceptance of technology within the same. The modified model seeks to increase the ability of individuals to operate efficiently in any current or future smart environment. It is proposed for use by both in-service and pre-service instructors with varying amounts of knowledge. Research has shown that there is a need to seriously consider and ensure the proper training of instructors in the correct use of smart labs. The role of staff training, along with the other additional elements, is to positively influence the PU (perceived usefulness) and PEU (perceived ease of use) components of the current model (TAM). The adjusted model should serve to increase the motivation level of students and teachers alike in the use of classroom educational technologies. Moreover, the adjustments should serve to bridge the gap between the external and internal variables at play in ensuring users are receptive to using technology in education.

2.1.1 Background and Problem Estimation

Information and communication technology has been incorporated into many fields because of its essential value to these areas. In the last decade, technology has been introduced into the education system as a useful and motivational tool for practising educators. There are, however, some barriers to the adoption of technology which may lead to resistance from those who do not believe in technology and its benefits. These barriers include lack of time and resources, the infrastructure of schools, teachers' abilities, and the most weighty one being teachers' beliefs (Ottenbreit-Leftwich et al. 2010). For instance, researchers have found that some teachers, in particular those who are from the previous generation and pre-service teachers, are resistant to the use of technologies because they lack the skills needed to meet the challenge. In other words, educators unfamiliar with the use of technology prefer to use ordinary processes in their teaching. In spite of these constraints, it is believed that lots of educators with technological knowledge require their students to use computers more than once a week to facilitate and enhance their learning. A U.S. survey, for example, shows that the majority of education stakeholders are very likely to use technology for tasks such as administration and communication to meet their responsibilities in the education sector (Ottenbreit-Leftwich et al. 2010; Tondeur et al. 2012).

Satisfaction level among technology users is very important in the process of achieving information transmission inside the classroom. The concept of technology acceptance refers to the great desire for educators to use technology in their teaching to enhance the efficiency of information delivery from teacher to students. Over the years, most educators have become more willing to adopt technology to assist in this endeavour. Because of this, they have been able to identify and understand the factors influencing technology in various settings. The acceptance of technology should serve to narrow the gap and improve the relationship between the appropriate use of technology and the accompanying advantages. It is necessary to understand and identify the shape or design and approach of user acceptance to minimise the resistance or rejection of users interacting with technology (Teo 2011). Therefore, there is a need to re-investigate user acceptance with technologies that have already been implemented because of the increasing request for educational applications of Information and Communication Technology (ICT) and the constant changes in the use of technology. Some pre-service teachers spend a large amount of time trying to devise strategies on how to best deal with the technologies within the classroom, and these circumstances may have led them to form negative attitudes toward the use of technology. The system, therefore, needs to come up with new methodology for increasing technology acceptance.

2.1.2 Technology Approaches for Improved Acceptance

Because of the potential it has to effectively enhance the learning process and because it is necessary for individuals to develop the high level of skills needed for this to succeed, educators are becoming aware of technology in education. Most pre-service teachers in this generation are familiar with a variety of basic technology tools (Ottenbreit-Leftwich et al. 2010; Sadaf, Newby & Ertmer 2012; Tondeur et al. 2012). However, older teachers and those who do not believe in technology performance are resistant to the integration of these tools because they are not well prepared. Outlining the benefits or the value of using technology in education may cause some changes in their beliefs. According to Ertmer (2005), one fundamental factor hindering successful technology integration is the personal beliefs of teachers (Sadaf, Newby & Ertmer 2012). Therefore, there is a need to identify and modify teachers' beliefs within education programmes or specific additional programmes are needed to prepare for successful technology use in classrooms in the future (Sadaf, Newby & Ertmer 2012).

2.1.2.1 Teacher Education Programmes (TEPs)

Experience with technologies should be included in teacher education programmes (TEPs) to influence teachers, particularly those who are at the beginning of their education career. Though it seems that technology is being underutilised by pre-service and beginner teachers, it is important to note that gaps exist between the implementation of technology and the ways it is supposed to be used inside the actual classroom by teachers (Dawson 2008; Kirschner & Selinger 2003; Tondeur et al. 2012). A study reveals that pre-service teachers are unprepared for effective technology use inside the classroom due to a number of factors including insufficient access to technology, lack of time for teaching, and lack of technological skills (Tondeur et al. 2012). These factors contribute to the lack of technology integration, increasing lack of access to technology, lack of time, and lack of technological skill training. Moreover, Tondeur et al. (2012) point out that for technology to be integrated into future classrooms, teachers will need to be fully skilled, though technology skill training does not seem to be thorough enough to prepare beginner teachers for successful technology implementation. Consequently, teacher education programmes need to assist teachers who are at the beginning stage in their experience to build a firm knowledge base of good pedagogical practices, technical skills, and content knowledge for effective technology integration (Tondeur et al. 2012). Several programmes have since recognised that developing teachers' abilities is one of the challenges associated with technology use in classrooms with.

2.1.2.2 Introductory Educational Technology Course (IETC)

Teacher education programmes have struggled to come up with the most effective strategies on how to prepare teachers to deal with technology in classrooms. Attempting to develop teachers' technology skills through an introductory educational technology course (IETC) is one solution that has been used in many programmes (Polly et al. 2010; Tondeur et al. 2012). Therefore, teachers are expected to be able to handle technology in their future classrooms after going through the IETC (Brush et al. 2003; Tondeur et al. 2012). However, teachers must focus not only on how to use technology but also on knowing how it can be channelled into the teaching and learning processes to increase the appeal of using technology for ill-prepared pre-service teachers. The new approach is to target only those who have basic skills in technology through education programmes. Many studies have suggested integrating technology skills, particularly in curriculum studies, in order to support teachers and provide them with adequate skills and experience. These practices underline the benefit of technological training in real teaching performance and will lead to a varied range of approaches throughout lessons, for instance, information delivery `based on technology in "hands-on technology skill building activities" (Tondeur et al. 2012) and technology practice in the field.

2.1.2.3 Technological Pedagogical Content Knowledge (TPCK)

The concept of Technological Pedagogical Content Knowledge (TPCK) has been introduced based on the assumption that technology should be connected to specific content. The TPCK consists of a comprehensive base of technological skills and knowledge. It also encapsulates the knowledge of learners, subject matter content, and the pedagogy needed to equip teachers with the skills to use technology in classrooms (Koehler & Mishra 2009; Tondeur et al. 2012). According to Tondeur et al. (2012), the TPCK framework emphasises the importance of preparing technology users to make their own choices in their use of technology when they are teaching any specific group. Teachers, therefore, select specific technological tools or applications based on their beliefs. In this respect, many studies point out that technological skill training should be incorporated into teacher education courses in order to give teachers sufficient experience before they step into classrooms (Tondeur et al. 2012). As a result, some solutions have been proposed and some strategies have been developed to help teachers learn how to incorporate technology in the classroom setting.

2.1.3 Models of Technology Acceptance

It is difficult to estimate the impact of technology on various areas, like education for example. Because of the radical advancements and rapid infiltration of technology into our settings, people are becoming increasingly positively responsive toward technology (Fraser 2015). This may affect various aspects of their lives including job satisfaction, the nature of office work, and the quality of their working life. There are also arguments, however, that improperly utilised technology may not lead to the efficacy and effectiveness being targeted (Edmunds, Thorpe & Conole 2012; Teo 2011; Tondeur et al. 2012).

Ineffective technology use by teachers has led to extensive time and money wastage. The programme PT3 (Preparing Tomorrow's Teachers to Use Technology), for example, has been implemented by the United States' Department of Education to estimate technology usage. The programme provides funds to support the development of teachers' technology learning experiences (Tondeur et al. 2012). A study on this has shown that the development of teachers' technological skills is a complex, multi-faceted procedure that requires several adjustments in training programmes.

2.1.3.1 The Impact of Teachers' Beliefs on Technology Implementation

Changing attitudes regarding the role of technology in education is one of the challenges to implementing technology. Some teachers find it difficult to adopt technology because they do not really know what technology does to help students (Tondeur et al. 2012). However, studies have revealed that the development of a positive attitude to technology helps in combating resistance from teachers in the process of technology implementation.

Technology is quickly becoming the primary means of information communication in several fields in the world today, education notwithstanding. A study done on the Malaysian education system shows that there has been a move to transform their primary and secondary schools alike into smart schools. This shift has not, however, guaranteed the acceptance of technology at the individual level (Ramayah & Jantan 2004). Some individuals have had negative experiences with education and are therefore unwelcoming of it, while others are less resistant but not very welcoming of it all the same. Agarwal and Prasad (1999) remarked that persuading users to use new technologies has become the fundamental challenge facing the implementation of the new education system (Ramayah & Jantan 2004).

General instructional practices play a critical part in a teacher's beliefs according to Ottenbreit-Leftwich et al. (2010); and thus it has indicated that practice is more influenced by teacher beliefs than by teacher knowledge. In order to change teachers' intentions, they must see that using technology in the classroom will lead to increased collaboration within the class and help make achieving educational objectives easier(Ottenbreit-Leftwich et al. 2010).

2.1.3.2 User Acceptance of Technology Models Acceptance

Several models have been developed to investigate and understand the factors affecting acceptance of technology acceptance in different fields. These models include the Technology Acceptance Model (TAM) and the Theory of Reasoned Action (TRA). According to Ramayah and Jantan (2004), the Theory of Reasoned Action (TRA) was put forward by Ajzen and Fishabein in 1980. Understanding the benefits of the product and the enhancement that it bestows on learning are the major factors determining one's acceptance or rejection of any particular technology. The TRA model states that an individual's attitude has a social influence on their behaviour (Ajzen & Fishbein 1980), and that the outcome of one's behaviour primarily depends upon the nature of one's belief system. This in turn influences one's behavioural intention which results in one's actual actions (actual behaviour) (Ramayah & Jantan 2004).

There are two major factors that determine behavioural intention which are an individual's attitude toward the product in question and the subjective norm in their environment (Ramayah & Jantan 2004). User behaviour refers to a person's judgment, whether they feel positive or negative about the action, while the subjective norm is a function of the individual's repertoire of normative beliefs. According to the TRM model, the individual's immediate behaviour is a result of their intentions.

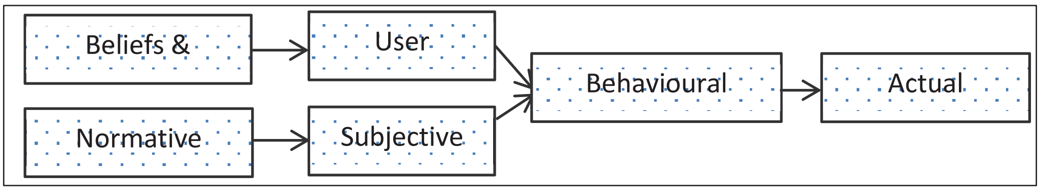

Figure 2. 1: The Theory of Reasoned Action (Ajzen & Fishbein 1980; Ramayah & Jantan 2004)

2.1.3.3 The Technology Acceptance Model

The Technology Acceptance Model (TAM) was developed by Davis et al. (1989). They developed the TAM by expanding the TRA and introducing the aspects of perceived usefulness (PU) and perceived ease of use (PEU) as keys regulating the implementation of technology (Ramayah & Jantan 2004). Expansive studies on this idea done by Davis et al. (1989) revealed that software use is a better predictor of behaviour than behavioural intention. TAM posits that three factors are at play in the acceptance or rejection of technology (Teo 2011). These are:

- perceived usefulness
- perceived ease of use
- behavioural intentions

It was found that behavioural intention is directly influenced by both PU and PEU according to the TAM. Moreover, PU also has a direct effect on PEU. The TAM has recently been used by researchers to investigate a wide range of user technology acceptance issues. A wide range of issues in educational settings, including students acceptance of online course, effective course website tools, online students communication for class, e-learning, and teachers' perception of computer technology in relationship to their behavioural intentions, have also been investigated (Teo 2011).

Teo (2011) also indicates that there is a need for the extension of the TAM to encompass the external variables that influence the factors explored by the TAM including computer-self efficiency and training. Moreover, it has been found that there is a relationship between user attitudes and intention to use technology on one hand, and user beliefs about technology usefulness on the other hand (Davis, Bagozzi & Warshaw 1989). It is believed that there is a need to have training programmes for technology use which should influence PU and PEU and serve to increase motivation level thus leading to the acceptance of technology among users.

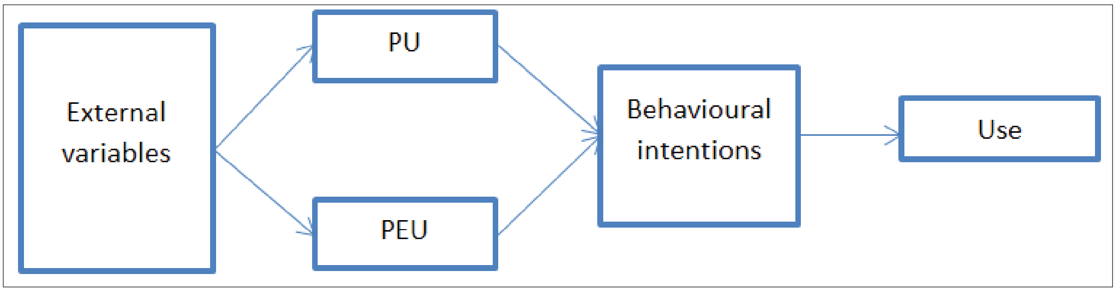

Figure 2. 2. The Technology Acceptance Model (TAM) (Davis, Bagozzi & Warshaw 1989; Teo 2011)

2.1.3.4 Training Methods for Technology Use

In spite of increased access to technology for teachers, education systems are experiencing difficulties with integrating new technologies and effective usage of the same. There are a number of barriers to the training of teachers in the use of technology for the education process. Lack of teacher training programmes has been shown to be one of the greatest barriers to this endeavour. According to Brand (1998), teacher training and development consume less that 15 percent of the technology budget in most schools. A review of the literature shows that a well-structured staff development programme on educational technology provides good insight into the individuals with negative attitudes toward technology use, among pre-service teachers in particular (Brand 1998). Addressing the significant issues in teacher training methods, including lack of time, lack of confidence, lack of experience, lack of onsite support, and lack of incentive, will assist in technology integration.

2.1.3.4.1 Lack of Time

Dealing with technology demands extensive time from those inexperienced in the use of technology. Teachers need extra time to learn and understand technology if they are to fuse modern technology with their curricula. However, research shows that schools have not yet scheduled time to create the kind of training programmes needed to give teachers the knowledge and skills they want and need in order to effectively integrate technology into classrooms (Brand 1998; Harvey & Purnell 1995). Because different individuals have different needs, training time varies. It has also been noted that the teachers in need of training do not have the time to attend workshops because of their busy daily schedules (Batane 2004). If training time needs are met, it may be easier to ensure the acceptance of technology. A solution to this problem may be to schedule training time for teachers outside their school time. Their work-load must be considered as well; therefore training time must be flexible.

2.1.3.4.2 Lack of Confidence and Technical Support

Even though teachers are well trained, many of them do not feel comfortable using technology. Educators do not wish to appear incompetent or to be "out-knowledged" by their students in their use of technology in the classroom (Batane 2004). Because technology is not part of their training experience, many teachers have doubts about using it in their teaching procedure. The point here is that knowing how to use technology is not enough. Teachers must be knowledgeable about technology and self-confident enough to overcome this dilemma (Batane 2004). Technical onsite support should serve to increase confidence levels among teachers in their use of technology. It has been found that some teachers shy away from using technology because of the unavailability of onsite technical support; they feel that they would be embarrassed in front of their students if anything were to go wrong and they were unable to sort it out themselves. Introducing such support systems as a policy may therefore serve to solve this problem, thus increasing self-confidence and effective technology use among teachers.

2.1.3.4.3 Lack of Experience

Lack of experience plays a major role in the use of technology. Regardless of teachers being able to use technology or knowing how to deal with smart environments, if they have insufficient experience the technology will be useless. Prawd (1996) stated that because the use of technology in classrooms follows particular strategies, teachers who have not undergone training in this are less likely to use technology to run their classrooms (Batane 2004). Because of this, the need for training and understanding the use of particular strategies is very important to achieve pedagogical targets.

2.1.3.4.4 Lack of Incentive

Another factor responsible for resistance to technology acceptance and implementation is lack of incentive. Due to the scarcity of encouragement from the education system, some teachers do not see the need to adopt technology or to receive training on the same (Batane 2004). The need for an incentive from the organisation is vital to convince teachers to get involved and to make time to learn and implement technology in their lessons. Additional incentives may recognise teachers' efforts publicly and reward them in a bid to increase their commitment to using technology in their classes.

2.1.4 Summary

Recent advancements in technology have led to the need to adjust education methods in many educational institutions. Since the start of the use of technology in education, this approach has gained a lot of attention from the education sector and it has been applied across many areas in the academic field. So, technology acceptance is indeed one of the most important of the factors underpinning the integration of technology within education. The models that are already in existence as well as the many studies and research papers that have been written to try to explain the behaviour of people with regard to technology have proven that we must ensure that technology is accepted, however, it will not come naturally. The classroom of the future will be laid within bedrock of technology, and if our systems are relevant, efficient and effective in the transfer of knowledge; then it must lay the proper foundations now for posterity.

However, there is a need to support the implementation of technology by modifying the TAM model using the additional factors in education programmes. This should serve to increase the motivation level of instructors and students alike. Moreover, it should grow the need for using modern technology in the education environment influencing users' attitude to accept and use the advanced ICT tools for better educational outcomes.

2.2 The Smart Classroom and the Design of System Architecture

ICT is increasingly becoming part of our day-to-day life. ICT is significant in learning environments for interactive and collaborative approaches, but it has not been fully integrated into education system. An advanced Smart Classroom may be equipped with audio-visual to capture human motion, utterance and gesture, and computer equipment allowing the teacher to lecture to both local and remote students through the internet. The objectives of this section is to research current state of the art design and architecture of the Smart Classrooms and to identify the potential benefits of integrating this technology in the school curriculum by identifying the challenges to the expansion of the system.

2.2.1 Introduction

A classroom is a physical environment used in the implementation of education curriculum. In the current age, a new form of classroom has been created which is not only convenient for acquiring educational resources but also presents effective teaching contents. It promotes interaction between the teacher and the learner, with context awareness using environment management. In this regard, education sectors have applied teaching and learning approaches like ICT to heighten the effectiveness of education system in their institutions. The use of ICT not only enhances collaboration, but it also introduces meaningful accessibility and usability of learning material. The Smart Classroom introduces a new education system which also creates a learning environment for long term ICT skills development. The use of pervasive computing tools which provide human-computer interfaces and communications enhances the classroom experience, where the teacher can interact with local as well as remote students while the learners can give their feedback to the teacher.

In addition, the ambient smart classes have a positive impact among student, such as maximising their potential, cognitive retention, flipped classes, supported by the student-centre learning method. Therefore, the main object of the smart technologies in classes is to assist the student and the teaching progress which results in better achievement among students. The ICT equipped class can also entertain and educate students through visualisation, providing highly engaging visuals and animations which will lead to the learning environment becoming more enjoyable for both the teachers and the students as well as improve their overall academic performances (Jena 2013).

2.2.2 The Traditional Classroom: Background

Historically, early Greeks had established the notion and practice of the classroom leading to the modern classroom; teaching technologies have been evolving since that time (Bouslama & Kalota 2013). For instance, blackboard and chalk have transformed into whiteboard and dry erase marker, which has also been transformed into dartboard and magnetic pen (Bouslama & Kalota 2013). The Association of educational Communication and Technology (AECT) defines educational technology as " the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources" (Januszewski & Molenda 2008). Thus, the goal of Educational technology is to facilitate the learning environment with several technological process. According to Bouslama and Kalota (2013), it is highly recommended that technical and pedagogical aspects be considered when introducing any technologies in education procedure by the classroom space architecture.

The Smart Classroom was motivated by Smart Space research at NIST who have defined Smart Space as 'an environment equipped with information equipment, computers, and multi-mode sensors which allows interaction for efficient performance of task through provision of unlimited access of information and help from the computers' (Rosenthall & Stanford 2000).

Modern Smart Classrooms supplement the traditional classrooms. This has evolved over the past decade through different research activities, from simple multimedia education systems to intelligent systems. It may have different functional interfaces, which makes it possible for instructors to create an effective 'real' classroom just like in a conventional classroom with face to face teacher-student interaction. In a nutshell, a Smart Classroom is an intelligent classroom for instructors engaging in teaching and enables teachers to practice actual teaching and learning approaches.

Shi et al., (2002) studied how intelligent tools can incorporated so as to bring together the traditional learning environment with tele-education among the students and teachers. His group produced 3D user interface software meant to bring about a real classroom experience (Shi et al. 2003). Other research is focused on making intelligent tools which function as meeting aides in a Smart Classroom which requires the use of state-of-art technique in addition to complex software framework (Singh, Bhargava & Kain 2006). Although Smart Classrooms provide interactive environment for distance education among various groups of people, there are challenges that hinder its effectiveness in teaching systems. The problem has been common when delivering teaching content where some students become passive and may not interact fully with the teacher.

2.2.3 The Concept of the Smart Classroom

The Smart Classroom concept aims optimise interaction between the teacher and the learner, increasing access to resources, utilising an awareness of the context and improving classroom management. It can be summarised as: Showing, Manageable, Accessible, Real-time interaction and Testing (S.M.A.R.T).

Smart tools enhance teacher presentation capabilities which provide visible, learner suitable content to optimize learner's material knowledge and processes. Smart Classrooms help in overcoming the learner's thinking discontinuity normally caused by single screen presentation (Sobh & Elleithy 2013).

The management, layout and equipment are optimally convenient and easy to manage. This includes classroom layout, physical environment, equipment and tools, network, safety etc. The layout is aimed at reducing passive learning, should be flexible, enabling diverse teaching and learning activities, but also takes care of the placement of different devices for space efficiency (Sobh & Elleithy 2013).

The resources and equipment are also made accessible in a classroom, which include selection of resources, content and the speed of accessing the materials. It enables conducive, interactive and personalized learning. The selection of teaching resources in a Smart Classroom provides diverse teaching resources to support teaching and learning activities such as smart phones, PCs, PDAs, interactive boards, projectors and other equipment that can not only facilitate access and interaction, but also enhance operation. The learning terminal is facilitated with the teaching contents, lessons plans and curriculum and teaching tools. The speed of accessibility should not effect the classroom activities (Sobh & Elleithy 2013).

The system can be accessed in real-time enabling interaction between the teacher and the learners through media tools. The interactive equipment is interfaced with simple, clear navigation, depending operation characteristics, using voice, touch and visual interaction, which improve man-machine interaction. The hardware in the Smart Classroom meets the interactive requirements of the multi-terminal points. The Smart Classroom should be able to record and store basic data in the computer, so as assist in decision making of the participants as well as use them for self-assessment (Harrison 2013; Sobh & Elleithy 2013).

The system can also take into account physical environmental factors such as air, light, temperature, colour, sound etc., and learning behaviour in the classroom environment, and how it affects the mental and physical activities of the students and teachers. With the use of sensor technology, sensors can be installed in convenient places in the classroom to detect automatically parameters such as noise, temperature, odour, light and others, as well as adjust lamps, air conditioning so as to maintain temperature, light, sound and fresh air which are suitable for mental and physical status in Smart Classroom (Augusto, Nakashima & Aghajan 2010).

2.2.4 Smart Classroom Layout

A Smart Classroom is a physically built room equipped with audio-visual to capture human motion, utterance and gesture, and computer equipment allowing the teacher to lecture to both local and remote students. Two projector displays are mounted across the two walls. One display is called media board in which the teacher uses it as a blackboard, on which the course content are displayed and the second display is called student board which display the information and the status of remote students as part of the class online (Sobh & Elleithy 2013).

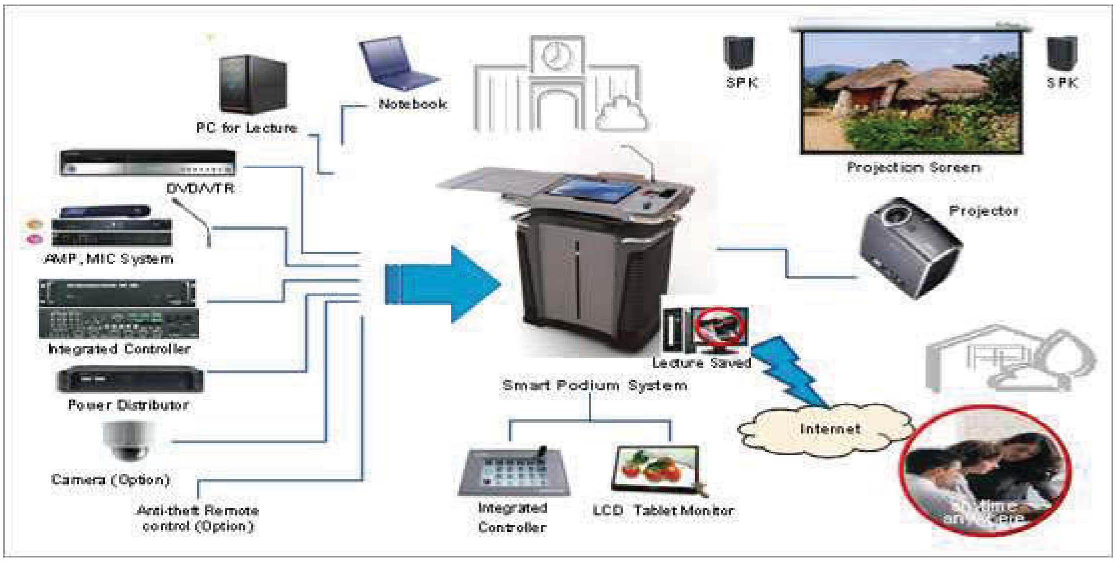

Figure 2. 3. Smart Classroom Layout (K.I.T.A 2008-2014)

All the components converge and are controlled by a CPU and that is linked to the possible largest repository server for resource (data) management as shown above. A Smart Classroom in a school will have a unique delivery model. For example, a knowledge-centre can be created inside or outside institutions, which may be linked to the main knowledge-centre if it exists. In some institutions, the knowledge centre is the entire library and that library is connected to other libraries across the globe through the internet. The teacher can also extract important materials like animation or video to be used in class lessons and through the help of the interactive devices, the teacher and students can interact with each other responding to the given material (Jena 2013).

2.2.5 Smart Classroom Haptic Equipment

Smart Classrooms integrate interactive software approaches such as blackboard and digital content or material, and hardware approaches which include PCs board, projectors, speakers, sensors, voice-recognition system, computer visions normally referred to as intelligent tools, which enable tele-education environment that can be compared to the traditional classroom. In other words, it is the use of digital smart devices that interact and collaborate to conduct teaching and learning process. Such equipment has basically transformed the way of teaching and learning between teachers and students in school as it uses powerful techniques to create interactive classroom (Jena 2013).

An interactive white-board is an electronic board mounted to the wall of the classroom and connected to the lecturer's PC for controlling. The teacher can then use it to project the pedagogical materials as multi-visual scenes on the projector. The white interactive board allow users to select point and control the PC's interface. As stated by Al-Qirim (2014), the interactive board not only enables teachers and students to control system applications by touching the screen and write digitally, but it also facilitates more professional and efficient delivery of the digital material (Smith et al. 2005). It increases the effectiveness of teaching and learning method both qualitatively and quantitatively (Al-Qirim 2014). Moreover, the interactive board features and software application deliver different learning styles making the lessons more enjoyable for students; and this leads to students benefiting from different teaching and learning experience (Al-Qirim 2014; Mezgár 2006).

There are other devices, which have been introduced and integrated in Smart Classrooms for different purposes. Tablets, smart phones, smart controller, interactive board and smart projector are an example of those advanced technologies that have been implemented to support the learning and teaching methods (O'Malley, Lewis & Donehower 2013). Tablets and other devices have gained impetus for lots of students and instructors. Consequently, it has been stated from some researches that a potential benefits have occurred while using this type of advanced technologies in classes. According to O'Malley, Lewis and Donehower (2013), there were benefits in increasing independent tasks especially among autistic students while they were using tablets in classes. Moreover, a study shows that there are advantages of using mobile technologies that provide easy access to the information, creating collaboration, improving attitude, and enhancing learning styles. Regardless of those benefits, the study also mentioned that the ease of accessing information could lead to the distraction of learners in some situations. Nevertheless, the impact of the distraction is less since it is possible to control access of the information by some special applications. It has been found that due to the development of ICT, there is a high demand to come up with an intelligent system architecture that underlines the intelligent ambient technology especially internal and external smart interaction for the 21st century Smart Classroom to enhance visual contents and materials (Rossing et al. 2012).

2.2.5.1 Teacher and Student Perspectives in Smart Classrooms: Problems

Despite the scarcity and limitation of interactive tools in a classroom, educators unanimously agree on the positive impact of interactive materials in class (Al-Qirim 2014). However, a study shows that there are some difficulties in using interactive boards and other interactive materials because of the lack of experience and implementation (Al-Qirim 2014). Thus, researchers found that in spite of having interactive tools in class, teachers did not prefer using that kind of technology. The misunderstanding of smart board or other interactive tools leads to the lack of knowledge about the effectiveness of using interactive smart tools in education process (Ambrose et al. 2010).

The use of such interactive tools among students is limited. A study showed that, in some lessons, 29% activities are carried out by students with the use of interactive board (Gursul & Tozmaz 2010). Thus, there was limited use among students for such devices. Depending on how much the interactive board can be suitable to the lecture, the desire for using interactive devices is increased. Furthermore, learning factors can also enhance the usability of interactive board in classes. These factors include digital subject materials and teaching methods regardless of the students' general participation. Another study also showed that using an interactive board still provided many advantages to the teaching approach, such as: flexibility of demonstration; versatility in teaching; multimedia interaction; teaching efficiency; participation; collaboration level, idea sharing; access to vast electronic resources; the ability to record and save lessons (Al-Qirim 2014; Smith et al. 2005). Consequently, it has been found that equipped classroom with digital interactive tools promote positive social norm and learner-centred pedagogy (López 2010). This advantage allows increasing various developments in terms of learning and teaching themes and shared meaning. Therefore, within the use of interactive board in classroom instructors are begging to share their direct instructions with students in an intelligent method. As a result, there is a need to create a Smart Classroom framework for that connectivity to function and exchange information without the loosing of the advantages to each integrated technology in the system (Ambrose et al. 2010).

2.2.6 Benefits of Smart Classes

The use of Smart Boards – a key feature of Smart Classrooms - has many advantages. To begin with, it is interactive and good for demonstrations. Students enjoy the lessons because the content would come alive in class making difficult concepts simple. Through modelling, the teacher could reinforce the content and thus enhance knowledge. New concepts can easily be communicated by use of variety of teaching techniques including the use of two or three dimension techniques. Therefore, it is suitable for students with different learning styles. For example, some students can learn by doing and interacting with the medium, and students would be free to manipulate and explore the concepts of the course. All the students' education levels have more interest and enjoy the interaction available in this technology. The attention of students is captured and this encourages participation (Smith et al. 2005).

Smart Classrooms do not only support the academic development and performance for both local and remote students, but they also enhance the capability of the system for both teachers and students in and after class hours, so that the education activities are made easier (Wu 2009). While technology based models has not statistically been proven to enhance learning outcomes, it has been shown that students and teachers enjoy multiple delivery of the content. In other words, there is flexibility of online learning and 24/7 support services which are valued especially by remote student populations, who usually have other responsibilities apart from the pursuit of education, the students can study in own their convenient time through a learning framework. The regular class meeting in a traditional classroom presents a challenge to students who perform other responsibilities in addition to the academic coursework (Anderson 2008).

Smart classroom brings about a complete revolution in classrooms. They not only bring accurate and faster understanding of class content but it also an aid in the improvement of the overall academic performance of the learner. Teachers can engage learners during the learning session and get immediate and accurate assessment of the achievement outcomes at the end of the session. It also enhances cooperative work through brainstorming and makes learning enjoyable for learners, through teaching of content in a thrilling and exciting way. The students are better engaged with the concepts on the smart board because it is visually appealing and dynamic (Shi et al. 2003; Wu 2009).

Another benefit to the teacher is that it enables access to a variety of electronic resources at a convenient time. For instance, it provides instantaneous access to the internet during the lesson, so the students' questions which could not have been answered can be answered immediately. The teacher can also plan lessons more effectively due to the use of automatic generation. Some smart-boards come with customisable layouts to fit the needs of the teachers and their own programs as appropriate. This can assist teachers who do not have a lot of time to prepare for a lesson (Shi et al. 2003; Wu 2009). In addition, apart from facilitating sharing of information and materials in real-time and in offline, online teaching experience is reported to have more democratic and open environment, with minimum discrimination due to visual perception. Students who may not speak out in a traditional class are less intimidated by online setting, and they participate more in the discussions with the teacher and with other students (Shi et al. 2003). As students work through an open online learning environment, the participants are able to interact in real - time. This creates:

1) Immediate and objective feedback to the students;
2) Feedback to content designers so that they can make improvement depending on the real use;
3) Feedback to the teachers so that they can create the best lessons that meet the students need;
4) feedback to the science researchers so that they can validate and improve the education content (Anderson 2008).

2.2.7 Converging Smart Technologies: Novel Content and Advanced Pedagogies

Smart Classrooms combine pedagogy, collaborative teaching and up to date technology teaching tools to produce modern and effective learning environment in education setting. Smart teaching uses both the physical and virtual teaching space in learning environment. Smart teaching space has specific furniture and technical specifications of physical environment and virtual learning platform to support pedagogy. In order words, it brings flexibility and simplifies learning process (Sobh & Elleithy 2013).

Due to the technology revolution in the education sector, education experts require novel content and advanced pedagogies, and new smart systems. Recently, the expansion of technologies in classes have created e-learning environments; this is a most prominent change in the field of teaching and learning (Lee, Park & Cha 2013). Subsequently, the extension of evolving and emerging technologies in classes with ICT development has led to innovation in the Smart Classroom.

Regardless of this revolution in ICT, a study shows that there has been less impact in the actual school setting (Lee, Park & Cha 2013). Thus, the use of some technology tools in the class remains limited and discrete because of the pre-existing approaches. For that reason, it is important to establish and create new innovative changes in teaching approaches or system to meet the growth of ICT. A smart learning approach has been designed for teaching and learning process in Smart Classroom. Smart learning is a new model that involves or comprises of:

- smart pedagogies
- smart content
- learning methodology
- smart equipment

There are other aspects which effect the smart learning model. These include best practices and communication services between the elements. The best practices as applied in management involves quality running of the system with deliverables which facilitates teaching and learning process (Chaczko, Davis & Mahadevan 2004). On the other hand, communication process is vital as it allows communication between the models domains as shown in the figure 2.4.

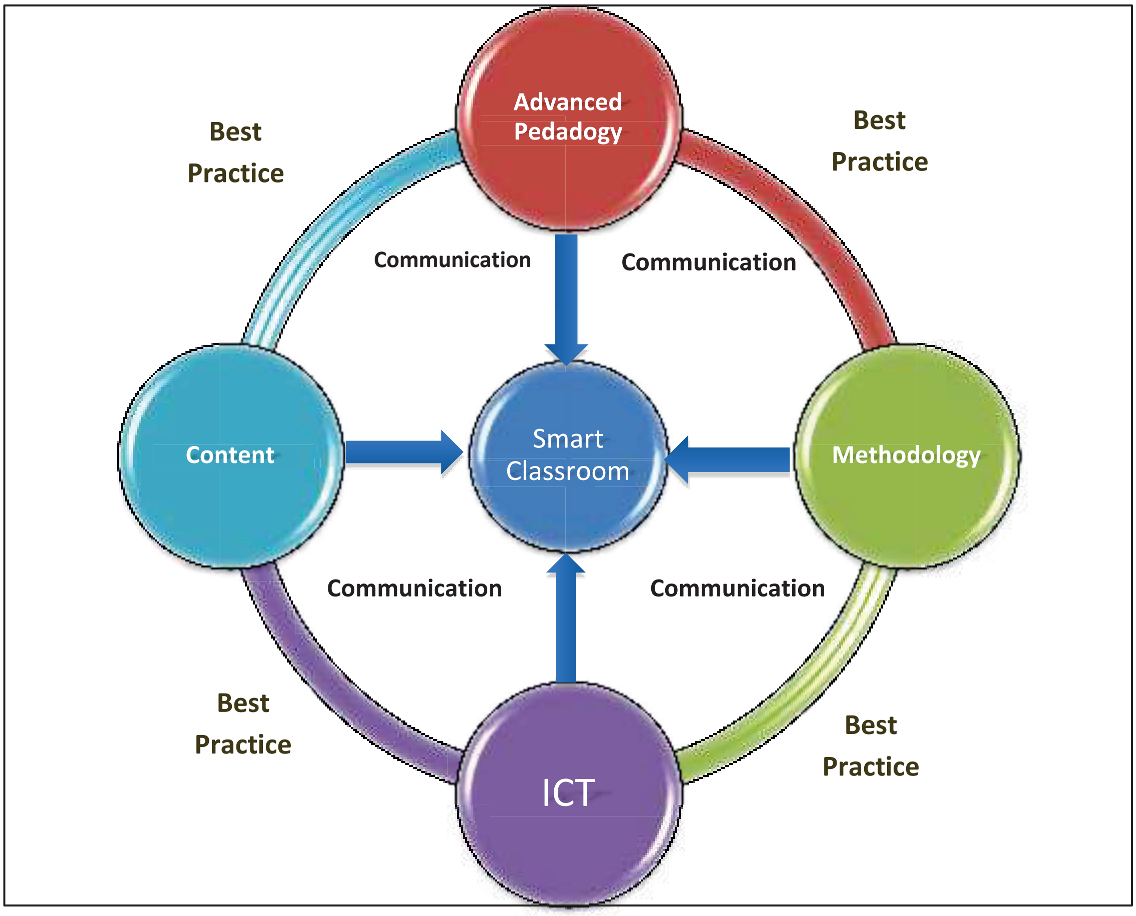

Figure 2. 4. Smart Classroom learning key Components

All of these elements can deliver insight of the smart system architecture for intelligent classroom.

Advanced pedagogies are represented as new smart pedagogies that can suite the age of technology while the smart content is managed from different perspectives with evaluation of learning environment types, such as e-learning, u-learning and m-learning (Lee, Park & Cha 2013). Educational environment have variant teaching and learning characteristics, and different approaches have been used which are Learner-Centred Learning, Cooperative Learning, Problem Based Learning and Flipped learning. In recent times, one-sidedly delivered from teacher to students is the main relied approach in classes. Therefore, claims are indicated from education experts to construct learner centred for more efficient learning. Hence, Smart Classroom architecture must be designed to adopt and facilitate two-sided learning (Lee, Park & Cha 2013).

In addition, co-operative learning describes group work that aims to achieve shared goals. In addition, it is one of the educational approaches used in classes. Thus, the Smart Classroom must consider learning performance interaction between the group members as well as with their own instructor inside or outside the classroom.

Finally, problem solving is another approach that is often prominent in smart classes. Problem-based approach emphasise learners' activities to solve problems (Lee, Park & Cha 2013). Thus, the approach is learner-centred and corporative. The Smart Classroom arrangement strongly supports these methods allowing a sustainable learning effect.

2.3 Augmented Reality in Education: Environments, Techniques and Impacts

Augmented Reality (AR) technology is increasingly being adopted within the education sector as another effective innovative device-based approach. This part of the literature review aims to show how AR technology has evolved to suit the specific demands of the education sector. AR technology allows flexible, convenient and effective solutions that can enhance learning outcomes using its various forms and techniques. However, there is a demand to tailor the technology and align it with the ever-changing requirements and capabilities of various users in order to improve interactivity.

2.3.1 Introduction

Despite being around for over three decades now, Augmented Reality (AR) has not elicited very much attention in the corridors of the education sector as it has now. Educators are increasingly finding AR suitable for implementing in the education sector(Montero et al. 2013; Zarraonandia et al. 2013). This interest can be put down to the increasing scope of what technology can provide to both educators and students. However, the increase in use of technology has primarily been generated by the increasing adoption of information communication technologies, which now dominate every aspect of human life. Technological inventions, especially in the computing and mobile telephone industries, has revolutionised the use of technology to attain learning outcomes and other pedagogical objectives and goals such as the development of social and interpersonal skills which are imperative for the overall growth and development of students. Achieving these objectives and goals requires learning beyond the traditional classroom setting. It requires interactive learning where students can fully utilise both their objective and subjective thinking.

It is these demands of pedagogical objectives and goals, which has seen more and more technology like AR being incorporated into learning and teaching processes. Learning requires the use of instruments and approaches that learners can easily identify with and learn from without many obstacles. Today's world is dominated by technology, especially computing technology. The need to incorporate these technologies into the learning process has seen AR play a vital role in increasing the visualisation of reality content in the learning and teaching process. It is a merger between technology and reality. AR is essentially a marriage between the virtual world and the real world with the aim of making learning well rounded, fulfilling, rewarding and fun. It works by generating a composite vision for the user in real time by superimposing virtual reality onto the real environment and offering a platform for customising learning. It is the combination of real time scenes and virtual scenes generated by the computer that results in new additional information or scenes. The augmented reality system allows students to discover and explore the virtual materials as if they are real through the use of overlaid scenes (Freitas & Campos 2008).

Ideally, augmented reality shifts virtual materials into the classroom environment using spectacular technological techniques. The technology combines digital pedagogical materials with real objects. The use of AR and its associated technologies in education permits both instructors and students to experience virtual interaction in real time (Cuendet et al. 2013). Real time learning, sharing of information and pedagogical interaction is a new concept that is in line with the level of civilisation in the world today. It is flexible and can make use of the technological platforms and devices already available such as personal computers, laptops, tablets and mobile phones. These are devices commonly used by students and educators alike. Moreover, they are easy to use and therefore suitable for students of various age groups and education levels.

Billinghurst (2002) points out that a smooth transition between reality and virtuality will enhance and create a new experience. However, integration into any system needs to be through an intermediate interface to allow for collaboration. Hence, many AR and other tangible user interface systems have been introduced into classes specially equipped for use with AR (Billinghurst 2002). In contrast, in ordinary classrooms with no special instruments, instructors are responsible for conducting lectures and activities by converting course books into a digital form and using computer facilities. Learners follow the instructor's guidelines and the whiteboard, handouts and slides shows are used.

However, AR equipped classrooms are relatively expensive making it difficult for them to be integrated into the highly collaborative environment that they must be in. Teaching using both virtual and real time materials or pre-planned activities in class is still fairly structured and limited for use with AR (Chen et al. 2013). In the education sector, many educators attempt to teach and help their students to acquire the curriculum in an enthusiastic style. By using advanced interactive technology in education, classrooms are likely to be the favourite place for the teaching and learning process. Augmented reality has shaped a new method of interaction in many sectors other than education. Consequently, a new interaction level has rapidly increased in popularity by introducing AR. The new advanced technologies within the classroom play a vital role in elevating the motivation levels of students while they are taught which is vital when it comes to attaining learning outcomes and other pedagogical outcome objectives.

2.3.2 Background / History

AR gives users a view of reality which has been tweaked or enhanced. The technology augments scenes derived from reality by superimposing virtual reality onto the real context. The distortion is achieved by mixing technology with the actual world familiar to the user. Such simulations of the real world can be applied to any situation or environment and hence its suitability in the education environment where students are supposed to learn and interact with a wide range of situations, ideas and topics in the real world. Therefore, using embedded smart devices with AR in today's classrooms enables students and educators alike to explore the content or information delivered in an innovative way according to their desires and the learning outcomes and expectations.

AR was developed in 1960 by computer graphics pioneer Ivan Sutherland and his students at Harvard University (Höllerer & Feiner 2004). However, the advancements made to the technology are a result of several studies by a small number of researchers who studied AR in various institutions such as the U.S. Air Force's Armstrong Laboratory, the NASA Ames research Centre and the University of Carolina at Chapel Hill between 1970 and 1980 (Höllerer & Feiner 2004). In early 1990, Boeing scientists developed an experimental AR system for training purposes (Neumann & Majoros 1998). In 1996, a group of researchers at Columbia University developed the Touring compact AR system or the machine known as “MIThrill”. More recently, current research is ongoing at the Naval Research Laboratory in Washington D.C which is aimed at developing a “Battlefield Augmented Reality Systems” (BARS) to supplement real action. This new technology is aimed at developing a system that can integrate the virtual and reality to produce tangible real action that can empower and enhance the learning process. The new technology will provide an intelligent way for instructors and learners to access the content easily and in an exciting way.

2.3.3 Characteristics of AR

Augmented Reality is a mixture of both the virtual and real worlds. It is characterised by the superimposition or projection of computer-generated images or virtual reality onto real-world elements. Such projection sometimes comes with distortion, enhancement or twisting of the real world. To achieve this, AR simulates real world elements and enables users to have an expanded view of the object. Paul Milgram and Fumio Kishino (1994) argue that AR is actually a continuum between the two extremes of the real environment and the virtual environment. Even though AR projects the virtual onto the real world, the user is still able to stay in touch with reality. It enhances the real world using digitised content and information by creating a virtual overlay; it is an interactive media which forms the basis for its use in learning (Milgram & Kishino 1994).

AR creates artificial information using data and sensory input, including sound and graphics, to enhance how users perceive reality in real time. The digitised content is given image codes which act as markers. Using applications embedded in devices, the user can then access the content and information as they interact with the object or real world in real time. This is further enhanced by object recognition which enables the device to recognise objects in the real world and it automatically provides a plethora of information in a layered format. Advancements in technology have also led to advancements in the features of AR applications. Users can now digitally manipulate images to provide finer details. AR enables users to view an image from three dimensions supported by detailed information superimposed on the image.

2.3.4 Advantages of Using AR in Education

With its three dimensions and real time interactivity capabilities, AR has key advantages over the traditional classroom and this has seen it revolutionise the learning process. It uses some of the commonest technologies in today's world - computing and mobile telephone technologies. Most of the devices using these technologies are very portable and therefore learning can occur anywhere; that is, AR permits learning on the go. Such convenience enables students to learn with relative ease without the need to be confined within the walls of a traditional classroom setting. It allows for educators to disseminate content to the students from a remote location. It is an important cog in the wheel of e-learning, the popularity of which has increased with the advent of computing technology and the internet. Educators and students have a platform where they can interact in real time and share ideas.

Shelton and Hedley (2002), in their study of the impact of AR in the education sector, found that there was a positive impact among undergraduate student using AR in geography lessons. The study targeted over thirty students and found that there was a significant improvement in student understanding when AR was used during the learning process(Shelton & Hedley 2002). They also established that there was a reduction in student misunderstanding of the various lesson concepts (Freitas & Campos 2008). This is because not only does AR improve motivational levels of learners, it also improves the creativity and innovativeness of learners. Students are provided with a wide array of platforms including games and puzzles based on a given classroom topic. Finding solutions to quizzes and playing games expands their knowledge and hence their understanding of the topic. Moreover, AR superimposes and enhances information on the real world elements. Such contextual information, which combines visual and sensory information, results in improved cognitive skills and enhances associative learning (Chen et al. 2013; Liarokapis & Anderson 2010; Montero et al. 2013). AR provides learners with a friendly interactive interface which is rich in knowledge leading to high motivation. It is modern and most learners and educators in today's world can easily identify with it which leads to high learning performance (Chen et al. 2013).

In the education sector, the most vital component of learning is the memory of learners. Learners must not only be able to acquire knowledge but they must also remember it and retain it for an extended period of time. Without the ability to retain knowledge, the learning process is essentially futile. AR has been shown to enhance students' ability to not only acquire knowledge but also to retain it (Chen et al. 2013). This is because of its ability to inspire and motivate students to learn through an interactive platform where they can create their own content and enhance the real world with virtual information. Learning using AR is interactive and associative; the students can physically interact with the real environment and with the technology and they are therefore able to easily associate their personal experience with the knowledge they are acquiring.

The modern learning environment and pedagogical objectives and goals require an approach that is not only interactive but also flexible enough to meet the demands of time. AR comes with versatility which enables students to learn a wide range of topics and subjects without necessarily moving from one class or geographical location to another. From geography to literature, physics and art, students are able to learn these subjects right from their devices (Kaszap, Ferland & Stan 2013). And with the advent of digital technology and mobile telephony, they can access this digitised content from their devices and manipulate images digitally to view them in three dimensions which is useful, especially in subjects such as physics, chemistry and art where such views are required. Using such applications as PhysicsPlayground and MITAR Games, students are able to carry out experiments virtually (Kaszap, Ferland & Stan 2012).

Using AR in classrooms allows users to access a predetermined context-aware route that is designed based on a series of learning activities and targets as required by the learner (Chen et al. 2013). The AR system is therefore set up in the education environment with a teaching plan management module and content management module. The teaching management module allows instructors to determine the level of difficulty for the learning objectives. The content management module allows instructors to easily switch to different activities or remove them from the course. It enables educators to classify the course materials based on their difficulty levels (Chen et al. 2013). Such customised content enhances the ability of educators and students to achieve set learning outcomes.

2.3.5 Development Methodology and Techniques of the AR System

During the early phase of the integration of the AR system into a smart-lab or Smart Classroom, there is a need to involve an interface system to deal with and control AR prompts by the users. One such interface system is called Tangible User Interfaces (TUIs), for example, the Digital Desk which was created by Wellner in 1991. It serves to bridge the divide between digital and paper documents (Cuendet et al. 2013). The main purpose of employing AR with TUIs as assistance tools is to increase and encourage collaboration. However, testing the implementation setting ignores the complexities of labs or classes. Therefore, the benefits of the additional elements in classrooms can lead to not achieving classroom objectives. Hence, evaluation of AR and TUIs in classrooms or labs should be carried out by creating a specific prototype that can be assessed frequently. As a result, several studies have pointed out some aspects that must be taken into account in order to achieve a high level of acceptance and implementation. These aspects include being aware that superficial changes can have effects that are hard to expect: there must be multiple-interfaces to ensure access to more than one, ensuring that using particular technologies will not interfere with AR and its TUIs; the physical size and shape of the equipment must also enable collaboration by making interaction possible (Cuendet et al. 2013).

2.3.5.1 Constraints and Requirements

A study reported that there were diverse constraints when it comes to the integration of AR into the education system, especially with regard to the attainment of pedagogical goals. These include time, classroom equipment, discipline and the curriculum. Therefore, the design of the learning and teaching environment needs to take into consideration four principles for successful implementation of the system which are integration, enabling, flexibility and simplicity in implementation (Kerawalla et al. 2006).

Due to their physical mechanism features, TUIs play a crucial role in education systems. According to Do-Lenh et al. (2012), gesturing, physical movement and embodiment can add instant value to the learning and teaching process. Gesture plays a role in problem solving and learning by providing the external representation of an object or problem (Alenazy & Chaczko 2016). Moreover, it helps learners to create interpretations by “freeing up the cognitive load”. Using AR also gives strong cognitive knowledge to learners because it provides a balance of the virtual and reality (Do-Lenh et al. 2012).

The combination of the expressive-movement-centred view and the space-centred view of tangible interactions creates the data-centred view which causes tangible interaction (Cuendet et al. 2013; Hornecker & Buur 2006). The expressive-movement-centred view emphasises “the interaction itself rather than physical-digital mapping” while the space-centred view focuses on the position of the user in space.

2.3.5.2 Construction and Implementation Design

In order to integrate any of the innovation systems into modern classes, some considerations must be taken into account for successful implementation. Learning outcomes are the result of learning activities in class, thus subject content-specificity, learners’ characteristics and the norm of education consciousness and how the content can be learned must be considered. Furthermore, individual constraints involve “previous users’ experience and cognitive load”. External and internal constraints need to be satisfied for users to achieve the objectives of integrating AR into classrooms. Moreover, Kerawalla et al. (2011) suggests that successful deployment of AR should take into consideration that: 1) there should be system flexibility to adapt to the users’ (instructors or students) desires; 2) lecture duration must be short; and 3) content visualisation should be included (Cuendet et al. 2013).

Augmented reality “uses a calculated field position and camera angle to impose a layer of virtual objects over real background scenes” (Chen et al. 2013). Due to the mixture topology, users at this stage can interact with virtual objects and access relevant information easily. Despite the limitations of AR applications which could limit the availability of information, studies show that the use of AR and its applications will become common and widely accepted in the near future (Dunleavy 2014). So, AR systems can be designed and deployed to provide users in the education sector with personalised scaffolding and assistance to create their own personal knowledge as they observe and experience the real world context. Furthermore, through a proposed system, known as the interactive Multimedia Augmented Reality Interface for E-learning developed by Liarokapis et al. (2002), to explore AR instruction by overlaying Virtual Multimedia Content (VMC), AR techniques can serve as a shared medium resulting in a collaborative learning environment (Liarokapis et al. 2002). Consequently, this will effectively increase learning motivation, engagement and retention among learners because images are more memorable compared to text (Liarokapis & Anderson 2010). As a result, by considering classroom constraints, the usability of the system in classrooms will be increased.

2.3.6 AR Forms and Principles for AR Learning

Digital information is embedded within the physical environment in Augmented Reality platforms. AR is an emerging technology that utilises smart devices characterised by context-aware devices that enable participants to interact with real-virtual objects for a specific purpose. According to Dunleavy (2014), in order to utilise and develop the AR system for learning, three strategies are important for efficient AR learning including:

- enabling and challenge aspects
- learning styles
- the conversion of unobserved objects into real objects.

These strategies are designed to address AR affordability and the limitations of the medium (Dunleavy 2014).

2.3.6.1 AR Forms

Currently, there are two main AR forms: location; and vision. In general, AR based on location serves to leverage GPS into smart devices, presenting digital media to users while they are outdoors. On the other hand, AR based on vision displays an overlayed object through the camera as a digital media for users (Dunleavy 2014). These two AR forms have positive impacts for both students and instructors because of the immersive sensitive context experiences provided by the virtual and physical environment reactions. Furthermore, this can also provide a novel and potentially transformative instrument for the education process.

2.3.6.2 AR Strategies

a. Challenges: cognitive overload

Cognitive overload has been reported as one of the challenges students experience frequently in some typical AR classes. AR comes with design strategies that enable students to manipulate the content by accessing and processing and therefore they challenge themselves critically. However, the content processing can also be high-level and complex leading to cognitive-overload amongst students. To resolve this, content material analysis should be taken into account by creating a simplified experience, increasing the complexity as the experience progresses, and framing each experience at every step to reach the chosen learning behaviour. Consequently, based on specific learning objects, AR can be used as a learning experience (Dunleavy 2014).

b. Learning Styles: Games

The second strategy involves students learning through games, stories or narratives. By creating interactive stories that are distributed and embedded within physical environments, AR allows students to collect and synthesise different information in the learning process. So, at this stage, AR instructional designers take into consideration two different learning styles in classes which involve historical fiction and playing games (Dunleavy 2014).

c. Visualisation: the conversion of unobserved objects into real objects

The third strategy enables students to visualise invisible objects. This can be done by the combination of two AR techniques to make unseen things more realistic. Interactive augmented reality uses both location and vision-based cues to trigger AR on devices which enable learners to turn to 3D models for example. As a result, the combination of techniques shifts ambiguous objects to real-visual objects that are animated and interactive.

2.3.7 Visualisation Enhancement and Real-Time Interaction Introduced by AR in Classes

Visualisation systems open new dimensions of human computer interaction by providing accessibility and providing a novel user interface. AR provides interaction between the devices and users which leads to a decrease in tangible interaction (Chun & Höllerer 2013). On the other hand, traditional interaction in classrooms has limitations and allows less functionality to be accomplished in the workplace. However, technologies that provide an advanced technique, such as gesture and speech interaction, help us to interact with real world objects in a more natural way in our daily activities (Prasad, Peddoju & Ghosh 2013). Thus, the functionalities of a reality-based-interface provides the next generation interface to interact simultaneously with real and augmented environments (Prasad, Peddoju & Ghosh 2013).

To address all obstacles in traditional classrooms, the augmented reality technique plays a crucial role in enriching learners and helping them to achieve their goals efficiently. In subjects like physics, chemistry and biology, students often have difficulty visualising things which creates of big gap in their understanding (Prasad, Peddoju & Ghosh 2013). AR tries to solve these issues by combining real and virtual information so that students can visualise things using the interaction function to help them understand.

Over the last few years, augmented reality has become one of the most utilised technologies. It has been used in many ways for different purposes. This technique can be installed or set-up in various systems for performance improvement. However, there is still a need to improve the method of interaction in a way that will provide reality of interaction with objects (Chun & Höllerer 2013). Supporting the AR technique needs to be improved by applications and tangible novel devices. Most of the applications do not support gesture-base direct manipulating of the augmented scene which is responsible for user interaction with objects for more real interaction efficiency (Chun & Höllerer 2013). Therefore, researchers have come up with solutions that enable AR interaction which includes new methodology, use of user's hands and fingers for both virtual, and possibly physical, interaction with objects that will be shown to the end user.

According to Dunleavy (2009), a simulation study shows that technology-mediation within AR helps with interaction and collaboration within the highly engaging environment in which teachers and students operate. Although the AR simulation system provides prospective added value to the learning and teaching process, there are some technical, manageability and cognitive challenges (Dunleavy, Dede & Mitchell 2009). It is expected that AR technology will continue to progress to deliver high quality multimedia-interaction for more powerful mixed reality. Three complementary technological interfaces have shaped students' learning and these include the familiar world of the desktop, the emerging multi-user virtual environment (MUVE), and augmented reality (Dede 2009).

Through the network media, the familiar world of the desktop interface provides distribution of knowledge and expertise accessibility across space and time. The interface delivers the models that lie behind most applications, tools and media in education, in particular at the K-12 education level. The emerging multi-user virtual environment (EMVE) interface provides students with a virtual graphic context which actively engages them. It is an interface which provides a rich graphic interaction environment with digital objects and tools. The augmented reality interface enables "ubiquitous computing" models (Dunleavy, Dede & Mitchell 2009). Students' experiences and interaction are infused into the real world by the digital resources of the AR interface. Multiple applications and immersion in virtual environments and augmented realities dramatically influences and shapes participants' learning styles, strengths and preferences in a new way.

A study has shown that integrating the AR system into a smart-environment is essential to support the system with different types of interaction, such as selection, transformation and control. Recently, AR applications have been installed in laboratories for educational purposes. However, the implementation has enormous set-up demands for computers, gadgets, sensors and large displays. These requirements are major obstacles to wide AR acceptance. Nevertheless, most embedded smart devices come with the AR feature enabling users to experience AR applications at anytime and anywhere (Chun & Höllerer 2013) which leads to increased acceptance and greater enthusiasm.

During the early stages of AR, many applications were not widely available on smart phones in games, navigation and references (Chun & Höllerer 2013). Many of these applications did not give much consideration to interaction and concentrated on formation display on top of real interaction (Azuma et al. 2001). Chun and Höllerer (2013) came up with the idea of "demonstration of direct free-hand gestures in AR and also enabling a direct interaction in a special lens of smart AR based devices". Designing different interaction types allows users to move and control objects accurately. The model works efficiently and is engaging.

2.3.8 AR in Classroom Settings

AR allows for the establishment of collaborative environments through teacher and student interaction with virtual objects leading to the creation of various interactive scenarios in the classroom. Virtual reality is the combination of various display and device interfaces which results in an immersive interactive 3D computer-generated environment. Mixed reality (MR) refers to the merger of virtual objects with the real three dimensional scene (Pan et al. 2006). There are two models that have been developed for MR in classrooms to support classroom teaching and self-conducted learning. The MR for learning underlines the participant's intention which is reflected directly by the perceived usefulness and indirectly through perceived ease of use. As a result, this indicates the importance of involving advanced technology in education as an essentially tool (Liarokapis & Anderson 2010). It allows for participants to engage in group work, to carry out experiments and to interact with the superimposed virtual information in real time. However, Liarokapis and Anderson (2010) suggest that AR in classes would be more effective if the level of collaboration required was determined based on users' awareness.

AR can be used to teach physical models. In chemistry, a study has shown that the ability to manipulate AR models using markers and observing rotating virtual objects is an enjoyable experience for students. So AR encourages experimentation and improves spatial skills for students, particularly those who need to construct 3D geometric shapes in "geometry education". Moreover, AR supports the dynamic presentation of information. Duarte et al. (2005) notes that AR educational applications is useful in physics because estimations of information that varies in real-time, such as acceleration and velocity, can be made (Freitas & Campos 2008). With a blend of hardware and software applications, the use of AR in education will prove a key component in future in the education environment.

2.3.9 The Use of AR & VR Systems

When designing a learning system for a specific educational stage or level, the subject content on one hand and pedagogical and psychological matters on the other need to be taken into consideration. So the AR system as an extension of VR systems has the potential to make an impact by presenting information to users and dealing with multiple tasks at the same time. This attribute allows the learning process to improve users' performance while the lesson is conducted using real objects. However, it must be taken into account that individual users have different learning styles and ways of communicating which is very important when designing and implementing a mixed reality approach (Liarokapis & Anderson 2010). The idea of multi-visualisation in AR allows learners to switch interactively between the different content presented (Liarokapis & Anderson 2010). In addition, if students are able to navigate and explore multi-dimensional augmentation of the material in detail, their concentration level will increase during the learning process.

Using AR is beneficial to the teaching and learning progress. With AR audio-visual content, students and educators have an alternative method for improving their learning outcomes. The virtual multimedia content enables students to see real life 3-D material and to interact with it naturally. Moreover, it is also possible to support AR systems and applications with the use of compatible sensor devices or computer vision techniques to address important registration issues between real and virtual information (Liarokapis & Anderson 2010).

2.3.10 The Use of AR & RFID

In the education sector, many information technologies have been merged into learning environments in order to overcome the drawbacks associated with old-style classes. Some of these technologies, such as WSN, have been introduced into Smart Classrooms to improve learning outcomes and to increase the motivation level. The use of advanced technologies leads to ubiquitous learning because of the tools available in the classroom. This aspect has the potential to impact students' attitudes and behaviour. However, there is demand within the technology revolution to leverage the learning environment with a value system to make the teaching and learning process far more effective. Introducing augmented reality to the learning process provides rich information to learners.

There are plans to develop a new smart environment which integrates different advanced technologies. For example, Radio Frequency Identification (RFID) allows for the improvement of any environment when installed because of its mobile features as a wireless sensor device. According to Hwang et al. (2011), the integration of e-maps, ubiquitous learning applications and RFID technology enables learners to assess their cognitive knowledge because of the activities during lessons (Chen et al. 2013). Moreover, this approach also helps instructors and students to deal with different kinds of knowledge or subjects at anytime and anywhere depending on learning demands. As a result, using advanced technology leads to a new innovative teaching model.

2.4 Smart System and Smart Classroom Framework: The Open Group Architecture Framework

A Smart Classroom is equipped with audio-visual to capture human motion, utterance and gesture, and computer equipment allowing the teacher to lecture to both local and remote students through the internet. The objectives of the study are mainly to research on current design and architecture of the Smart Classrooms and identify the potential benefits of integrating this technology in the teaching and learning process.

Creating an innovative and active learning environment to achieve some goals requires concerted effort by the stakeholders, who include: educators/teachers, students, institutions and system designers. This can be approached in three domains:

- through planning and identification of course content and education objectives;
- selecting and implementing the tools and methods for delivering the content and enable the learner achieve the goals;
- evaluating and assessing the implementation to find out if the objectives have been realized and interpreting the outcome

(Harrison 2013)

Therefore there is a need to redesign and build the proper classrooms which underline the demands of cyberspaces equipment. The learning environment will be equipped with desks, whiteboard, classroom facilities. However, understanding the design of Smart Classroom effectively and flexibly is essential in addressing modern pedagogical methods that involve spaces, student-centred, corporative and problem based learning (Bouslama & Kalota 2013).

Knowledge has evolved in the educational sector and technology is indispensable in the management and organisation of the processes. The use of technology in the past was confined to a specific time and place to meet the lessons objectives. But it is now necessary to integrate technology such as in Smart Classroom, so as to increase the interactive level and enhance education. The two key concepts, which are integrated in Smart Classroom, are pedagogical process and technology. The Open Group Architecture Framework (TOGAF) is one of the frameworks which support planning, designing and implementation of new technology system as well as provide structural modelling and understanding on the relationship between the Smart Classroom technologies and the pedagogical requirements (Harrison 2013). In the instructional design space in education it creates a common background or consistency and communication among stakeholders of the Smart Classrooms (Bouslama & Kalota 2013). TOGAF is the framework used in here in the design process.

TOGAF contains four layers as shown in the diagram below.

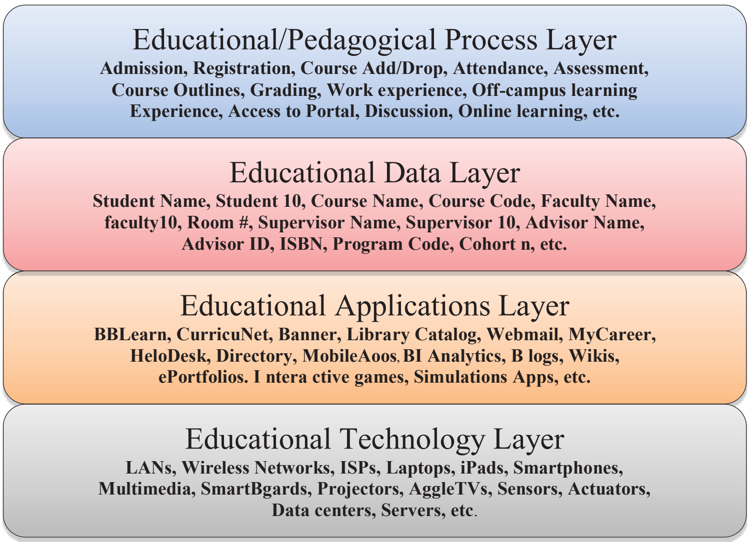

Figure 2. 5. Educational Technology Layered Architecture (Bouslama & Kalota 2013)

Figure 2.5, shows the relationship between the technologies and pedagogical process in the technology-based learning environment. The architecture system design can easily define the differences between the traditional classroom and the Smart Classroom. The Smart Classroom should be able to support different types of teaching and learning activities in the class such as synchronous and synchronous, which are not restricted in time or space (Bouslama & Kalota 2013).

A software architecture designed for the Smart Classroom should adapt to various technologies to function simultaneously. Besides, the success of the education technology depends on integrating the technology inputs from all stakeholders as well as the critical analysis of existing process and procedure (Augusto, Nakashima & Aghajan 2010).

2.4.1 Smart Classroom Requirements

2.4.1.1 Functional and Technical Requirements

In one of the studies to derive functional requirements on teaching environment, UML was used to support various environment teaching criteria. Various multimedia interactions, teaching-learning environment, various technology equipment, interface interaction and instructors to control learning process were assessed (Lee, Park & Cha 2013).

From this, we understand that multimedia should not only support the two and three dimension s between the instructors and students, but also provide the flexibility for diverse subjects or pedagogies to be placed in class. Secondly, a wide variety of technological equipment should fit into the classroom furnished setting to ensure the learning and communication process is running accurately (Lee, Park & Cha 2013). It is also necessary to produce a simple to use interface and simply operated equipment. Although, the teacher should be able to have control over the learning environment, the students should also be given a chance to keep track of their learning progress. The techniques should also support various pedagogies. The content can be divided into:

- management,
- production
- evaluation

Each piece of learning content should have a tool for that purpose and the content should also be made of text and images (Augusto, Nakashima & Aghajan 2010).

2.4.1.2 The System Architecture: Middleware

The Smart Classroom has different format and design based on the information, communication devices and also user requirements. However, most of the organisations and educators have been developed in a discrete manner and use for different status that appeared, somehow, that there are inherent difficulties to applying advanced Smart Classroom in future (Lee, Park & Cha 2013). At this point, there should be a proper system architecture design strategy that considers the difficulties and users demands and expectation for advanced technology deployments.

According to Lee et al. (2013), the integration in pre-existing classroom systems has unsuccessfully controlled and managed different types of equipment. Often, various devices are connected separately for reasons; these habits minimise the level of system accessibility. System developers suggest that by providing a single interface from the smart teaching and learning method and simplified the operation system, it will ensure convenience, consistency and better performance. Thus, Smart Classroom system provides symmetric integration and easy to use. In terms of separate connection of devices, it has been showed that smart system allows different cabled device to be integrated and connected into smart system which leads the class being managed conveniently. Three layers have been organised by the designer in the system architecture in figure 2.7 which are: controller layer, database layer and middleware layer.

<table>
<tr><td>Terminal connection controller</td><td>Gathering Information controller</td><td>Service management controller</td><td>Utility Controller</td><td>Controller Layer</td></tr>
<tr><td colspan="4">Context control Middleware</td><td rowspan="2">Middleware Layer</td></tr>
<tr><td colspan="4">Communication Middleware</td></tr>
<tr><td>User database</td><td>Content database</td><td colspan="2">Context</td><td>Database Layer</td></tr>
</table>

Figure 2. 6. Architecture of a Smart Classroom System (Lee, Park & Cha 2013)

- The controller layer serves to gather information, terminate connection, managing services and useful controller.
- The middleware layer is driven by two sup-layers, which are context control and communication middleware.
- The database layer has user, context information and content database.
- The controllers' layers establish the communication between end-nodes, such as users' to-devises and devices-to-devices.

The termination connection controller is the responsible to connect or terminate user with the equipped devices for learning purpose. Information gathering plays a key role for inserting and extracting information from devices. To control the entire system form the authorised user, service management controller is also shown. Therefore, the instructors are capable through this unit to dominate the whole education process and content. The utility controller is used to aid in the connectivity and the usability of any further devices. Middleware works to establish the communication between the controller, database and data processing (Lee, Park & Cha 2013).

The object of context controlled middleware is to analyse the occurring events in the controller and process them in dictionary form. On the other hand, the communication middleware layer facilitates the communication interface. The database layer works as repository to store learned information. The three components layer data management. The user database is responsible to integrate and store general or necessary information concerning the learners' status, learning process and the level of competence. Furthermore, the content database is responsible to store the learning content, while, the last component, "context information database stores information related to the processing of events used by the context control middleware" (Lee, Park & Cha 2013). As a result, the Smart Classroom with the proper system architecture design can play a vital key role for education enhancement because of the wide variety technologies equipment and wealth data are used.

2.4.2 Challenges to the use of ICT

There are a number of challenges to the adoption of technology in education in the community. These include:

- favouring the traditional classroom over innovation through organizational bias
- lack of professional training
- lack of articulated plans and their development,
- lack of the institution research capacity to monitor outcomes
- poor support for the implementation of the online learning practices
- poor long term cost effectiveness due to the absence of planning.
- lack of development of ICT facilities in remote places.

(Mezgár 2006).

The Smart Boards technology is very expensive, and remote schools which have low funding would have challenges in accessing this technology. Teachers are also required to be trained to use this technology. Some of them are slow to learn and may hinder the use of such technology in schools. Another disadvantage is that the system needs maintenance. This may require additional technology so as to solve this problem.

2.5 Conclusion

Smart Classrooms will continue to evolve due to the increased popularity and development of ICT. Hence, it is important to understand how the future classrooms will be and how it will reformat learning and teaching experience (Bouslama & Kalota 2013).

Nevertheless, the aim of developers is not only how to build or enhance the classrooms; it is also how to create a more efficient smarter classroom as well. This could be done with a view of both pedagogical and architecture considerations achieving the goal for of Smart Classroom development.

AR is increasingly used in educational environments. AR offers assistance to integrate the learning environment and to support the learning process, creating meaningful learning when used in conjunction with an interactive platform. AR plays a key role in raising motivation levels by presenting students with a more interactive, exciting and familiar environment for learning. It elevates learning to a higher level and enables customised learning. AR gives learners a taste of both worlds - it mixes real world experience with virtual reality with the latter enhancing the former. Such enhancements give more detail to real world elements compared to traditional classroom learning approaches. It uses a platform, information communication technology, which modern day learners and educators are familiar. With such familiarity, it is easily adopted within learning environments. It is also flexible as it can be used for different topics and subjects while the portability of devices using AR adds much needed convenience in the Smart Classroom.

However, there are inherent challenges that come with using technologies such as AR. The seamless integration within the current learning environment is challenging because of the need to take into account the various learning needs and personalities of the users.

Therefore, this study is focused on the relationship between system architecture design and the implementation of AR and Haptic devices. The literature states that due to the new ICT adaption and users' demands, the Smart Classroom needs to be redesigned or at least modified. This requirement calls to modify the model integrating system architecture with ICT tools such as AR and Haptics, to create an improved user experience. Moreover, establishing a new system architecture requires some specific modelling and designing tools. A balance is sort between pedagogy and up-to-date technology integration; this approach will promote convenience and communication of information over the system in real time for Smart Classroom. The following chapter presents the research methodology in details.

Chapter 3
Research Methodology

The chapter shows the methods that have been used to investigate the research aims. The research methodology refers to a set of systematic procedures used to solve the specific research problems. Various research methods were used in software designing and development, these include: action research; system architecture design; field experiment, and survey.

3.1 Introduction: Key Approaches

3.1.1 Action Research and Research Review

The research investigation utilises Action Research. Action Research is a process of progressive problem-solving designed to improve strategies, practices or a working environment. Action Research strategy is useful in human-centred design research offerings: it seeks meaningful characteristics of real-life events, making the research practical, and assuring the developed methods and processes are usable in practice (Avison et al. 1999; Baskerville 1997; Järvinen 2007; Stringer 1999).

Action research comprises of two approaches: Practice-Based and Practice-Led research. The practice-based research is the foundation of the contribution to knowledge that is results in creative artefacts/solutions (Schön 1983). Moreover, it describes an original investigation to produce new knowledge by means of practice and the outcomes of the practice. Practice-led research refers to research activity that contributes to a new understanding of the specific practice. It is a research of practice that leads to new knowledge advancing operational practices. Therefore, the core focus of this approach is to advance knowledge about or within the practice (Candy 2006).

The work here involves both practice-led and practice-based research. Practice-led research is applied in the development of modelling and design of system architecture. Practice-based research occurs at the design of experience and the implementation of new tools, such as haptic and AR, within the purpose of improving user experience in the Smart Classroom system. A user survey was conducted in this section.

In regards to the research process, the problem-solving technique required modelling and designing tools and empirical development. The methodology is further summarised as follows:

3.1.2 Descriptive Design

Descriptive Design endeavours to explain and interpret situations of the present system architecture for the Smart Classroom, and all its stakeholders (Takeda, Veerkamp & Yoshikawa 1990). It aims at studying the rational design and usability of the system, in particular, scenarios for better collaboration in education. Descriptive Design was conducted using a case study (scenario) that involved description and interpretation of events, conditions, circumstances or situations that exist in the proposed systems. The case study was used to identify the complexities of the new classroom architecture to find the importance of specific technologies to enhance the proposed system architecture.

3.1.3 Design Implementation

The innovative design aimed at establishing the causes underlining the gaps, requirements, solutions and to evolve the conceptual design. Architecture design and test-bed platform led to the development of middleware, components of AR smart-grid and components of haptics in order to test or examine the interacting elements. The Architecture design provided an overall and accurate skeleton or framework while the test-bed platform provided a testing technique for a particular function or module (see 3.1.4). The framework was based on the modules; and thus, the modules were conducted as if it is already part of an extensive system.

3.1.4 Test Study

Usability testing method, which aims at completeness and correctness, was used in the study in order to verify and validate the experiment (Dumas & Redish 1999). The pre and post-test utilised the experiments to evaluate the design system evaluating feasibility of the design. Therefore, the qualitative research method determined each experiment to examine contemporary real-life situations, providing the foundation to the system.

In addition, statistics testing by survey was used to check the system at the end of the test development to verify the introduced solution to users and to ensure an accurate response to the research question (Blakstad 2008).

The research method can be summarised as shown in the figure below. The figure demonstrates the correlation between the research techniques.

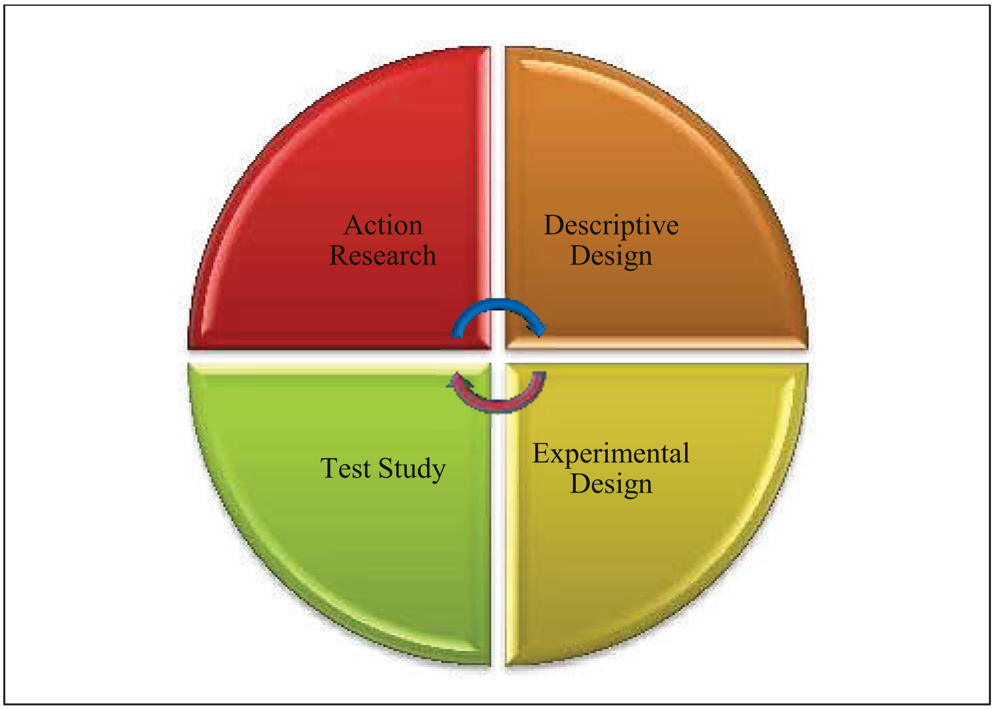

Figure 3. 1: Overview of Research Approach

3.2 Designing and Modelling Methods

This key modelling and design method used was Model Driven Architecture (MDA). This technique provided an overview of the life-cycle development. The Spiral Model was used in the life-cycle process (Boehm 1988). The spiral model provided a systematic way for combination of these methods in the development of the system so as to achieve an optimum outcome. The problem-solving process of MDA provides a procedure for developing the system. It involves understanding and solving the problem as well as implementing the proposed solutions (Alhir 2003). The combination of the processes will minimise unique risks in the development of the iteration process. The system implemented is as shown in the following diagram:

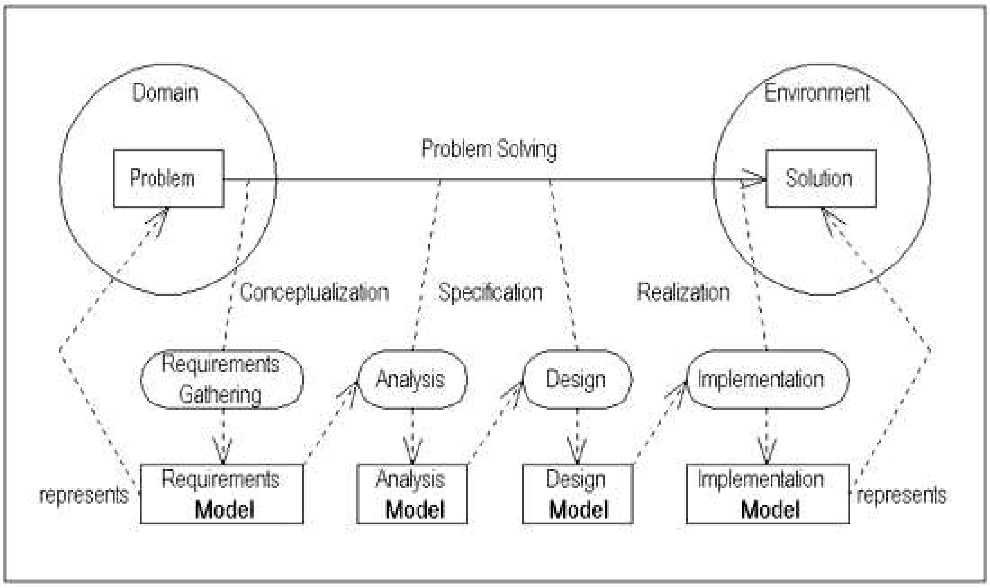

Figure 3. 2: Systems Development Lifecycle Process (Alhir 2003)

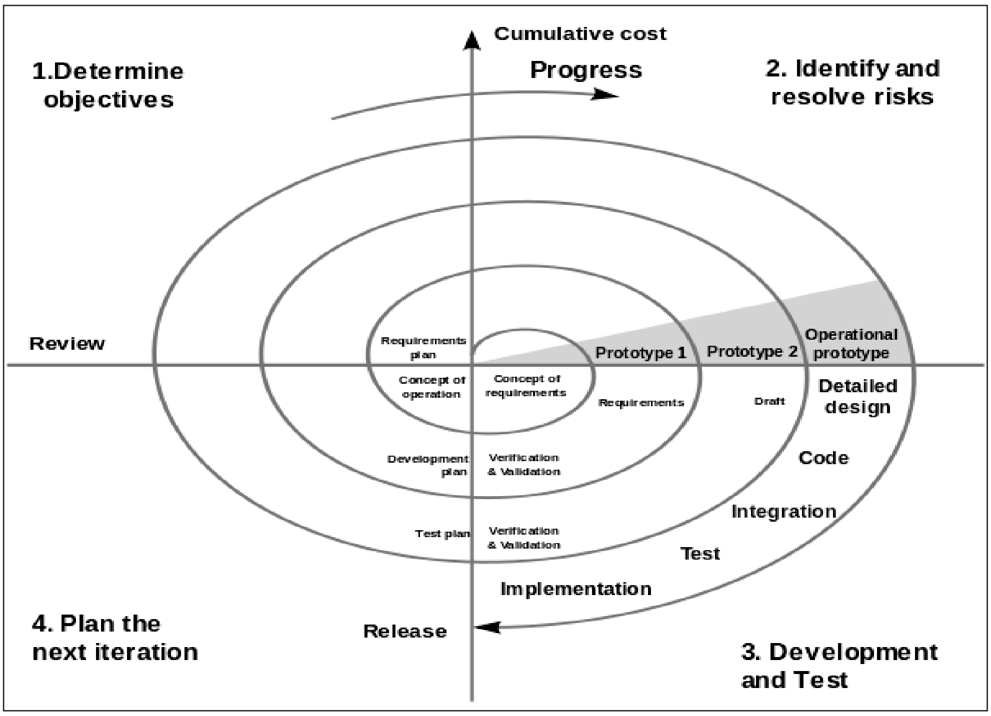

Figure 3. 3: Spiral Model (Boehm 1988)

The spiral model is an effective technique for developing software prototype and reuse. Here it used in conjunction with MDA. It involves four stages of development that include:

- determination of the objectives
- identification and solving the risk
- development and testing
- planning the next iteration

The model plays the main role in the development of the software and creates a risk driven technique for software development process (Boehm 1988). It also has the ability to incorporate the strengths of other models and thus helps to resolve most of the difficulties. In addition, MDA can be placed in the phase iteration in the spiral model. The lifecycle development can either be descriptive which is used in understanding and improvement of the development process, or perspective model which supports the research, and can be enhanced through:

- Identifying and creating guideline of the feedback loops between stages
- Creating initial incorporation prototype in the research lifecycle
- Providing frameworks to organise and plan how the software development activities can be performed and sorted

This arrangement will help in eliminating many difficulties encountered previously through the research project stages.

3.2.1 Model Driven Architecture Functionality

Objective Management Group (OMG) developed the MDA model as new software architecture standard with the aim of reducing the complexity, lowering the cost and to assist in the introduction of new systems (Alhir 2003). MDA has the ability to address the complete development process which includes analysis and design. It also enables the faster development and application of new specifications for new platforms and technologies. Implementation is simpler, it resolves issues, concerns and risk, and thus streamlines the integration process, as well as providing a comprehensive, structured solution which enhances the portability and interoperability for effective use of existing as well as evolving technologies (Truyen 2006).

3.2.2 Justification for the MDA model

The goal of MDA is to facilitate the flexibility and the creation of machine-readable model (Truyen 2006). The benefits of using MDA can be summarised as follows:

- ***Technology obsolescence***: existing designs can be integrated and used to support new implementation of infrastructure.
- ***Portability*****:** enables integration of new environments and platforms with the existing system functionality.
- ***Quality*****:** the separation implied, consistence and reliability of the artefacts produced by this approach contribute to enhance the quality of the system.
- ***Integration*****:** the production of the integration bridge is facilitated.

- ***Maintenance***: the availability of the design as machine-readable simplifies maintenance tasks.
- ***Testing and simulation***: generated models can be directly tested and used to simulate the system behaviour upon the design.

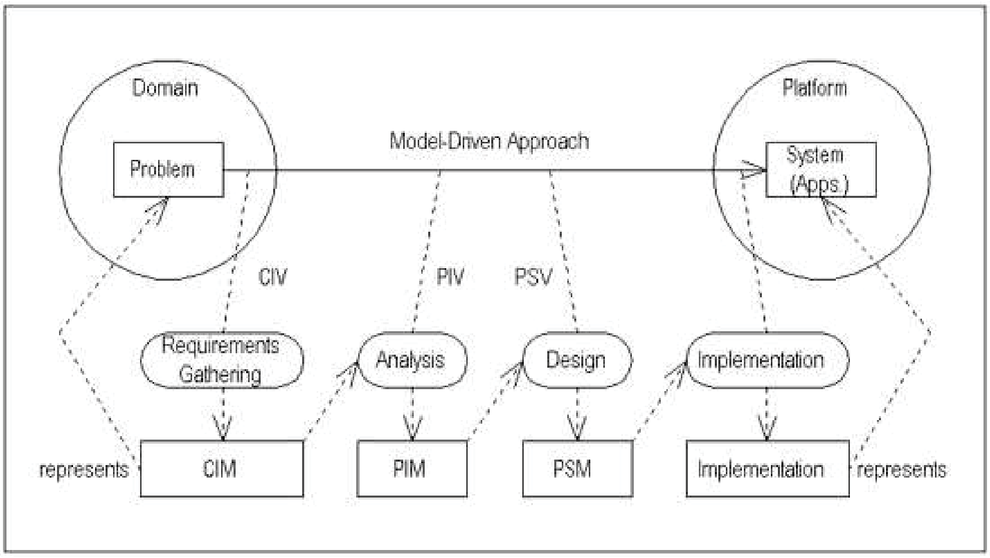

Figure 3. 4: Foundational Concepts of the MDA (Alhir 2003)

The MDA method solves system complexity by separating and relating the developed platform independent models (PIM) and platform-specific models (PSM) through transformation techniques. PIM has no specific implementation technology model, while PSM has specific information for implementing the technology. For example, PIM has a generic system description, while PSM describe the system though coding like .NET or java. Mapping process the process of converting PIM to PSM. The main reason for the application of these processes is to sustain and implement technologies and requirements which bridge the gap between any independent changes (see figure 3.4) (Alhir 2003).

3.2.3 MDA Key Concepts: Description

3.2.3.1 Platforms, Application, and Implementation

Platforms are technologies which cover interface and pattern use functionality. They can be specific or generic. The Platform model provides functionality through the installed applications (Alhir 2003). System applications that are supported by platforms and information for interpreting contribute to the implementation.

3.2.3.2 Architecture and Viewpoints

Architecture describes system elements involves the make-up of the system and the correlation between those elements to provide the functionality (Alhir 2003). The representation of the system from the perspective of a viewpoint is known as the viewpoint model.

3.2.3.3 Model Procedures in MDA

A platform specific model (PSM) which describes the operation of the system from one or more platforms. It corresponds to the specification perspective's design mode. It offers:

- A computation independent model (CIM) which describes the system domain and requirements. It corresponds to the conceptualisation perspective's requirements model.
- A platform independent model (PIM) which demonstrates operation of the independent system in a platform. It corresponds to specification perspective's analysis model.

3.2.3.4 Other Concepts of MDA

A computationally independent viewpoint (CIV) that focuses on the requirements of the system and its environment corresponds to the conceptualisation perspective.

- A platform independent viewpoint (PIV) which describes the independent operation of the system at any platform.
- PIV corresponds to the specification perspective's analysis activities and model.
- A platform specific viewpoint (PSV) which focuses on the system operation based on specific platforms. PSV corresponds to the specification perspective's design activities and model.

3.3 Development Method for System Design and Modelling

In this study, the TOGAF framework and ArchiMate modelling tool were the foremost approaches used for modelling and designing the prospective system (see figure 3.5). TOGAF framework consists a process, which relies on architecture development method (ADM), and describes system viewpoints that include techniques, reference models and the type of building system blocks that make up architecture (Group 2012). Specifically, the study focused on the ArchiMate Core layers. The advantage of this is the ArchiMate specifications described the viewpoints with a well-defined representative language that was needed to design and build the referenced system precisely. Moreover, it aided stakeholders in assessing the impact of design choices and changes.

ArchiMate specification comprised of the core language (ArchiMate Core) that underlined the descriptions of the four TOGAF standard architecture domains. The ArchiMate core consisted of the layers Business Architecture (Business), Information System Architecture (Data Application) and Technology Architecture, as well as their interrelationships (Group 2012). The business layer showed the beneficial products and services to the users, which were realised in the ICT Smart Classroom system through the notations of business process performed by business users/actors. The application layer supported the business layer with the demands applications services, which is realised by a set of software/application(s). Lastly, the technology layer at this point offered the infrastructure services needed to make up the applications realised by computational hardware and system software. In and between these layers, there are a set of relationships that tailor the entire components consistently. Moreover, the shown extensions relate to TOGAF in the framework and served to model the motivations extensions for the architecture and its implementation and migration planning (Group 2012).

The processing steps of developing the proposed system followed two steps: Archimate initial setting; and Testable Architecture. Each of these steps consisted of the three core layers. In step one, it was predicted that the system architecture was going to be defined and designed in its last version. After that, the following tests and verified the referenced model components and interactions according to the components relationships through the core layers. As a result, this stage represented the action study that was set and implemented to achieve the demands of the research project.

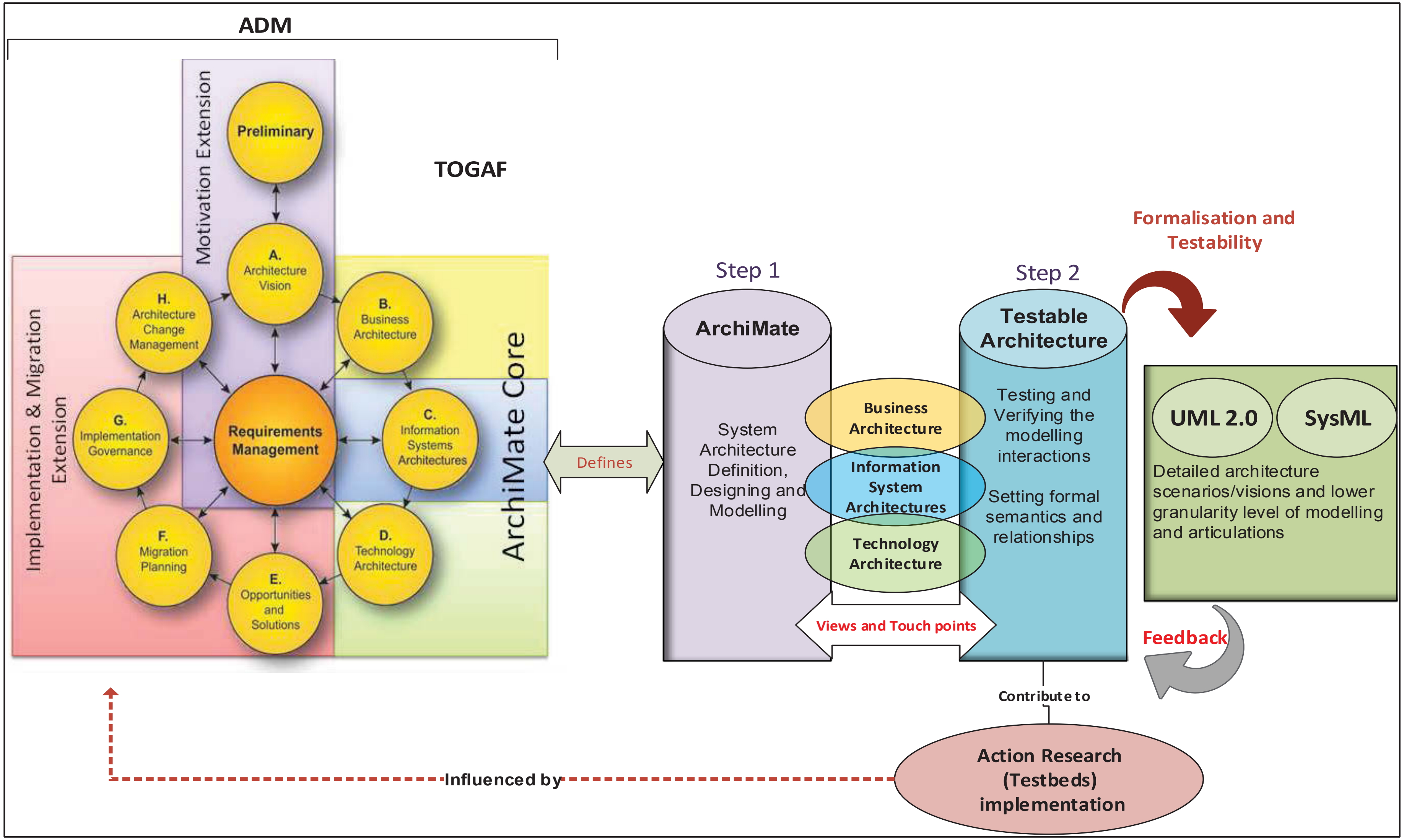

Figure 3. 5: Adopted TOGAF Framework System Development Stages

Accordingly, the purpose of applying the ArchiMate framework was to provide a visual language of communication to describe enterprise architecture and to conceive the designed system architecture via explicit graphical, understandable and semantic modelling approaches (Group 2012). Therefore, the combination of these approaches led to an established system of development method tailored for modelling, designing and implementation of the new Smart Classroom.

3.4 Research Progress

This section describes the research progress through the adopted methods.

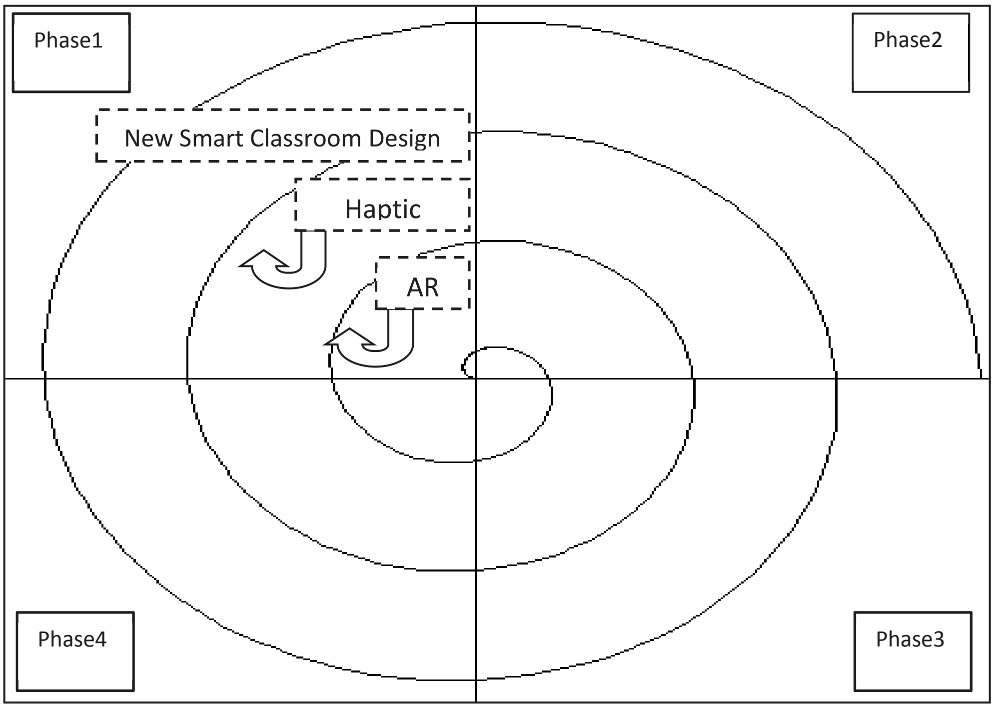

Figure 3. 6: the Adopted Spiral Model

The spiral model shown in the figure above accommodated ADM for various system developments. The ADM revealed the hierarchical relationship between services and standards, and the architectural methodology model was used. Different phases represented ADM in the spiral model management. The phases are shown in figure 3.7.

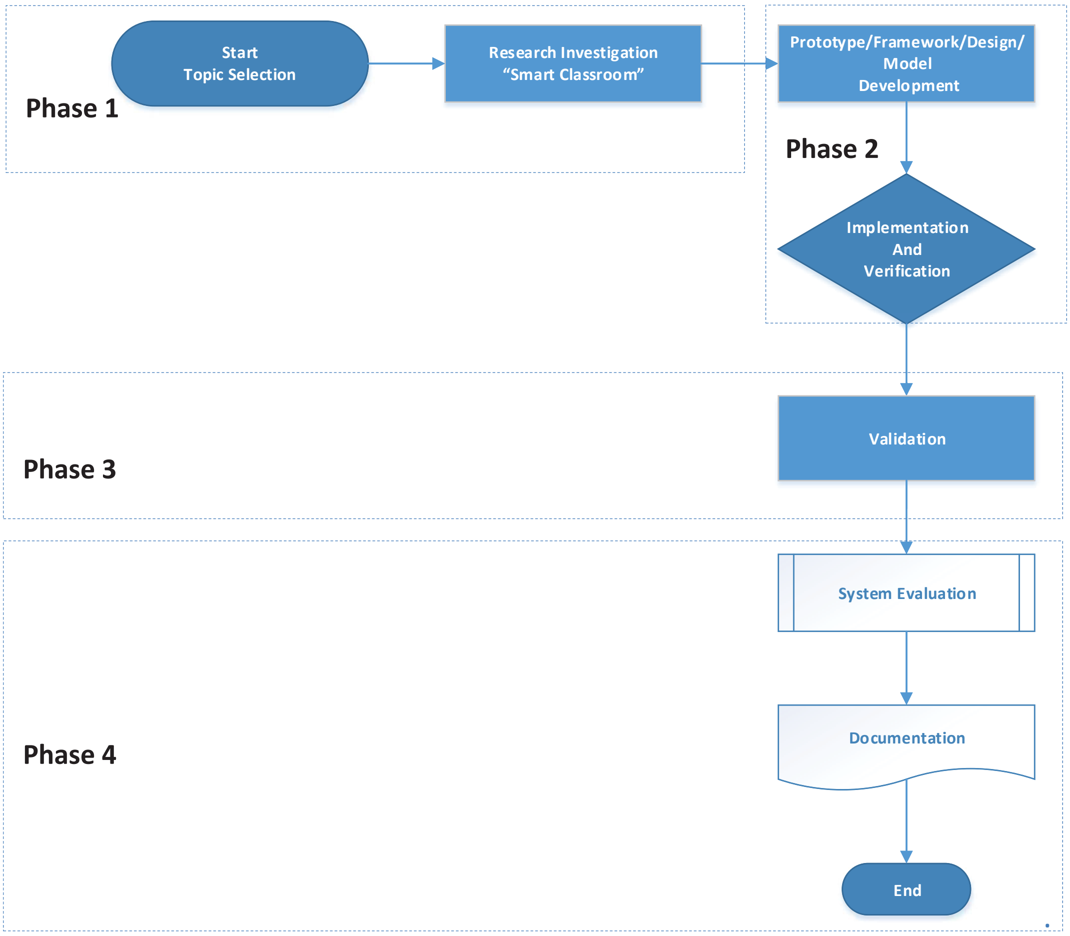

Figure 3. 7: Research method flowchart

During each phase a singular operation consisted of several activities was performed before passing to the next phase. The phase processes are elaborated below.

3.4.1 Phase 1: Topic Selection and Research Investigation

The focus of each phase was based on: area of selections; problems identified through the literature review; and identification of existing constraints and limitations on the state of the art with a clear research scope. More specifically, it focused on characteristics of Smart Classroom layout, augmented reality and haptics used to develop the proposed system architecture. The model described the problems and their solutions. The activities that were represented in this phase include:

Step 1 Topic selection: The choice of a research topic was influenced by personal interest, observation, literature reviews that describe previous theory and research in the area, social concern or any current study issues. In this study, the choice of the topic was mainly influenced by literature reviews and personal interest.

Step 2. Literature review: The literature review was the essential component of the research process. It was the first step to discovering the study area and identifying state of the art in the research topic area. Thus, the existing literature was retrieved and critically reviewed.

Step 3. Find problems / limitations/ inhibitors: This was based on discovering the area of and identifying problems or limitations found during the literature review.

Step 4. Identify the research problems and its limitation. The results of the literature review illuminated the nature of the research question. Therefore, the existing literature on the topic was reviewed with the aim of identifying gaps and limitations for the study.

Step 5: Finding a solution. Depending on the previous phase, finding a solution was the most critical stage that raised scale of the anticipated system and subsystems.

3.4.2 Phase 2: Framework Development

This involves solutions and initial system architecture which are shown in figure 3.7.

Step 1 Developing initial model/ Prototype driven development: The development of the prototype was driven and rechecked to underline the research questions and achieve the research objectives. The prototype of the design was reviewed to ensure that the resulting prototype would fit the project's goals as well as meet research requirements.

Based on the existing work in the literature, the proposed system architecture framework was constructed through proper technique. In particular, the primary function of the proposed framework was to enhance the effectiveness of augmented classroom by introducing some advanced technologies and techniques that aim to improve the interactivity inside the classroom. A new design was developed for a smart software architecture model that integrated various haptics and AR smart-grid to be deployed. Archimate tool was used for the development of the initial system architecture design. Archimate is a UML based tool for modelling and architectural purposes. At the end of the design activity, the initial design was accomplished for the new Smart Classroom setting.

Step 2. Verifying the proposed system architecture: The next task was to determine whether the proposed architecture met the standard requirements. This step, within the development process, was crucial in the verification of the approved framework. The specific method for system development contained some verification tools. For instance, the system architecture design went through a verification stage repeatedly to ensure the best outcomes.

The MDA and ADM approaches provided a better understanding of the requirements needed in the proposed system design. Thus, an analysis model was defined; and the analysis model provided the abstract or implementation-independent solution based on requirement model. Moreover, the design activities assisted in determining system requirements as well. At this stage, the design model was created and the requirements for the real (specific-implementation) solution based on the analysis model was defined.

3.4.3 Phase 3: Prototype Implementation and Verification

Step 1. Implementation, verification: The implementation process took place based on the system architecture design. In this phase, the target design was modelled on the empirical experiment. As a result, the system was built based on *implementation activities*. Thus, the implementation model that describes the actual solution (physical system) for particular design model was introduced. Also, verification was implemented through the *testing activity*. The testing activities assured that the system met testbed objectives. As a result, the system performance determined the developed testbed attributes of completeness and functional correctness.

3.4.3.1 Prototype Testing of the Developed Testbeds

The prototype testing has considered the following challenges:

Step 1: The entire scene was divided into small or fragments scenes and a particular criteria was set for each window to occur through the smart gridding partitioning algorithm solution. The partitioning algorithm was designed to increase the partitions whenever the partition size exceeded a specific threshold.

The challenges also dealt with the connection and functional issues which will included the issue of object tracking. This was a high-level middleware service that is comparable to domain specific middleware system since it was designed for a given group of applications. The solution was to design and implement an experimental middleware for Smart Classroom system. The system was tailored for various devices with various Operating Systems (OS) for dynamic interactivity. The extent and range of services provided by the operating system depended on the characteristics and needs of the environment to fulfil user visible functions of the OS.

Step 2: The integration of IoT with AR based visualisation services was another challenge. The solution was to provide the connected services using dedicated middleware platform for the IoT which offered an abstract layer interposed between the applications and the IT infrastructure.

3.4.4 Phase 4: Quantitative and Qualitative Measurements

In the study, the system design development was evaluated and documented. Therefore and prior to that, each experiment was tested and estimated for functionality in regard to the test bed objectives. Therefore, this showed the reliability and versatility of the developed application system. After the empirical results showed the completeness and functional correctness, there was an observational attitude assessment via a conducted survey based on a theoretical acceptance modelling approach e.g. ETAM.

Step 1: Survey Structure

A survey was conducted to investigate and measure specific concepts, such as behaviour, behavioural intentions and attitudes to predict technology acceptance at a statistically significant level. Therefore, the oriented study produced investigation results that were both understandable and relevant to practitioners (Pihlanto 1994). The sample population consists of tertiary academics who were using ICT tools in their learning practices.

In order to design and conduct the survey, a practical application was tested through the development process to minimise system deficiency. In this respect, the study was conducted through pre-experimental tests to validate the feasibility (as indicated) of the ICT tool before the actual system was run by the practitioners. After that, the survey was launched to measure users' reflections. The responses were based on existing knowledge of the system functionality and its benefits in education by running intuitive observable learning scenarios. After engaging the participants with the experiment, the survey was conducted and recorded.

The questionnaire consists qualitative methods. The questions used for analysis were 5 point Likert scale questions where the participant was required to tick the appropriate options, such as: like 1- strongly disagree; 2- disagree; 3-neutral; 4- agree; and 5- strongly agree. The questions also were open-ended asking participants to come up with their own responses allowing the researcher to document the opinions of the respondent in his or her own words. These questions were useful for obtaining in-depth information, opinions, attitudes and suggestions, or sensitive issues. Completely open-ended questions allowed the researcher to probe more deeply into issues, thus providing new insights, bringing to light new examples or illustrations allowing for different interpretations. Moreover, the qualitative responses were converted into a quantitative form to facilitate and unify the result.

Step 2. Evaluation and Documentation: Evaluation and documentation were the main proposed phases of the project results. Based on the successful functions of the developed system (experiments) to reflect the entire system architecture design of the new Smart Classroom, survey responses measured usability and acceptability. As a result, the proposed solution was documented and evaluated.

3.5 Conclusion

The Action research approach was a first step in conducting the study. It progressively solved the research problem demonstrating how various user actions and the working environment could be improved.

Further, the approach consisted of several case studies that examined in depth the ICT tool adoption in the new Smart Classroom environment. The individual cases involved: single faced application of architecture tools; application of technologies; and statement of teaching and learning acceptance model.

The proposed system relied on system architecture design and development. It contained design and modelling, field experiment and verification and validation approaches. The study, as indicated, was based on a problem-solving technique taking into account the MDA and ADM experimental and designing methods. These approaches provided a systemic design of the system and its implementation.

Moreover, Archimate core layers (Business, Application and Technology) were considered as they provided a viewpoint presenting a representative language needed to design and build the referenced system precisely.

Furthermore, the research progress showed specific phases that reflected sequences of modelling and building of the referenced system. Each phase showed how activities are best followed as a process. Lastly, surveys showed the quantitative and qualitative measurement that took place to validate usability and acceptability of the referenced system among the research subjects.

PART 2:

Empirical Contributions

System Modelling and Design Development,

Testbed Development and Qualitative Verification

Chapter 4
Modelling and Design

The chapter contains three major aspects for designing the new smart teaching and learning environment.

Firstly, general modelling, design concepts are discussed. The conceptual design shows the blueprint of the prospective new Smart Classroom. Here, the study focuses on two nodes: visualisation; and haptic nodes. In addition, Archimate core layers and the system development has been designed and developed declaring the architecture design of the new Smart Classroom.

Secondly, an Extended Acceptance Technology Model (ETAM) has been introduced to empower users' acceptance. ETAM presents a new element representing information communication technology (ICT) tools to the users in education system.

Thirdly, a teaching and learning scenario, based on a selected ICT tools, has been provided to elaborate the teaching and learning process within the introduction of the ETAM model.

4.1 General Concepts: Modelling and Design

An interactive teaching and learning environment has gained researchers attentions in recent years. This environment with its rich advanced technological solutions, such interactive environment, offers its users significant benefits. However, the compelling features and affordances of the system must be aligned with the learning experience, instructional approach and technology system modelling design. While the state of art technology offers new teaching and learning style, it also can create serious challenges for educationalists, such as technological and pedagogical domains (Thompson, Higgins & Howell 1991). These issues may lead to a cognitive overload by creating and delivering of excessive amounts of information. Additionally, use of multiple technologies can casue difficulties in delivery of complex educational objectives. Therefore, by modelling and designing possible solutions, it may decrease the challenges while beneficial the advanced ICT in teaching and learning setting.

Due to the ICT evolution, recent technologies have attractive mush research attention for educational development. A variety of innovative technologies, such as smart sensors and actuator, wearable devices, AR and immersion technology can help to create and effectively utilise the new Smart Classroom environment. The new teaching and learning style is not solely focusing on the use of these technologies; it also works on how these innovative technologies can be integrated into the teaching and learning environment setting.

The new Smart Classroom can provide a fruitful approach for educators and researchers. The concept of Smart Classrooms could be further extended thanks to the increase of smart hardware and software that can be used to realise the smart teaching and learning environment. For example, connecting or the deployment such classes within IoT, WSN, Cloud computing and AR lead to reshape the concept of teaching and learning environment towards an intelligent classes that can understand users' prompts in the augmented environment. Moreover, the interactivity feature of the smart peripherals that introduced to classes would leverage the authenticity among users; and thus, increase users' interaction and acceptance (Khurana & Rana 2013). Hereafter, the new teaching and learning model makes the pervasive environment system is much possible.

Although the provision of high-end peripherals and devices could be not important for educators (Compeau & Higgins 1995), because these technologies can require sort of special skills to be controlled and worked efficiently(Thompson, Higgins & Howell 1991) . However, a study shows that the most important is to convince users and show the benefits that can be supported and afford meaningful to the teaching and learning process by these technologies (Lui et al. 2014). Considering the new Smart Classroom design in conjunction with ETAM as a concept of the future classes would be more productive for educators and institutions alike.

4.1.1 The Benefits of the New Smart Classroom

The investigated modelling process aims to enable teaching and learning process by interactive elements. By the addition of ubiquitous and interactive teaching and learning features, users have the opportunity to sense the presence, immediacy and immersion within learning objects. This aspect can bridge the gap between formal and informal learning styles. The interaction of physical and computational models perform significantly better than using previous model (Avison et al. 1999; Thompson, Higgins & Howell 1991). This study shows that learners in groups using computer and physical activities as a model performed better than groups of using either one of these models (Avison et al. 1999; Thompson, Higgins & Howell 1991). Nevertheless, this work claims that the essential model should be designed to offer class instructions that suit user's preferences.

The pervasive system of the Smart Classroom system can enable interactive, ubiquitous and situated learning to enhance the new Smart Classroom setting. This setting needs to address portability, interactivity, sensitivity, connectivity and user's individuality (Thompson, Higgins & Howell 1991). For example, learners in an environment that is equipped with sensory, actuating, multimedia tools and embedded devices can support experimentation, data gathering and analytics for various learning activities and tasks. Consequently, the proposed teaching and learning environment can provide a mediated space that offers users to embark a sense of being involve in the particular pedagogical objective.

It is important to explore method of ICT tools application that can be aligned with different teaching and learning setting in order to achieve the educational objectives. With this approach, the gap between the formal and informal learning setting can be mitigated and resolved.

Due to the nature of some teaching and learning activity, the implementation of the proposed approach can provide a significant result among users that counts on subset technologies. The Smart Classroom could exploit the affordances of multiple smart devices that run optimally towards expected learning gaols and influence learners to acquire course contents.

A study found that the education experts recognised the benefits of using ICT system in classrooms (Kerawalla et al. 2006); however, they would like to have more control over the whole class activity components that can result in addressing teaching and learning processing users' needs. It means that all of the emerging innovations provide new solutions as well as some challenges including technological, pedagogical and learning issues (Thompson, Higgins & Howell 1991).

Concentrating on the technological issue, it is the fact that more devices used can cause to the risk of devices failure. The critical point at this aspect is how to maintain the great stability of multiple peripherals. Certain emerged technology associated with its software. Therefore, due to the software applications, it can be expected that the peripherals portable devices are likely possible to be integrated and reliable with a smart middleware and interface for controlling and data management.

Moreover, the pedagogical aspect also needs to be considered aligning with other aspects of successful ICT integration. Similar to many educational innovations, the new approach might encounter constraints from the institution and resistance among users. However, the nature of the novel approach is quite different from the other teaching and learning style. With the multiple provided activities, the new Smart Classroom provides an ad hoc atmosphere and flexibility based on certain delivering content in classes.

4.1.2 The Conceptual Design: the New Smart Classroom Design

At the present time, ICT has a significant advancement in human computer interaction (HCI) and machine vision technology; and that including haptics interfaces and augmented reality. For particular, these technologies allow immersion and increase interactivity in the setting environment. With these concepts of user interactivity, the Smart Classroom might utilise new advanced technologies to increase the interactivity in the classroom. For example, interact with computer devices using sound, voices, gesture and motions detection. Therefore, there are many solutions that can be used for these advanced technologies to be integrated and collaborated toward the new Smart Classroom.

As it has been stated in chapter one, the main goal beyond all of these opportunities is to build an advanced computing and system architecture that will improve the Smart Classroom. Hence, the proposed solution will state the initial conceptual design, which integrates main aspects of selected ICT tools include:

- Haptics and Augmented Reality within the integration of cloud computing,
- Internet-of-Things (IOT) frameworks
- Sensor and Actuator Networks (SANET) Technologies

The proposed framework will offer a smart middleware that can unify and simplify through haptic gesture controls to enhance advanced user interactivity in classroom environment by using sort of configurations of sensing, control and monitoring devices. Moreover, scenes mapping and partitioning (AR Smart Grid) are also going to be explored for capturing, identifying and handling specific events (see figure 4.1).

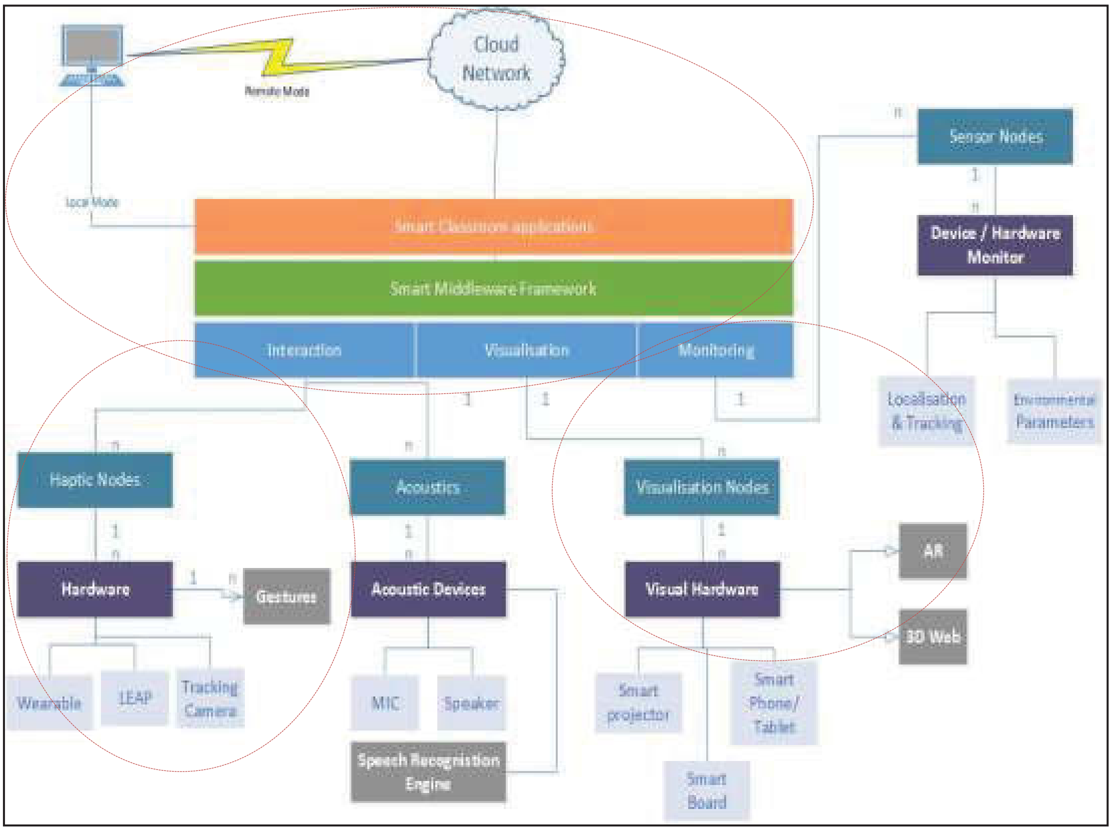

Figure 4. 1: The Conceptual Design of New Smart Classroom Layout

4.1.3 The New Smart Classroom Interaction Mechanism

The developed Smart Classroom objects include the Environmental Actor (EA), Human Actor (HA), and Technology Actor (TA) that resulted in Intelligent Classroom (IC). The HA is the human using the technology, who is the master in the intelligent environment. The TA is all the technological system within the room or space in which the users (HA) carry out their activities- the slave. The final actor, EA is the space or area in which the system is deployed, and the tools which serve to link it to the other actors, such as sensors; this can be very diverse. The IC is the intelligent connection that has been established through the networking among TA, HA and EA, which lead to create the meaningful of the intelligent classroom environment (Alenazy & Chaczko 2014).

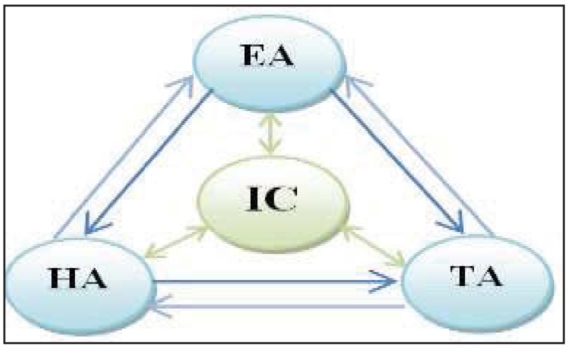

Figure 4. 2: The Dynamic interaction elements of the New Smart Classroom (IC) (Alenazy & Chaczko 2014)

As it shows in the above figure, the interaction of the three actors, the HA makes the decisions through commands, the TA receives the command and responds appropriately with the help of the sensors within the EA; they form a collaborative partnership. The technology in the classroom setup should serve transform the same into an intelligent environment - one which improves the lives of its habitants in a sensible way. The HA factor plays a role in the ways in which technology is manipulated, subsequently and the consequences of its use. These three actors should work together to form the intelligent classroom (IC) environment which helps its users perform their tasks easier; and it does this in a reliable, and sensible manner (Alenazy & Chaczko 2014). This set up serves to enhance its users experience holistically, and aid in the acceptance of technology within the classroom (Augusto et al. 2013).

4.2 The Proposed System Architecture Design: Business, Application, and Technology Layers

Based on TOGAF and Archimate Framework for system development, this section is introduces in depth the proposed solution that reflects the Top View system (see figure 4. 3) in a methodical way taking into account education system demands. As mentioned in Chapter 3, the Archimate core layers are going to conduct the system design architecture for the new Smart Classroom which includes: Business Architecture layer, Application Architecture layer and Technology Architecture layer. Relying on bedrock ICT tools can make different to any professional system, however, it is a crucial to determine the project boundaries for achievable consequences. In regard to these aspects, three main layers are going to determine, demonstrate and analyse the system modelling and design.

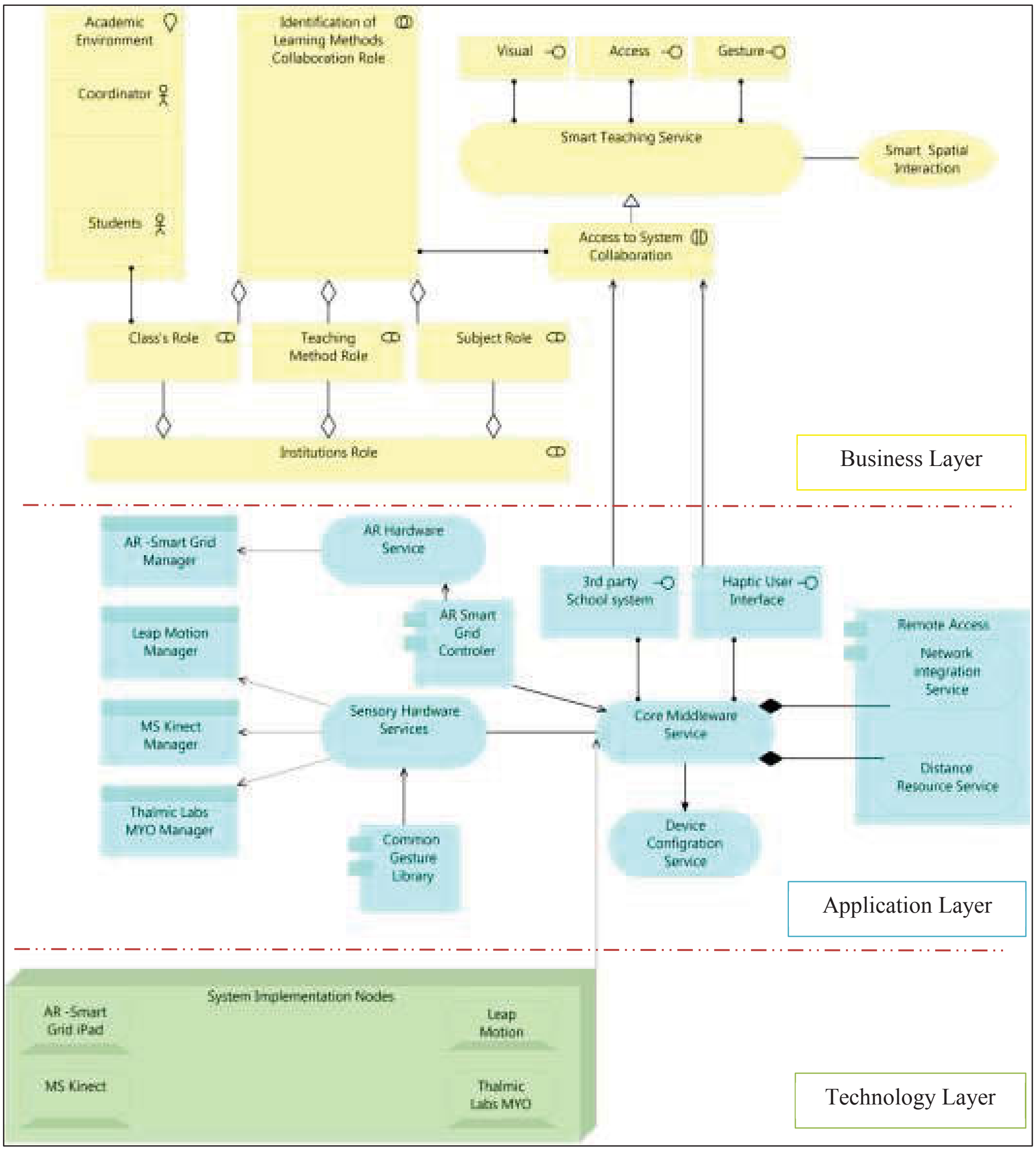

Figure 4. 3: The Entire System Architecture Design

4.2.1 Business Layer: the New Smart Classroom Services

The Smart Classroom relates to the optimisation of the interaction between the teacher and the learner, development of teaching presentation, accessibility of learning and teaching resources at own convenience, detection and awareness of the context, classroom management and others. The overall vision of the new Smart Classroom would include a collaboration of sensors, passive computational devices and lower power networks, which provide infrastructure for context-aware Smart Classroom that sense and respond to the ongoing human activities. This technology requires development in areas like distributed computing, networking, acquisition of sensor data, speech recognition system, signal processing and human identification, which can be summarised in the figure below (Sailor 2009).

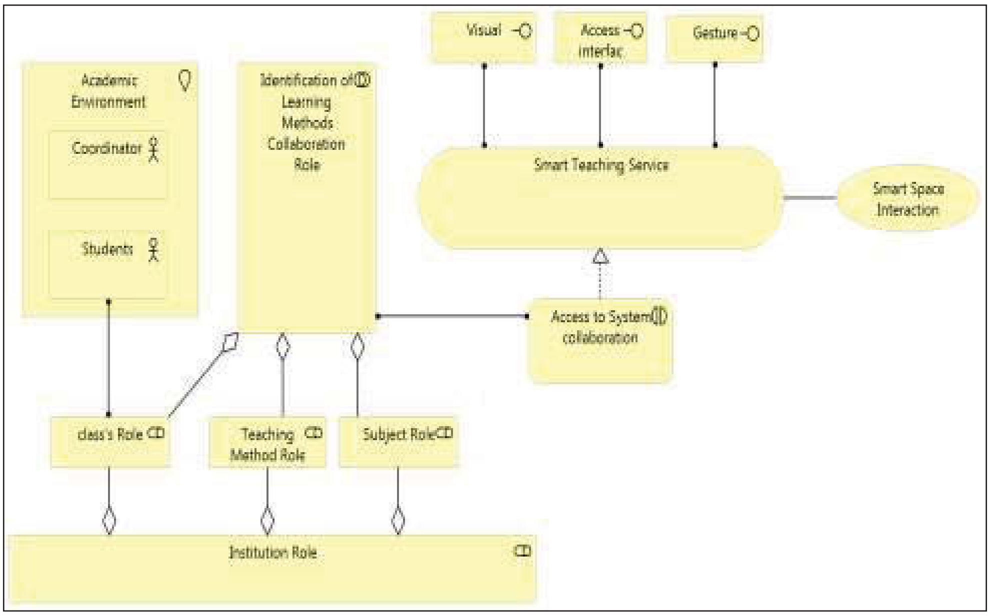

Figure 4. 4: Business Architecture Layer

The proposed model illustrates a business layer reflecting an overall view of the system components to fulfil the education needs of users and meet the main object of system function. This provides an overall insight of the perspective HMI and MMI to enhance the meaning of objects interaction in certain smart spaces.

The model also shows (see figure 4. 4) the collaboration of roles in the learning and teaching process to provide a useful role in the assigned system. Hence, business interaction is assigned to the collaboration role as a gate to access the reference system. On the other hand, the model also shows the provided service that is used by business interaction. The teaching progress service composes three facilitations, which are the Dialog process, Human-Machine-Interaction and Machine-Machine-Interaction. Those provisions result in association and access relationships that utilise the visualisation, gesture recognition interactions. The services can be accessed and controlled through the business interface by the end-users.

The new Smart Classroom integrates a group of technologies in order to achieve its multi-facet objectives. For example, (i) it enables the teacher to effectively teach in active environment; (ii) ensure security in the system; (iii) presents to the student an enhanced equipped classroom participation experience; and (iv) provides accessibility to contents. To achieve these goals, technologies which can facilitate multiple modalities for learning and teaching should be adopted (Sailor 2009). The technologies in a Smart Classroom can be put in the following categories:

Sensing- This includes capturing of important information in a classroom to achieve high level interaction, dynamic learning environment and effective delivery to teaching contents. The information is sensed through systematically arranged microphones and tracking cameras. The sensing quality mainly depends on the performance of the audio and video devices, appropriate positioning of devices etc. (Harrison 2013; Sobh & Elleithy 2013). Attentive teaching can further be enhanced through context-awareness sensing such as speech recognition system that interpret voice into command, tracking the speaker' signal strength, automatic zooming and focus from emphasis of vital images, sensor fusion which extract behavioural information in the classroom and gaze tracking to predict some actions. The sensed information is then rendered.

Sensors installed in convenient places in the classroom can detect automatically parameters such as noise, temperature, odour, light and others, as well as adjust lamps, air conditioning so as to maintain temperature, light, sound and fresh air which are suitable for mental and physical status in Smart Classroom (Augusto, Nakashima & Aghajan 2010).

Rendering- Information in future Smart Classroom can rendered through smart projection screens. The screens can display the teacher's motion, course contents, and the students in class. Overlain windows on the multiple screens can display the lecture close up; students close up through augmented reality scenes or contents. However, when the number of remote students may not fit the floor, more sophisticated methods are used like AR or 3D display, where the images are displayed as if the students were seated in a hall.

Presentation support- Quality deliverance of the teaching content is facilitated by allowing the teachers to use natural teaching modes instead of using or sticking behind the computer desk. Thus, the devices that can allow gesture controller provide more flexibility conducting.

Transmission of information- The transmission infrastructure which utilises appropriate technologies for maximum bandwidth utilisation is used to support Smart Classroom. It requires reliable delivery mechanism for information control and exchange of the teaching materials. A synchronised audio visual information delivery can be achieved through the use of special devices meant for Smart Classroom.

Synchronous and Asynchronous support - Used to facilitate collaboration between individuals and groups of people through the integrated advanced devices. This enables the participants to gain feeling of being in track anytime during the class running.

4.2.2 Application Layer: the New Smart Middleware

A Smart Classroom provides a physical environment for integrating multiple human computer interaction that enables collaboration for active learning and teaching method. This plays the role of acquiring information from events or environment for reactive or responsive system. The information is captured and transferred to high level reasoning modes and they are then applied in monitoring behaviour or reacting to a situation in line with the application on smart and ambient situation. Another interaction can be between the vision and high level application context through human's acts or visualisation in form of visual or video communication. In these types of system, there is two-way communication between the data processing on hand and the vision or between visualisation and high level reasoning. This enables effective acquisition of information by directing vision to relevant features, and confirming the output depending of the known context, accumulated behaviour and information(Aghajan & Cavallaro 2009; Saha, Mukherjee & Bandyopadhyay 2002).

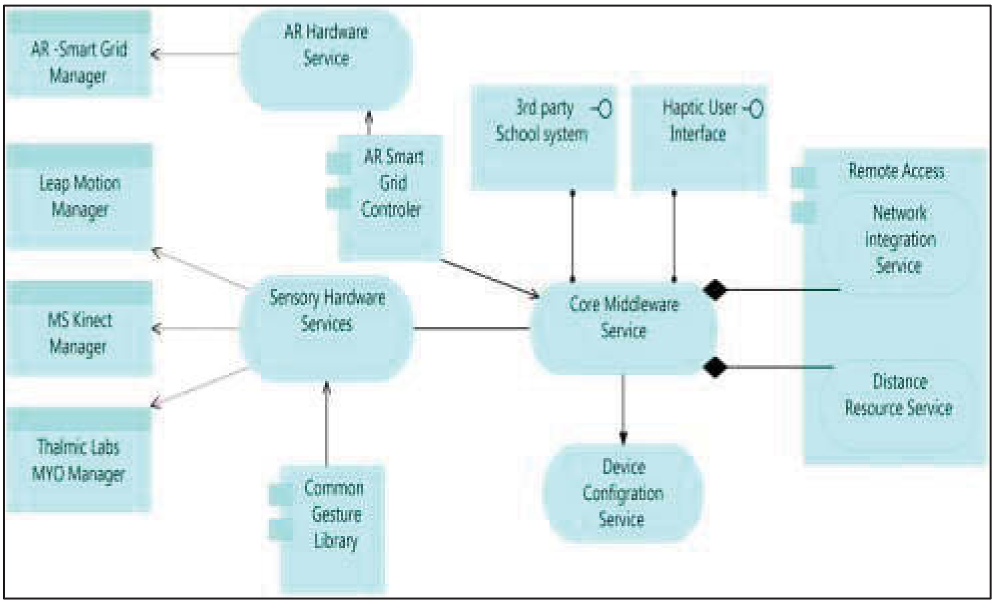

Figure 4. 5: Application Architecture Layer

The application layer (see figure 4. 5) presents the components applications that have been used to develop the core of the system. It highlights the core of the smart middleware that creates the communications and interactions among the integrated nodes. The smart middleware launches the hubs allowing interactions through the data transferring between these peripherals. It also tailors the technology layer with user interfaces in the business layer.

The developed haptic middleware prototype will be focused on the smart teaching business services where the Human-Machine-Interaction and Machine-Machine-Interaction will be improved upon utilising visual and gesture interactions as a proof of concept. The system implemented will address some of the current limitations that exist within the smart learning environment context.

Nevertheless, the new system can be accessed in real-time enabling interaction between the teacher and the learners through media tools. The interactive equipment is interfaced with simple, clear navigation, depending operation characteristics, voice, touch and visual interaction which improve Human Machine Interaction (HMI). The hardware in the new Smart Classroom meets the interactive requirements of the multi-terminal points. Multi-terminal means that in which a single active class can conduct multiple classrooms spanning geographically. The Smart Classroom can also record and store basic data in the computer, so as assist in decision making of the participants as well as use them for self-conducted (Harrison 2013; Sobh & Elleithy 2013).

These aspects of data transmissions require a smart middleware application that functions to maintain and stabilise the connections between peripherals application. The method need to develop the following:

- **LEAP Motion Manager**
  The LEAP motion manager manages all connections to the LEAP motion device and implements a defined set of methods that can return consistent data to the sensory hardware service. It implements a common gesture library.

- **Microsoft Kinect Manager**
  The Microsoft Kinect manager manages all connections to the Microsoft Kinect device and implements a defined set of methods that can return consistent data to the sensory hardware service. It implements a common gesture library.

- **Thalmic Labs MYO Manager**
  The Thalmic Labs MYO manager manages all connections to the Thalmic Labs MYO armband and implements a defined set of methods that can return consistent data to the sensory hardware service. It implements a common gesture library.

- **Common Gesture Library**
  The common gesture library contains a common set of gestures that can be implemented by different haptic devices. This library is implemented within the sensory hardware service.

- **Sensory Hardware Service**
  The sensory hardware service defines a common set of functions and data requirements for any device and defines a common set of gestures utilising a common gestures library. This service is handled by the Core Middleware service and its logic interfaced to select exclusive data from the haptic controllers.

- **Distance Resource Service**
  The Distance Resource service handles the resource selection logic based on the output from the sensory hardware service. This is achieved by assessing the distance of the user, the velocity as well as the confidence ratio of the device.

- **Core Middleware Service**
  The Core Middleware service is the main service which is used to implement the haptic control middleware. This is the service point which is used for other third party systems to interface and interact.

- **Device Configuration Service**
  The device configuration service is an XML configuration of all devices that are defined. This will contain the name of the device, the connectivity method as well as some basic capabilities of the item.

- **Haptics WCF Network Service**
  This is a network service which outputs gestures data out to the network space. This is aim at interacting systems across the internet using haptic controllers on the workstation.

- **AR Model View Controller**
  This controller is to manage AR- Smart Grid application that runs in the user interface for monitoring and detection purpose with Core Middleware Services.

4.2.3 Technology Layer: the New Smart Peripherals

The technology layer is the tangible or haptic components that show the nominated peripherals which have been integrated into the Smart Classroom system to develop the smart teaching and learning spatial. The system hardware reflects the selection of the advanced ICT tools where based on the latest useful approach in variant fields. Thus, it is expected to have a positive impact in Smart Classroom utilising the teaching and learning process.

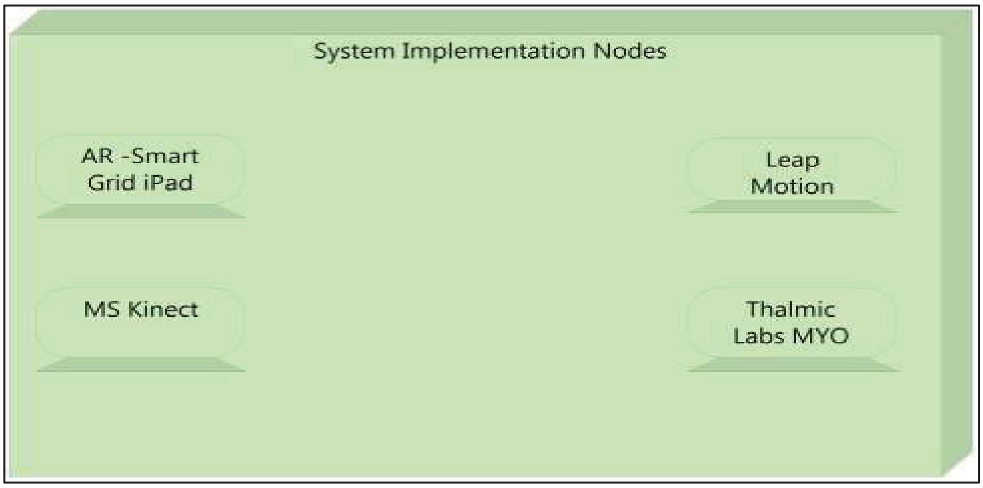

Figure 4. 6: Technology Architecture Layer

Regarding to the system development approaches, the following peripherals have been selected based on their functionality to support the consistent interactivity in a wide range coverage of the new Smart Classroom, include:

- AR Smart Grid application
- LEAP Motion
- Microsoft Kinect 360 (Xbox edition)
- Thalmic Labs MYO gesture armband

The development procedures have been discussed and presented in details in chapter 5. It involves two types of system application development reflecting developed system architecture of the new classroom. These testbeds include AR Smart-Grid for monitoring and controlling events in classes and Haptics Controller for the new smart learning environment.

4.3 Extended Technology Acceptance Model

A number of models have been developed to support technology inclusion in the classroom including the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), and now the Extended Technology Acceptance Model (ETAM).

The main idea is therefore to propose ways in which the TAM can be enhanced using additional elements in order to enhance the learning and teaching experience of teachers and students respectively within the equipped ICT tools in education system; thus improve the acceptance of technology within the same. The modified model (ETAM) seeks to increase the capability of individuals to operate efficiently in any current or future smart environments. It is proposed for both experienced and unexperienced users with varying amounts of knowledge. Research has shown in chapter 2 that there is need to seriously consider and ensure the proper training of instructors in the correct use of the advanced ICT tools in the Smart Classroom. The role of staff training along with the adoption of advanced ICT tools is to positively influence the PU (perceived usefulness) and PEU (perceived easy to use) components of the current model (TAM). The adjusted model can serve to increase the motivation level of students and teachers alike in the use of Smart Classroom. Moreover, the adjustments can serve to bridge the gap between the external and internal variables at play in the determination of the reception of technology among its users (Augusto et al. 2013; Ramayah & Jantan 2004).

Recent technological advancements have led to adjustments in educational methods in many educational institutions (Lui et al. 2014; Slotta, Tissenbaum & Lui 2013). Since the start of the use of technology in education, the approach gained attention from the education sectors, and has been applied across many areas in the academic field (Augusto et al. 2013; Teo, Fan & Du 2015). The idea is to support the acceptance of the technology implementation by modifying TAM model with the pre-acknowledgement of technology users using an additional element. This additional element should serve to increase the motivation level of instructors and learners alike. Moreover, it should grow the need for using modern technology in the education environment. The result of these changes should be to spur on those resistant to the adoption of technology to adopt and incorporate it into their teaching and learning process(Tondeur et al. 2012).

Technology acceptance or rejection is a function of several factors. These factors could be in their environment (external) or a function of the users' own pre-conceptions, beliefs, and attitudes (internal). Whether users accept or reject technology influences the outcomes of their lives. Owing to the radical advancement in technology in recent times, the way in which everyday life is conducted has changed due to the influence of technology (Edmunds, Thorpe & Conole 2012). Because the way life is lived has changed, the ways in which information and communication are done has changed with it as well. This in turn influences every professional field in the world over, education notwithstanding(Ottenbreit-Leftwich et al. 2010).

Though technology is a part of most people's everyday life, it is ironically not well received in professional settings (Zualkernan 2012). The Technology Acceptance Model (TAM) is designed to increase the tendency of users to accept technology. It particularly aims at those instructors who are considered pre-service. The TAM however, does not consider the in-service instructors with little or no skill in the use of technology within the classroom setup. There is evidence suggesting and supporting the conclusion that this model is deficient and in need of improvement (Teo 2011).

Further investigation has focused on evaluating the effectiveness of ETAM (see chapter 6) once it was implemented by the introduction of ICT advanced tools. It also seeks to uncover ways in which technology may be made more user-friendly in order to enhance its acceptance, and make it more relevant to its users' lives (Rezgui & Eltoweissy 2007).

4.3.1 The Nature of ETAM

The Extended Technology Acceptance Model (ETAM) refers to the additional element that provides a real value in order to enhance existed system to function effectively. Literature indicates that there is a great need for teachers to learn and use technology with their students (Tondeur et al. 2012). Practicing teachers are faced with a challenge to learn technology so that they are then able to function in technology-based classrooms that are being created in schools.

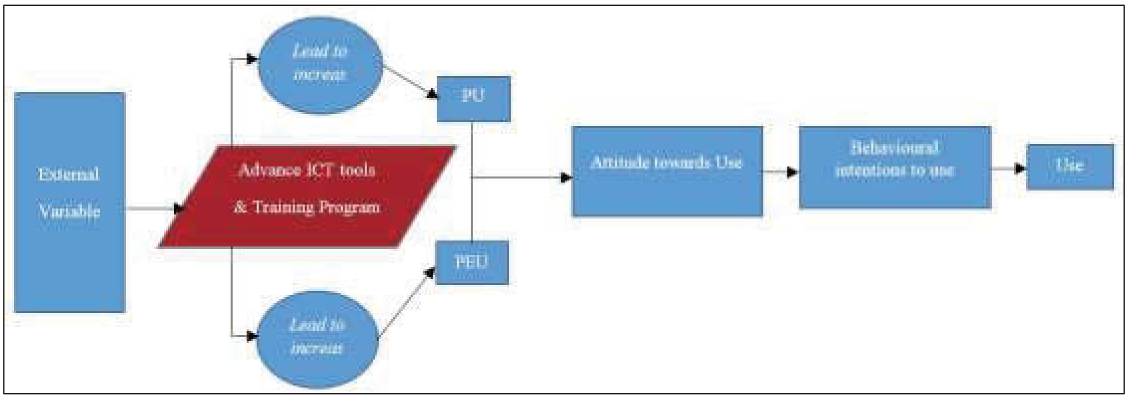

Figure 4. 7: The Extended Technology Acceptance Model (ETAM) (Alenazy & Chaczko 2014)

In ETAM, external variables such as training programs and easy access to advanced technology are seen to influence PU and PEU as shown in the above figure. Due to the recent technology tools attributes (easy to use), the training however does not necessarily have to be formal; therefore, it may be done individually using a book or physically through learning from an expert on the same. This should be the fundamental difference between the ETAM and the TAM.

4.3.2 Advantages of the ETAM for the New Smart Classroom

There are several reasons that encourage professional educators to accept this model. Some of these benefits have been summarised as following:

- **Autonomic Management:** As ETAM model uses new technologies and trends, advanced online website tools, educational operations of the institutions can be managed and run automatically.

- **Increase Usability:** The greatest advantage of ETAM model is that it allows users to perform tasks easily. Through its three major parts, namely as perceived usefulness and perceived ease of behaviours of teachers as well as students can be measured out toward the adoption of new technologies and trends.

- **Enhance User's Experience:** Based on reliability, adaptability, flexibility and facility, ETAM model is very useful to enhance the learning experience of the users.

- **Supports Users' Demands:** Deployment of the advanced ICT tools in educational institutes improve the interaction service between teachers and students help to promote creativity and increase the effectiveness if the system.

- **Introduction of interaction services:** allows for increase effectiveness and promote creativity

The acceptance model in learning is developed through the adoption of digital technologies into learning environment. It facilitates the learning environment with an effective style and a collaborative knowledge of growth in learning content and activities. The extended model will support different educational styles involved in the teaching and learning process.

4.3.3 ETAM System

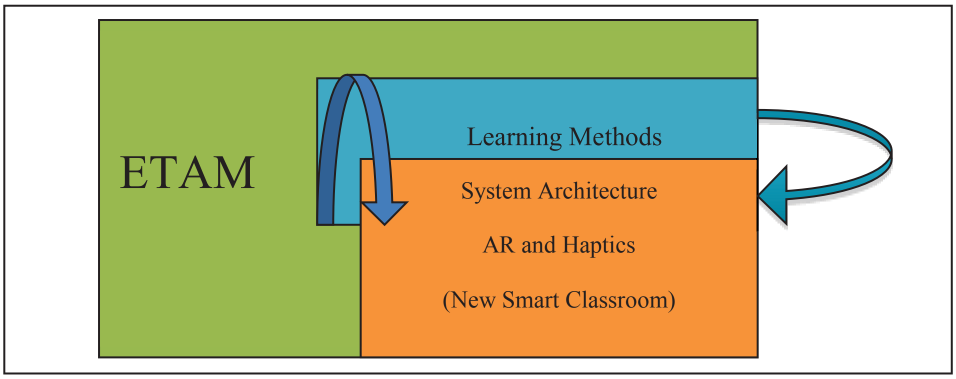

Figure 4. 8: ETAM Ecosystem Model

Recently, educational institutes increase benefits from the learning and teaching approaches such as the flipped learning (FL) and student-centred learning (SLC) methods. The ETAM ecosystem incubates multiple teaching and learning methods (see figure 4.8). For example, flipped learning strategy supports educators and students who have not actively engaged in actual class activities. It involves students to prepare and start the learning process prior the face-to-face classroom time through an easy and flexible access to online educational resources provided or recommended on their own time (Shimamoto 2012). Another example is student-centred learning method, which shifts the focus of instruction from the teacher to the student as an achievable learning method. ETAM on the other hand enhances the learning methods and efficiently benefit due to the introduction of advanced equipment teaching and learning environment resulting in an augmented technology approach.

The augmented ETAM approach introduces advanced ICT environments, providing various educational resources to users (Lui et al. 2014). ETAM augmented learning style creates a new Smart Classroom concept. The novel approach delivers best practice guidelines to the users while relating to pedagogy, contents and ICT resource allocation. Due to information and communication technology production, educational institutions constantly revise and improve their teaching and learning models to lead the competition and to provide up-to-date technology and learning resources (Slotta, Tissenbaum & Lui 2013).

Scholars have noted that technological learning approaches directly connect students to their educational materials (Abdul-Kader 2008). Based on this, instructors can govern the learning materials and lessons for students who then have multiple access and views before, after or even during the class time, resulting in more time for interaction and practice among students.

Furthermore, students who were conceived somewhere around 1980 and 1995 are known as the Tech-Generation. They have developed and depend on innovation in many parts of their daily life. As a result of the social and interactive networking growth, there is an obvious gap between the advance learning approaches and actual classic classrooms practices (Leal 2009). This generation of users have technical skills and are keen to engage in interactive learning styles to communicate with people with the same interests; therefore, they prefer to learn in dynamic learning environments instead of the traditional classrooms (Alenazy & Chaczko 2014; Freeman et al. 2014; Yang & Huang 2015). Consequently, the modification of the model implies that advanced ICT tools can overcome some issues related to learning and teaching methods (Alenazy & Chaczko 2014) creating a new Smart Classroom style.

On the other hand, teaching and learning using traditional lectures cannot currently survive, as educators are not resourced for new knowledge (Li & Liu 2009). Hence, the increased use of FL and SCL techniques in conjunction with advanced ETAM augmented classroom concepts lead to an improved active/interactive learning environment through a combination of traditional and advanced teaching and learning methods in the educational institutions (Alenazy et al. 2015). The Remote Lab with the additional application (see the experiment in chapter 5) is an example of an active smart teaching and learning environment in an education system. Therefore, it can be seen as a key development for higher education to achieve a successful new Smart Classroom design for future teaching and learning process when applying the ETAM model.

4.3.4 Scenario: The New Smart Classroom in Conjunction with ETAM

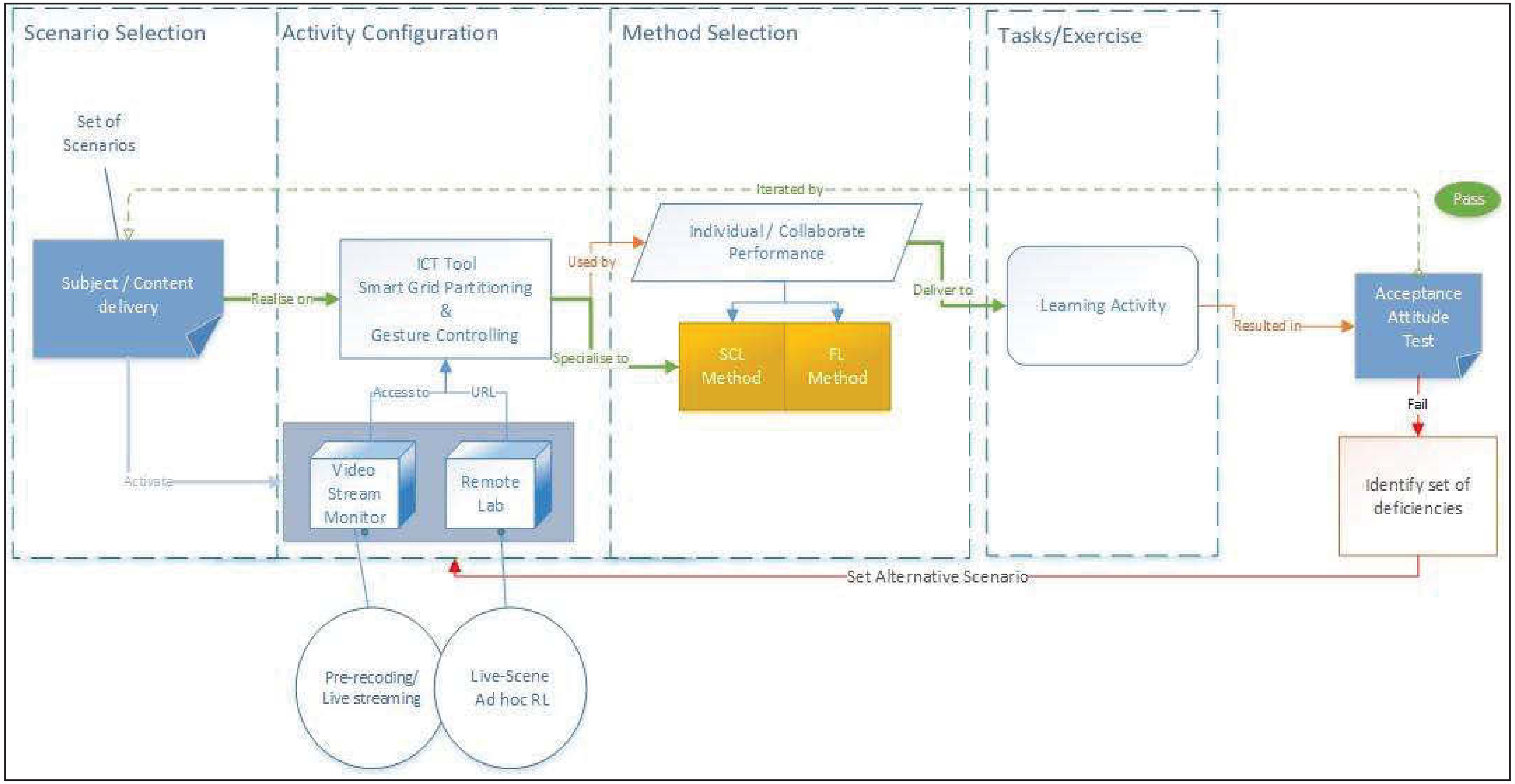

Figure 4. 9. Teaching and Learning Process in New Smart Classroom in Conjunction with ETAM

The novel approach (New Smart Learning Environment) brings a positive impact and influence to the users. Learners will be willing to expose and share their efforts anytime and anywhere based on the usages of ICT resources and its facilities. The learning model process shows the procedure to achieve teaching and learning objectives in a dynamic style within the adoption of a variant teaching and learning method (see figure 4.9). The subject coordinator is responsible for building the digital content scenarios in the context of the model. The activity configuration works on activating the learning content chosen for delivery, which is then adapted to the usability of the ICT tool.

The developed teaching and learning process comprises of an AR Smart Grid system application and haptics to assist in monitoring and controlling learning materials in the new Smart Classroom environments (Alenazy, Chaczko & Tran 2015). The AR Smart Grid application utilises AR elements to monitor events of scene, which can be a live video stream from the device's camera or a website, in a Smart Grid overlay (see chapter 5.1). The smart grid is fully configurable and consists of cells that function independently of each other. Each cell is responsible for its own are and triggers notification message or alert if a monitored event is detected. While the haptics middleware controller provides (see chapter 5.2) additional systematic aspect can establish the communication channels between the integrated smart devices to be interacted consistently (Wael Alenazy, Zenon Chaczko & Chan 2016). Moreover, it offers an alternative approach for inputting and controlling materials while using gestures.

A teaching and learning case study of the new Smart Classroom was carried out for a subject in Information Technology. The research subjects were academic professionals. Questions were posed regarding their perception of the new extended model based on the developed experiment. The key question posed was: did the teaching and learning process serve to increase the interactivity and create authentic environment to the learners? The experience attempts to measure the acceptance attitude and behaviour towards the effective used of the advanced teaching and learning environment.

4.4 Conclusion

In this chapter, it has introduced a new system architecture designs that created opportunities for innovative technologies for the education process, focusing on designing for a collaborative smart interactive learning space. The new approach showed how AR and haptic nodes could be integrated into the architecture of the smart learning environment, by designing components of service oriented software middleware, which can be achieved through proper architectural development and design. Consequently, the current design practices of learning environments were changed to support the evolving pedagogical techniques and to meet the students' expectations.

Moreover, due to the ICT revolution, the study proposed the modification of the already existing Technology Acceptance Model (TAM), which result into its transformation into the Extended Technology Acceptance Model (ETAM). The aim of developing ETAM was to increase technology acceptance among educators and students alike by getting the advantages of the advanced ICT tools implementation for future teaching and learning equipped classrooms.

The chapter to follow presents an empirical method to prove the system architecture based on the ETAM smart learning scenario.

Chapter 5
Empirical Developments

In this chapter, implementation was driven to reflect the proposed system architecture design in conjunction with ETAM. The system development focused on two nodes which are Visualisation and Haptic nodes.

Firstly, the visualisation node is based on AR within the introduction of Smart Grid technique for monitoring and controlling objects. The developed system shows how this could be achieved through the video stream and web based cloud integration. Augmented Reality (AR) allows for the establishment of collaborative environments through teacher's and students' interaction within virtual objects leading to the creation of various interactive scenarios in the classroom environment as a substitute for the traditional classroom environment using static devices. The aims of this AR Smart Grid implementation are:

- To monitor captured of scenes for studying purposes (scene perception), such as a video streaming
- To investigate the capabilities AR frameworks and Software Development Kits (SDK) for determining and selecting particular cell(s).
- Therefore, the experiment was implemented by utilising augmented reality (AR) smart grid elements in context of the smart learning environment known as UTS Remote-Lab.

Secondly, the haptic node was also considered as another integrated aspect that introduces advanced tools. Haptics Middleware based on software for interactions in the smart learning environment were developed. The design and implementation of integrating haptic technologies was designed using the components of middleware system, multi-sensors haptic devices and recognition algorithms. The purpose of this project was to;

- Increase the interactivity by replacing the traditional inputs on the system to simplify teaching and learning context.

For improving usability, different haptic sensors had been cross-implemented and connected through a central middleware framework implementing the Internet of Things (IoT).

Both projects were implemented using various platforms, such as iOS and Windows; thus they prove feasibility and versatility of the developed system architecture for the new Smart Classroom.

5.1 AR Smart Grid for Monitoring and Detecting Learning Events in Smart Classes

In an educational context, there are many situations where AR can be applied. For example, Montero et al. (Montero et al. 2013) have been leveraging "AR technology as a means to overcome the current limitations of Classroom Communication Systems (CCS), allowing teachers to obtain private feedback from students" (Montero et al. 2013). They have utilised this system to allow students to signal whether they understand the material being presented to them by their lecture in a non-intrusive manner. The flow of the lecture is not hindered and this method also overcomes the issue where students are too shy to speak up or interrupt (Montero et al. 2013). This system also allows the lecturer to gauge which students are not paying attention if they are not providing regular feedback. Another approach to determine attentiveness is to monitor the classroom for facial expressions and body language. This is a possible extension to the monitoring application, which would require advanced image processing and machine learning.

Augmented Reality (AR) allows for the establishment of collaborative environments through teacher's and students' interaction within virtual objects leading to the creation of various interactive scenarios in the classroom. Virtual Reality (VR) refers to the combination of various display and devices' interface which results from immersive overlay interactive computer-generated environment. In addition, the mix of reality refers to the merger of virtual overlay objects with on the real scene (Pan et al. 2006). Although in terms of acceptance technology, a recent model has been appeared and showed that because of some smart technologies features, users are capable to function those devices easily (Alenazy & Chaczko 2014). Hence, AR as a smart innovation system is being incorporated in the learning and teaching processes to achieve the pedagogical objectives and goals demand. The AR system in classes allows the students to locate and discover the virtual materials as they are in real through the use of overlaid scenes (Freitas & Campos 2008).

5.1.1 Experiment Objective

Based on the ETAM scenario (presented in Chapter 4), the testbed utilises augmented reality (AR) elements to select and monitor captured scenes for studying purposes, such as a video stream from an iPad camera. Here, a smart grid layout overseen is established. The objective is to investigate the capabilities of AR frameworks and Software Development Kits (SDK). The process utilised developed an application and investigated existing AR toolkits to leverage functionalities. The main focus of toolkits was to provide a simple way to overlay an image or animation over a video stream. Therefore, after a number of prototypes utilising different AR toolkits the project optimised an open source image-processing framework 'OpenCV' (Sholtz 2014). A case study was used as a base design using Metaio AR SDK, Wikitude SDK and Total Immersion's D'Fusion SDK (Immersion 2012). As a result, the monitoring functionality of this application required image-processing tools and because of that OpenCV seems was sufficient due to its characteristics (see table 5.1.1).

Table 5.1. 1: Initial System Requirements

Technologies	Tools	Framework
Objective-C and C Programming Language	Xcode 5.1	OpenCV
Objective-C++ and Programming Language	Dropbox	Cocoa Touch
JavaScript Object Notation	OmniGraffle	Pebble iOS SDK
SQLite3	OmniPlan	
	Apple Pages/Microsoft Office	
	iPad Mini running iOS 7.1.1	
	Pebble Smart Watch	
	TextMate	

Therefore, the monitoring application was applied to analysing data such as graphs and gauges. The researcher was required to observe an experiment with graph and meter outputs from sensor data. The events recorded were spikes in the output. The application was employed to automate this process.

5.1.2 Software Requirements Specification (SRS)

The SRS was derived from the User Requirements Specification (URS), which is typically supplied by the client. The SRS began by breaking down the requirements into single technical tasks. This list of tasks were categorised into functional and non-functional requirements (see the Appendix 9.A). The requirements were then analysed by utilising software modelling tools.

The following Figure 5.1.1 describes the interactions between the actors and the system. The system boundaries of a self-contained mobile application were typically straightforward.

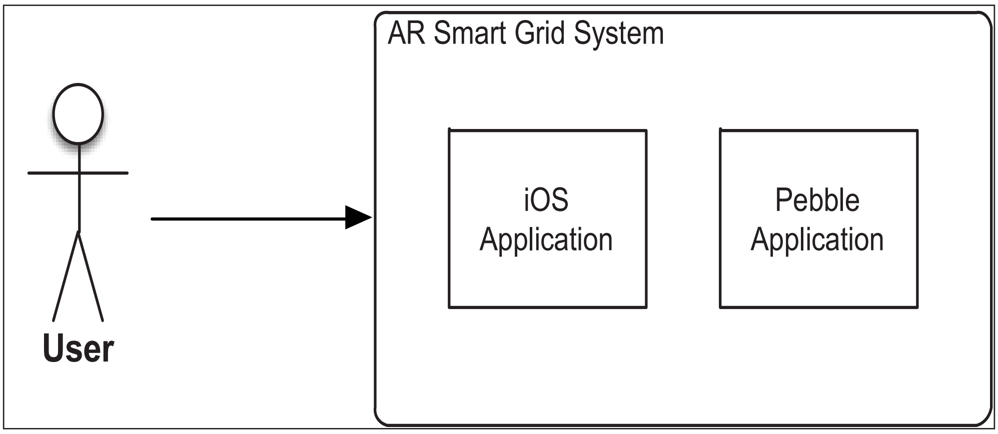

Figure 5.1. 1: System Boundary Diagram

5.1.2.1 Software Requirements

The table 5.1.1 list the technical requirements that were identified from the URS. They were categorised into functional and non-functional requirements. Functional requirements refer to features and functionality of the system. Non-functionally requirements refer to system qualities and constraints (see the Appendix 9.A.1).

5.1.3 Modelling and Design

The purpose of modelling requirements was to analyse the system requirements in order to gain a better understanding of each requirement. This was based on the referenced system architecture design defined in Chapter 4. The process of applying the following modelling tools, system interactions became clearer. The modelling tools were applied include a case diagram, use case descriptors and Swimlane diagrams. The models provided a basis for architectural and design decisions.

Rapid Application Development allowed this section to be shortened. The architecture served to capture the structure, interactions, and data flow of the system. Design decisions and assumptions were made in order to produce a definitive architecture. For more details individual diagrams of use case and use case descriptors and Swimlane diagrams (see Appendix 9.A.2).

5.1.3.1 The Features of the System

The features of the developed system include (see figure 5.1.2):

- Smart Gridding
- Customising Settings
- Saving Settings
- Grid Annotations
- Zooming and Panning
- Movement Monitoring
- Pebble Smart Watch Integration
- Pebble Smart Watch Notifications
- Fix Grid Option
- Light Monitoring
- Web View Input Feed

Moreover, diagrams and system functionality are demonstrated and referred to Appendix 9.A.3.

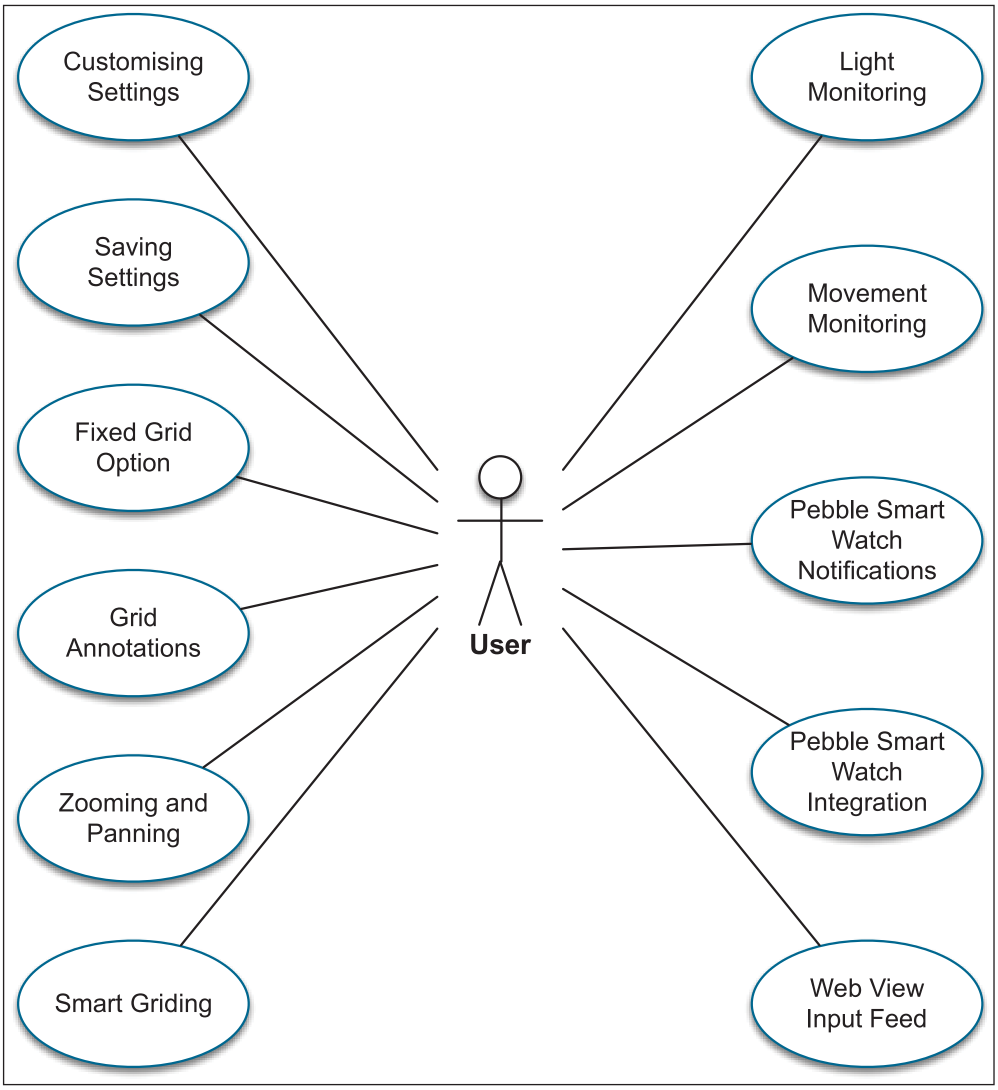

Figure 5.1. 2: Use Case Diagram for AR Smart Grid Application

5.1.4 Architecture and System Design

This section details the execution architecture view of the system. The architecture serves to capture the structure, interactions, and data flow of the system. Design decisions and assumptions were made in order to produce a definitive architecture. The architecture was developed based on the requirements modelling. The Use case maps also discussed and use cases were selected to map against the execution view in order to validate the architecture. For more details, see the Appendix 9.A.4.

The system design shows the conceptual architecture (see figure 5.1.3) with the high-level design and class diagrams. These were designed and shown as low-level class diagrams of the AR smart Grid application. For more details of the low-level class diagrams see Appendix 9.A.5.

5.1.4.1 Conceptual Architecture

The following diagram represents the conceptual architecture. Figure 5.1.3 refers to the UML diagram notations relevant to the conceptual architecture diagram that follows.

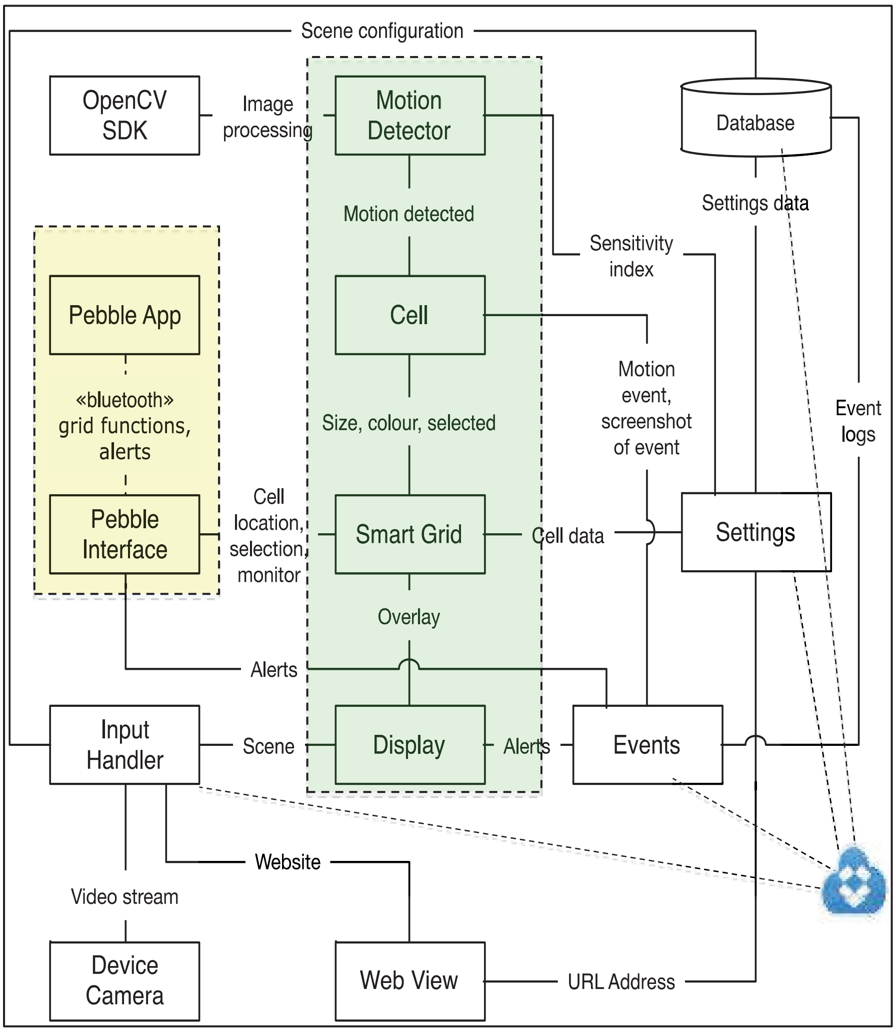

Figure 5.1. 3: Conceptual Architecture of the AR Smart Grid

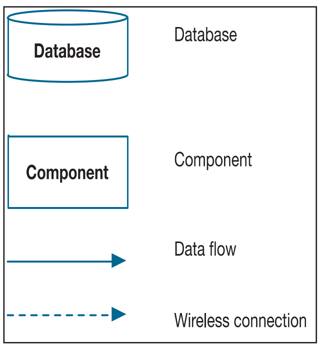

Figure 5.1. 4: Conceptual Architecture Notations

The above figure 5.1.3 shows conceptual architecture of the AR Smart Grid application. The Input Handler took either a video stream feed or a website as the scene to be displayed. Therefore, the Smart Grid provided an overlay of the smart cells of the grid. If a cell was selected, the motion detector monitored the cell. The motion detector utilised the image processing functionalities of the OpenCV SDK. If motion was detected, the cell generated an event, which was displayed on the screen. Setting and event logs persisted by the local application database and were uploaded into the cloud computing services, which was a Dropbox in this project.

5.1.4.2 High Level Design

The following diagram 5.1.5 provided a high level view of the system design. The pattern applied is the Model-View-Controller (MVC) model (Grignard, Drogoul & Zucker 2013). Being a self-contained mobile application, the architecture landed itself to this model.

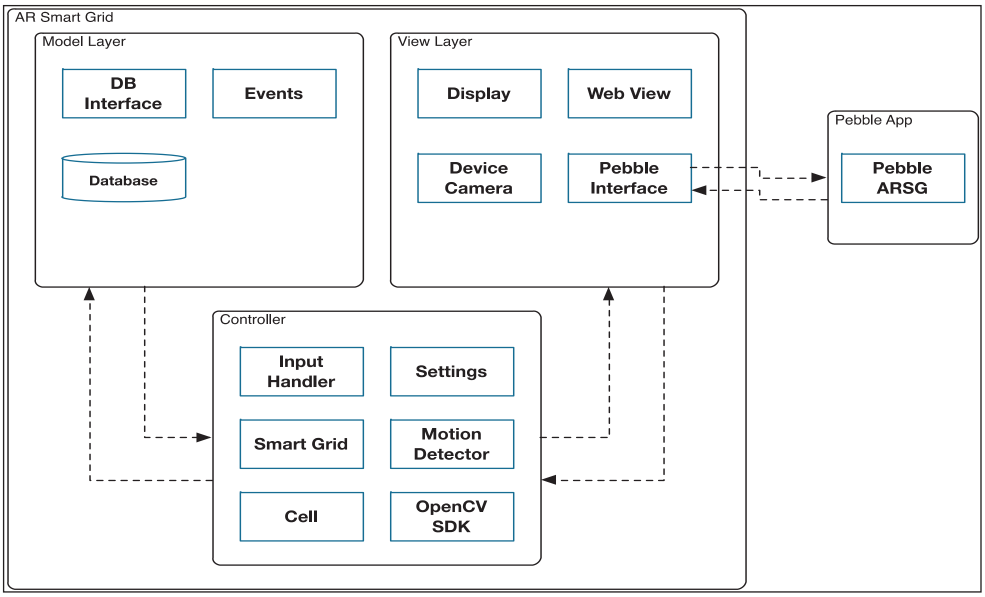

Figure 5.1. 5: High Level Design

5.1.5 Implementation

The solution that was developed was a prototype application that utilises a monitoring grid overlay. The application, AR Grid, was built on the iOS platform for iPad devices and interfaces with a corresponding Pebble Smart Watch application. The functionality of the app was that it monitors selected cells for movements or deviations that were selected by students or instructors while they were in the session remotely. The monitored scene could be configured for a video stream from the iPad device's camera or a web view of any website. Below the figures shows that the grid could be formed as fixed or free, where a fixed grid was laid out evenly according to a configurable number of rows and columns; or as a free grid organised by dragging and dropping cells freely onto the canvas.

When an event was detected in a selected cell by touching the screen or through Pebble Smart Watch, an alert popover overlayed the screen. A log of the event, including a screenshot and timestamp was registered (see figure 5.1.6). The details of figures like landing screen, Screen Input Options are shown in the Appendix 8.A.6.

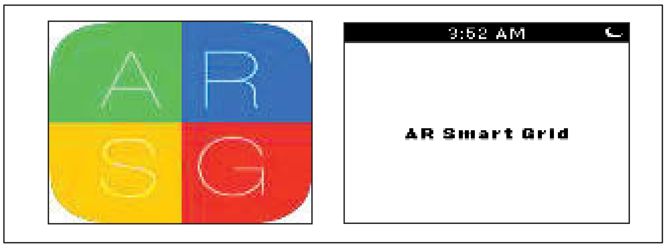

Figure 5.1. 6: AR Smart Grid app icon and Pebble app Landing page

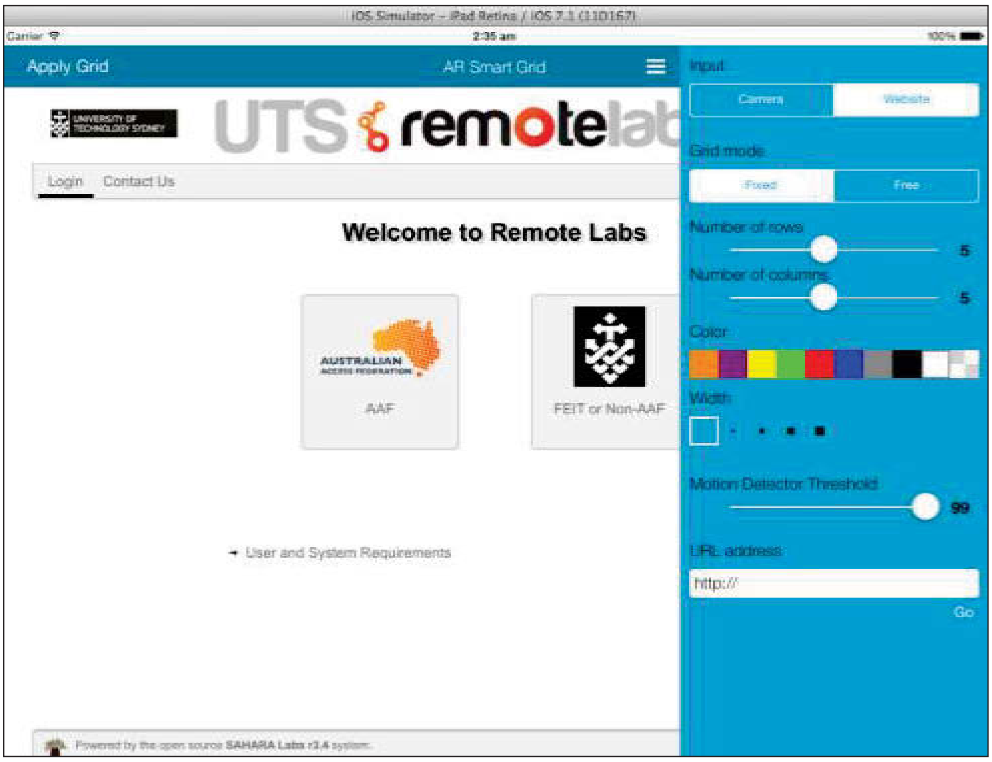

Figure 5.1. 7: Configuration menu to set input, grid mode and grid options

5.1.5.1 AR-Smart Grid Features

A: Grid Modes

There were two available grid modes: Fixed and Free (see figures 5.1.8 and 5.1.9).

- **Fixed mode**: allowed selection of the number of cells in the grid, selecting the number of rows and columns.
    - While it is possible to adjust the colour and width of the cell borders after applying the grid, it was recommended to do this prior to applying the grid due to performance issues.
- **Free mode**: allowed user to drag, place and resize as many cells on the grid as desired.
    - The grid was applied prior to drag and dropping the cell. The top left button should read "Remove Grid", if not then tap the "Apply Grid" button was an instruction.
    - Selection of the colour and width of the cell border prior to drag and dropping the cell was also made available.

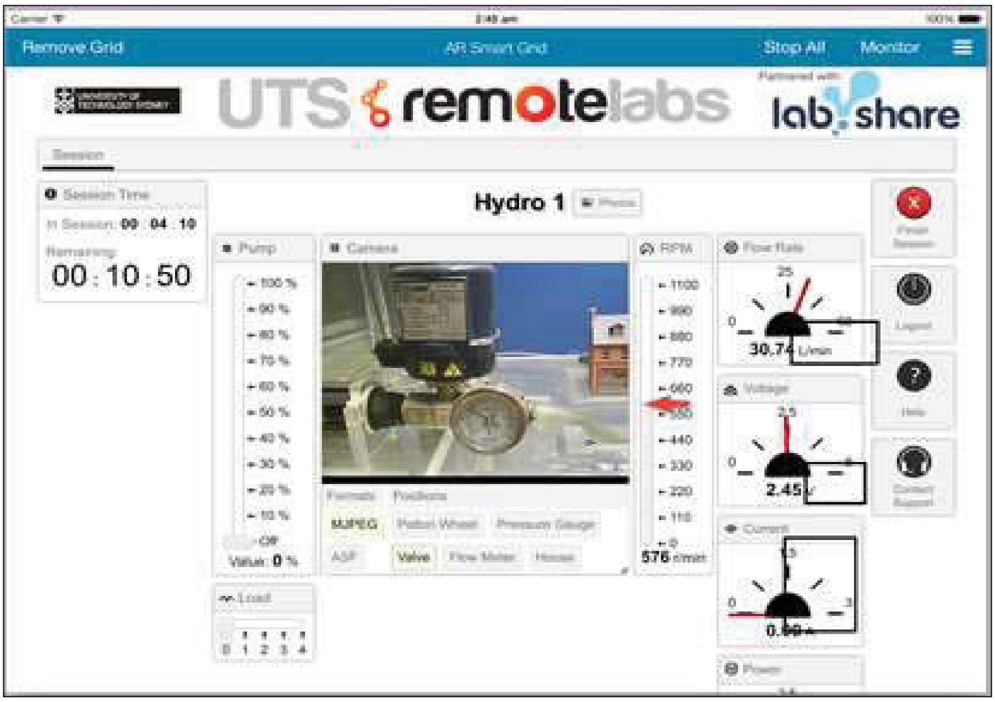

Figure 5.1. 8: Free Grid Mode by Dragging and Dropping Cells

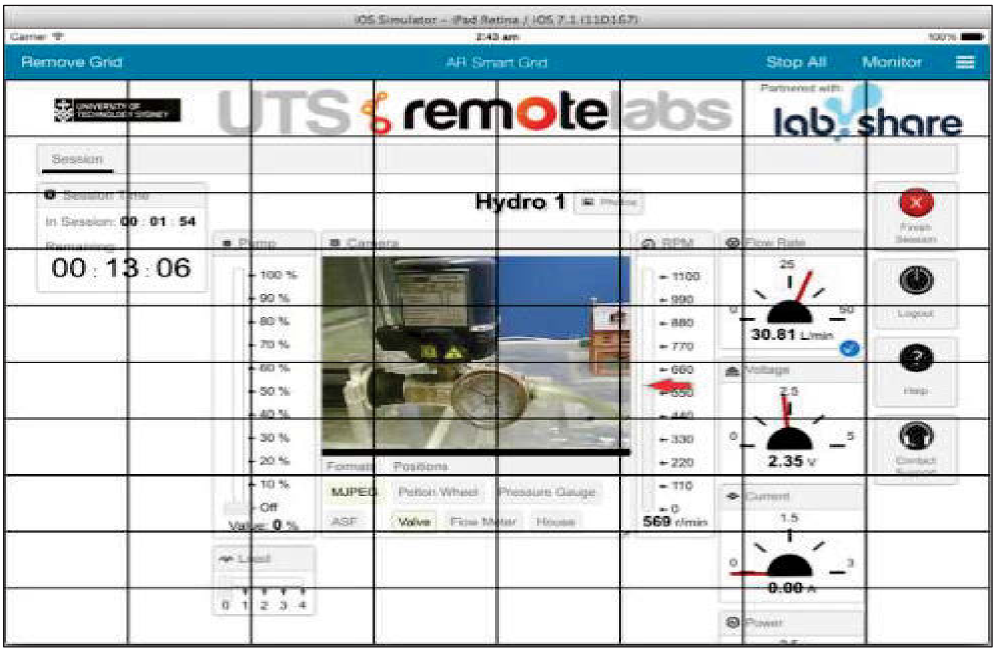

Figure 5.1. 9: Fixed Grid Mode with User Positioned Cells for Threshold.

B: Dropbox Account (Cloud Integration)

The Dropbox Account section allowed for logging into and out of a valid Dropbox account so that there was a destination for captures to be uploaded to.

As mentioned above, the saved images of the cell and grid were uploaded to Dropbox if an account was linked. If an account was not linked, the app would still try to upload to Dropbox but would prompt the user to login. If the login attempt failed, the image would not retry to upload. For this reason, it was recommended that a Dropbox account was linked prior to performing monitoring activities. The process of uploading the captures to Dropbox added essential value that showed the cloud computing integration as a new ICT solution. Therefore, the mechanism was showing a proof of concept that captures can be uploaded to any cloud or online service for storage or analysis.

C: Messaging Service

The messaging service was accessed from https://arsmartgrid.herokuapp.com. This was an invitation only service. The purpose of this service was to provide a method of interactivity between a central point and the apps, for example an instructor and their students using the app. For messages to be received, the device with the app must allow push notifications for AR Smart Grid. The web page is as follows in figure 5.1.10.

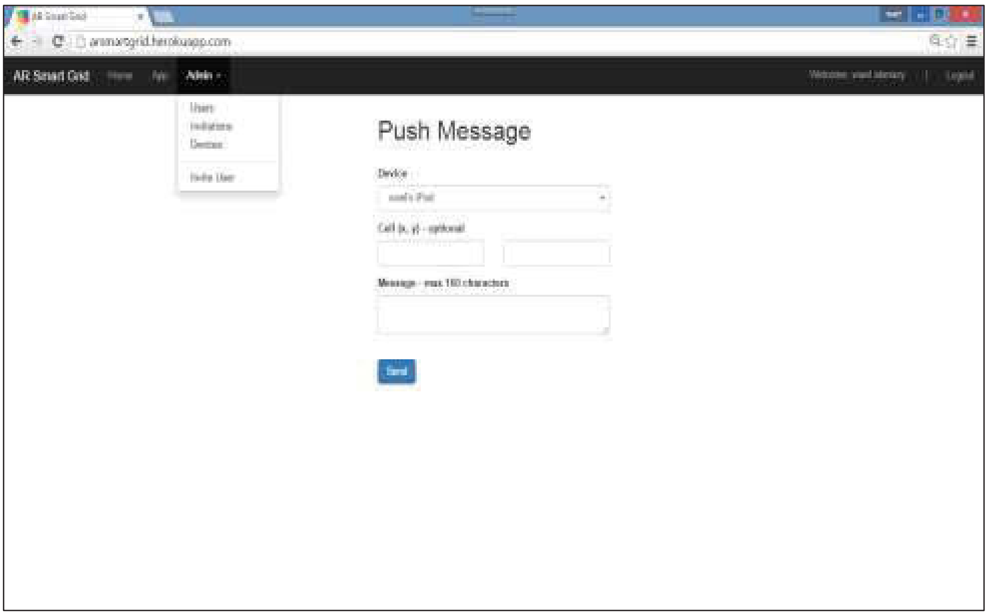

Figure 5.1. 10: Pushing Notifications Interface

The fields are:

- **Device –** A dropdown menu of all devices with the app installed and registered with the messaging service. To register a device for the messaging service, have the app installed and simply open the app at least once, while there is internet connectivity.

- **Cell (x, y) –** This is the x and y coordinates of the cell to post the message in. The top left cell has the coordinates (0, 0).

- **Message –** The message to send to the app. There is a limit of 160 characters because the payload of a push message to iOS 7 is 256 bytes and extra bytes have been allocated for the sender's name and the cell coordinates. However, since iOS 8 the push message payload has been increased to 2 kilobytes. But the limit remains in order to support iOS 7.

D: Message Scenarios

There were four possible scenarios when sending messages to the app depending on the variables outlined below. In each case, the sender's name was displayed to the receiver. The sender's name was the registered name of the account used to send the message as login is required.

- **Lock Screen Message –** When the message is sent while the iPad is locked (see figure 5.1.11)

Figure 5.1. 11: Lock Screen pushed Message

- **Home Screen Message –** When the message was sent while the iPad was unlocked and on the home screen or in another app (see figure 5.1.12)

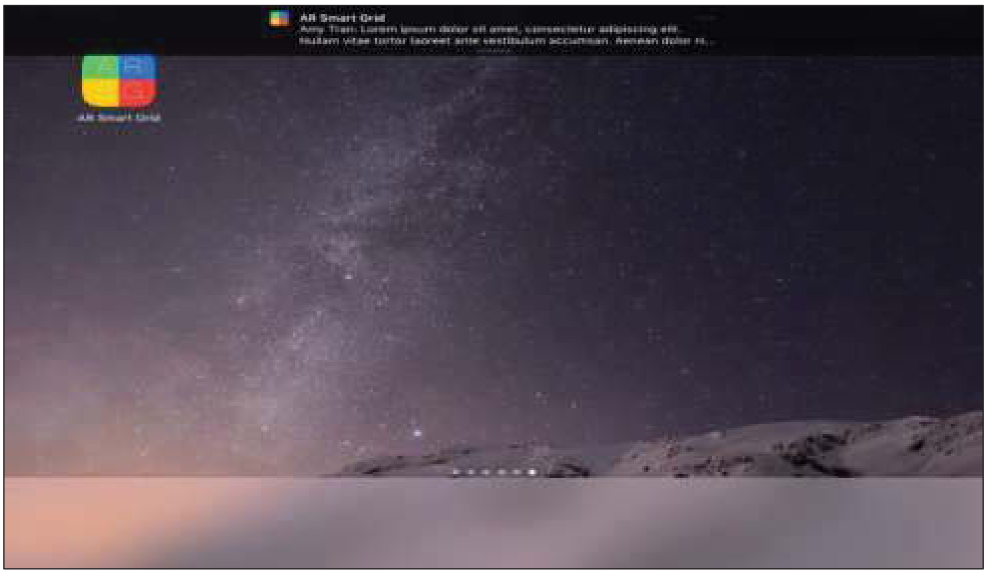

Figure 5.1. 12: Pushed Message into the Home Screen

- **In App Auto Message –** When the message was sent while the AR Smart Grid app was opened and no cell coordinate was specified or does not exist (see figure 5.1.13).

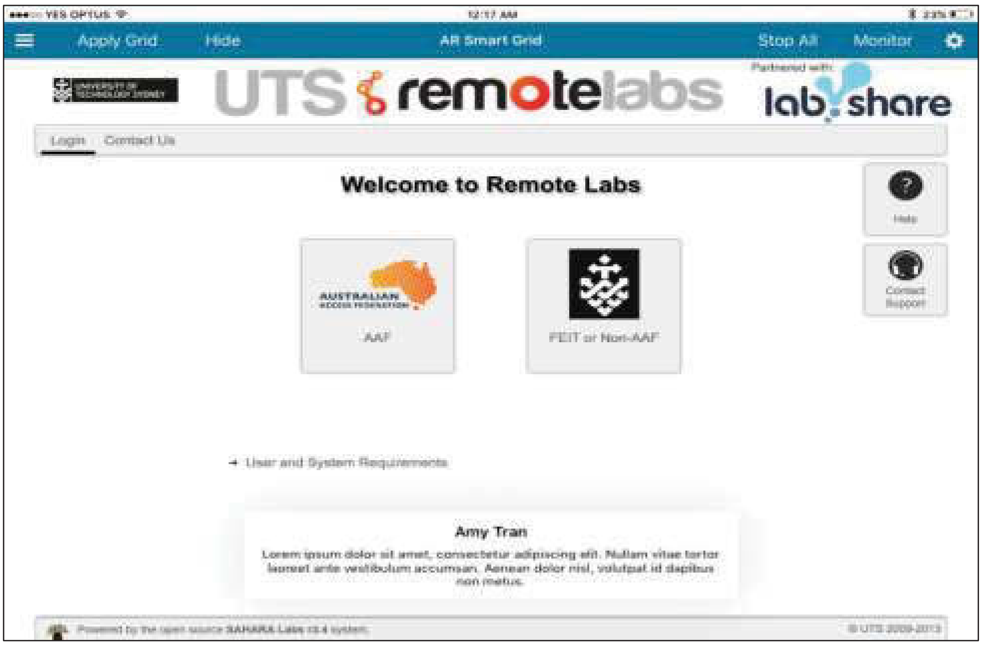

Figure 5.1. 13: App Auto Message

- **In Cell Message –** When the message was sent while the AR Smart Grid app was opened, a fixed grid was applied and a valid cell coordinate was specified (see figure 5.1.14).

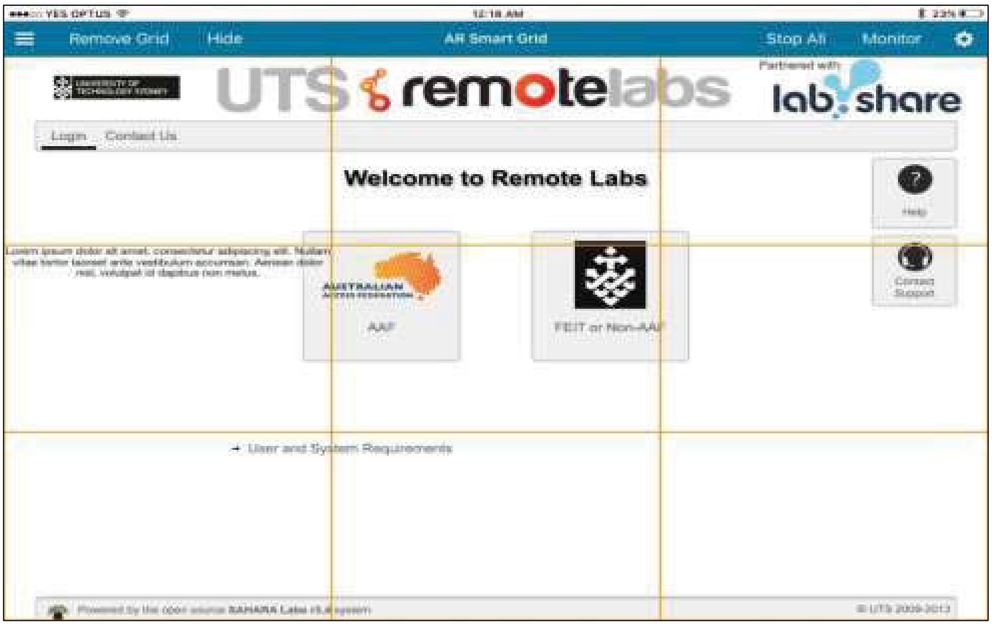

Figure 5.1. 14: In Cell Pushed Message

E: Feedback Messages

Feedback messages referred to the auto prompting of message alerts resulting from a background app process. The following possible feedback messages are detailed below.

- **Server Communication Successful –** Each time the app was launched, communication with the messaging server was polled. If successful, this auto message would appear. This message indicates the iPad was successfully registered with the messaging service.

- **Server Communication Error –** If the initial poll to the messaging server failed, this message prompt would appear. A few possible scenarios would cause this error. The main two were: there is poor or no internet connectivity available; the messaging server is down.

- **File uploaded successfully –** After an event was triggered and the captures were sent to the Dropbox, this auto message would appear to indicate the file was successfully uploaded to the linked Dropbox. This message would appear at least twice per event because the cell image and grid image were uploaded separately.

- **File upload error** – After an event was triggered and the captures were sent to the Dropbox, this auto message would appear to indicate the file did not upload to Dropbox. This may be due to: poor or no internet connectivity; or an issue with the linked Dropbox.

- **Dropbox Session Expired –** There is no Dropbox account linked, but the app tried to upload a capture to Dropbox anyway.

F: Smart Watch Integration (Wearable Device)

Pebble Smart Watch

This section demonstrates the companion Pebble Smart Watch application. Figure 5.1.15 shows a Pebble watch with the AR Smart Grid app loaded. In order for the Pebble to communicate with the iOS AR Smart Grid app, the watch was first paired via Bluetooth to the iPad. When the Pebble app was first opened, the text on the screen read “Waiting for app”. When the iPad app was opened, the program checked if there were other connected Pebble watches. If one was detected, text was appeared on the screen, in this case the text was “AR Smart Grid”.

After connection was established, the user would press any button on the right side of the Pebble. This would bring up the function button labels. A companion application was created for the Pebble Smart Watch platform to demonstrate the integration between the core app and a smart watch. The smart watch app was used to traverse an applied fixed grid to select cells and enable monitoring. In the Appendix 9.A.11 an example of the cell indicator that identifies the location of the smart watch position. When a valid connection between the smart watch and app was established, the device information was visible on the menu.

Figure 5.1. 15: Pebble Smart Watch

5.1.6 Summary

For the Smart Classroom quality enhancement, such as UTS remote-lab, a case study took place to adapt AR within an overlayed Smart Grid into the remote-lab for monitoring and selecting of scene events. The development of this prototype application associated with the advantages of using AR-Smart Grid in remote-labs was demonstrated to show possible leverage of existing technology for the purpose of monitoring and controlling. There is also opportunity to extend the monitoring capabilities of the application to include face detection and other features that could enhance the learning process for other future activity.

5.2 Haptic Middleware Controller for ICT Advanced Tools Integration

The project aims to improve the teaching and learning approach towards an automated control system by presenting analysis and development of a haptic middleware system. The system is aimed at replacing traditional system inputs, such as keyboards and mouse, in the Smart Classroom by integrating haptic motion control middleware systems to simplify the overall interaction process within a Smart Classroom context. Moreover, the prototype is created based on the architectural design to show a proof of concept for the middleware service.

5.2.1 Experiment Objective

The objective of this project is to substitute and to improve or enhance the interactivity in the Smart Classroom by taking into account the concept of new smart teaching and learning environment. Moreover, the new Smart Classroom attends to reform the traditional inputs like keyboard and mouse by integrating haptic motion control and developing a smart middleware systems based on Internet of Things (IoT) framework for establishing the interaction between the selected smart peripherals.

The traditional method in recent Smart Classroom is using basic methods even within the attempting to add some sort of technology, such as smart board and projector by the static methods. However, a Smart Classroom should be consisted of a physically built-in-room equipped with sensors that capture audio-visual information, such as gesture based human motion which includes both face to face environment that will credit to the teaching and learning methods.

The architecture of this project based on the recent developments in IoT architecture prototype to get interconnected by the sensors across the network to provide the smooth transition and to close the gap between the long range and short range sensors. Therefore, the project's was delivered to address the research aim and its relevant objectives for enhancing the interactivity in the new Smart Classroom.

5.2.2 Specific Development Approach

To handle long-range body and hand haptic control, a low powered Bluetooth gesture recognition device called MYO from Thalmic Labs was implemented to determine hand pitch yaw and roll, as well as hand gestures through electric signals through human muscle signals will be implemented with the aims to parsing these signals to integrate with the middleware system.

The two sensors long-range and short range contained a grey level in which the signals could not be determined. To achieve a smooth transition between the devices, the grey levels required an additional sensory device which closed the gap between long-range and close range sensors. If the sensory devices do not contain a valid object recognition library to communicate with the middleware framework, an object recognition algorithms was developed. An Open Computer Vision library is used to recognise the hand and body movement, a sample code is tested during the prototype of simple recognition of objects on a web camera.

To implement the remote procedure call .net frame work was used by utilising the Windows Communication Foundation framework. With TCP or HTTP endpoints were generated from on the server application. The simple prototype was created to handle HTTP requests via XML locations. The Major resource of the learning software library was to obtain data from the LEAP motion device; this is from the LEAP motion website. A special library called MetriCam was built for interfacing time of flight cameras by direct connectivity as well as via networking. This library was used to set up and integrate the middleware with the web camera as well as integrating with OpenCV and MESA SwissRanger 4000 via the intranet. The limitation of the library was that the middleware does not support gesture control.

A prototype was created to test the functionality of this middleware framework. Open Source Computer Vision (OpenCV) is an open source library for real time computer vision operations and this was used. The aim of utilising the middleware framework was to simplify the implementation process of haptic controllers by integrating all of them into a single layer. Softkinetic IISU was gesture framework used with the ability to detect general gesture controls.

5.2.3 System Development Requirements

The major components required in the project implementation were:

1. Haptic sensory devices
2. Middleware systems
3. Haptic recognition algorithms

These components showed the main development stages for integrating multiple smart peripherals to support interactivity in the New Smart Classroom.

5.2.4 Requirements of Middleware System

New haptic middleware system was defined by gathering raw requirements from multiple phases of prototyping as well as via discussion with the stakeholder. These raw requirements are then refined by extracting individual requirements on the core functionality of the middleware. For the detailed requirements description follow in the Appendix 9.B.4.

5.2.5 Software and Hardware Requirements

5.2.5.1 Software Tools

The requirements of the software tools target systems windows 7(32/64 bit) with the development with .NET framework 4.5, Visual Studio 2013, programming language C#, and the middleware IISU and many external libraries. The details of the all the tools can be checked in the appendix. The table with all the software tools has been shown in the Appendix 9.B.2.

Software Libraries

- Microsoft .Net 4.5 framework
- Microsoft Kinect Software Development Library
- Kinect Gesture Pak Software Development Library
- LEAP Motion Software Development Library
- Thalmic Lab MYO Software Development Library
- MYOSharp C# Wrapper API.

5.2.5.2 Hardware tools

Below are the lists of controllers reviewed in this project:

- **Leap motion**
  This device contained an infrared camera which has a reversed pyramid viewpoint of the environment. The range of this device was approximately up to 30 to 40 cm radius indicating that it only sensed close range hand gesture controls interpretations for the system.

- **Microsoft Kinect (Xbox 360)**
  This is a motion sensing input device which contains a one camera and an infrared camera. This devices were developed to work with the Microsoft Kinect software development kit in C++, C# or Visual Basic .Net. The sensing distance for the sensor is approximately 0.8 to 3.5 meters and providing help would be viewable at a frame rate of approximately 9Hz to 30Hz depending on resolution.

- **Thalmic Lab MYO**
  This haptic controller was a gesture control armband that sensed bio-electrical activity in the muscles controlled by the fingers of the hand. The armband communicated with the workstation clients via Bluetooth connection, which then interpreted gesture on motion signals via the software library provided.

- **MESA SwissRanger 4000**
  This is an infrared ToF camera which captured both the image as well as the distance of particles/pixels of an object. It is noted that this camera was very different to conventional cameras where the actual image of the object varies from blue to red indicating the existence of the reflective pixel. As the device provided can only handle network connections, it was unable to support the gesture control middleware IISU because the middleware could not detect and bridge network drivers for the camera.

- **DepthSense DS325**

  This was a short range ToF camera that had the ability to track gestures between 15 centimetres up to approximately 1 metre. The great thing about this camera was that it is compatible with the IISU middleware gesture framework.

- **Web camera**

  Research into gesture control via Web camera was originally part of preparation as a backup in the event where no haptic control devices were received from this project.

5.2.6 System Architectural Design

To design middleware system different architectural patterns were analysed and reviewed to meet the design of haptics motion controller middleware framework. Using layered System Oriented Architecture, this design was considered in the two level design. A high level design was developed using SysML which decomposed into lower level design, determining the functionalities of the component block (Friedenthal, Moore & Steiner 2014).

Service Oriented Architecture (SOA) was made up from a collection of discrete software modules, known as services that collectively provide the complete functionality of a large software application (Duggan 2012). This allowed users to combine and reuse them in the production of applications. Services were implemented using traditional languages including Java, C, C++, C#, Visual Basic, COBOL, or PHP. The prototype in development for this paper was chosen to be C#.

5.2.6.1 High Level Design

Conceptual Architecture

The key components of the conceptual architecture of the Haptic node are shown in the following figure 5.2.1:

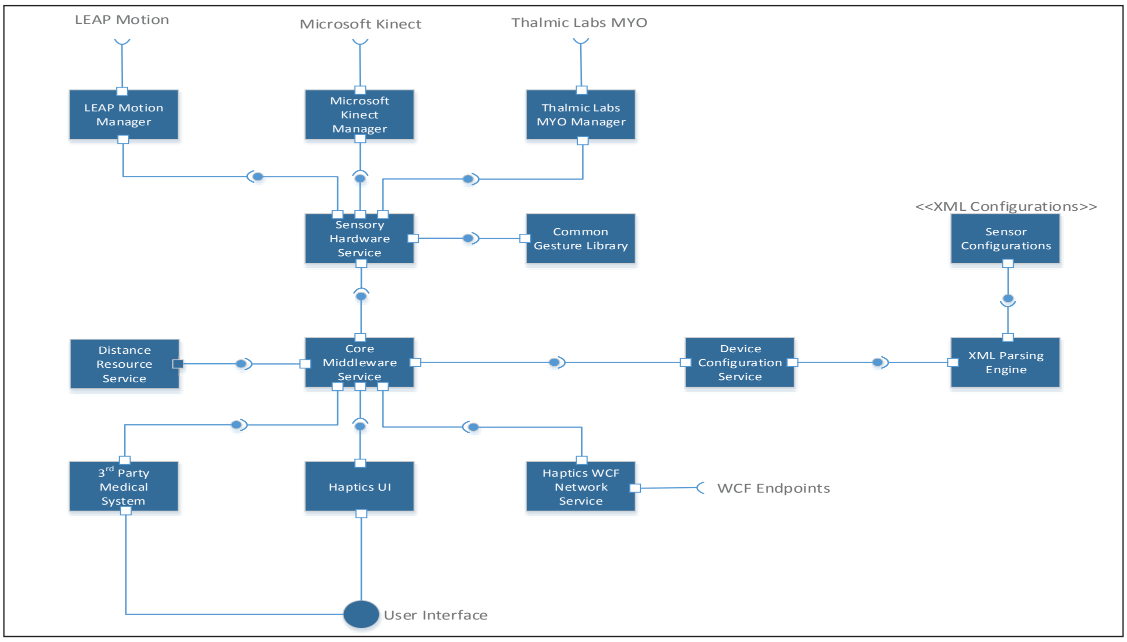

Figure 5.2. 1: Conceptual Architecture (Wael Alenazy, Zenon Chaczko & Chan 2016)

The figure 5.2.1 shows the conceptual architecture design for the haptic controller middleware consisting of several components, which delivered the interactivity aspect in teaching, and learning environment. These were:

- **LEAP Motion Manager**
  The LEAP motion manager managed all connections to the LEAP motion device and implemented a defined set of methods that returned consistent data to the sensory hardware service. It implemented a common gesture library.

- **Microsoft Kinect Manager**
  The Microsoft Kinect manager managed all connections to the Microsoft Kinect device and implemented a defined set of methods that returned consistent data to the sensory hardware service. It implemented a common gesture library.

- **Thalmic Labs MYO Manager**
  The Thalmic Labs MYO manager managed all connections to the Thalmic Labs MYO arm band and implemented a defined set of methods that returned consistent data to the sensory hardware service. It implemented a common gesture library.

- **Common Gesture Library**
  The common gesture library contained a common set of gestures that were implemented by different haptic devices. This library was implemented within the sensory hardware service.

- **Sensory Hardware Service**
  The sensory hardware service defined a common set of functions and data requirements for any device and defined a common set of gestures utilizing a common gestures library. This service was handled by the Core Middleware service and its logic interfaced to select exclusive data from the haptic controllers.

- **Distance Resource Service**
  The Distance Resource service handled the resource selection logic based on the output from the sensory hardware service. This was achieved by assessing the distance of the user, the velocity as well as the confidence ratio of the device.

- **Core Middleware Service**
  The Core Middleware service was the main service which was used to implement the haptic control middleware. This was the service point which was used for other third party systems to interface and interact with.

- **Device Configuration Service**
  The device configuration service is an XML configuration of all devices that were defined. This contained the name of the device, the connectivity method as well as some basic capabilities of the item.

- **Haptics WCF Network Service**
  This is a network service that outputs gestures data to the network space. This was aimed at interacting with systems across the internet using haptic controllers on the workstation.

Implementation Architecture

The implementation architecture design shows the lower level integration that was developed to reference the system. It consists of the following:

- **Lower Configuration Layer**
  The lower configuration layers implement the XML configuration of all devices that were defined. This contained the name of the device, the connectivity method as well as some basic capabilities of the item. This was achieved by utilizing an XML Engine to create and parse XML files.

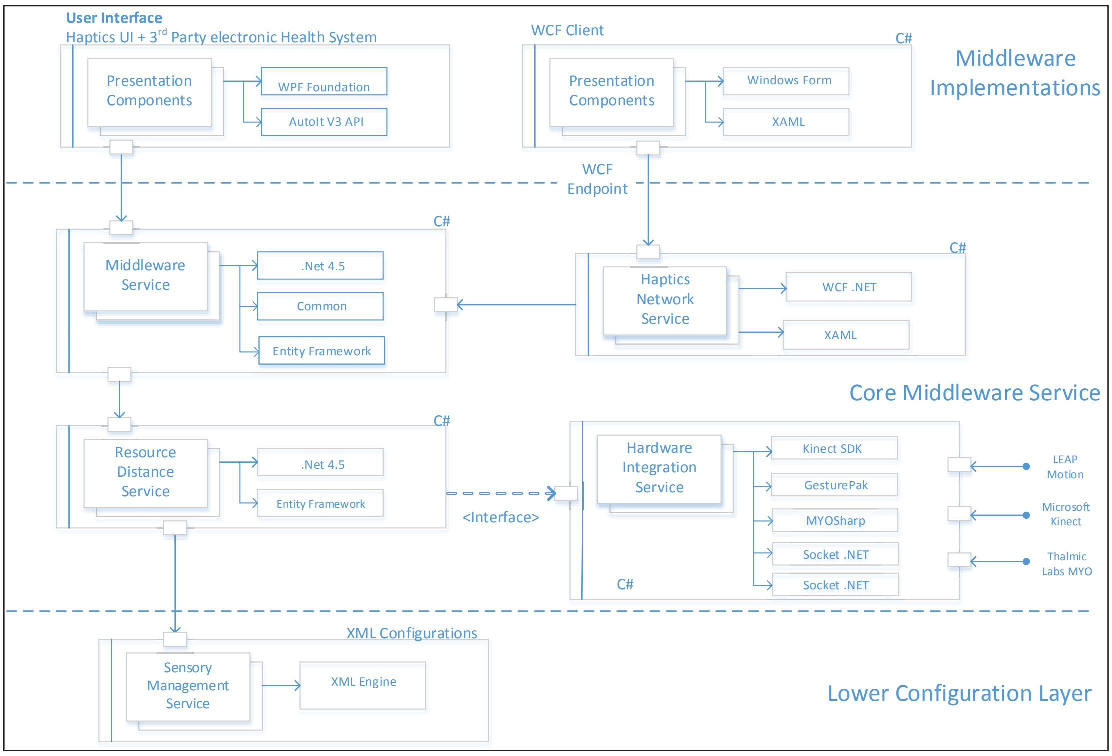

Figure 5.2. 2: Implementation Architecture (Wael Alenazy, Zenon Chaczko & Chan 2016)

- **Core Middleware Service**

The core middleware was the service that implemented the haptic controller framework. The service was composed of four main services:

- Middleware Service: this was the outbound service which implemented the middleware API for third party systems.
- Haptics Network Service: this was a network service which outputted gesture data across the internet via TCP/IP or HTTP endpoints. This utilised Windows Communication Foundation framework.
- Resource Distance Service: the resource distance service controlled the logic in switching hardware devices based on availability and other parameters such as distance and velocity.
- Hardware Integration Service: this handled all the devices connected to the middleware system. These devices were implemented using their corresponding libraries and uses a common interface for ease of interaction.

In the Appendix 9.B.6, details appear regarding the middleware implementation and its class diagrams for the low-level design.

5.2.6.2 Results and Testing

Figure 5.2. 3: Haptic Selected Peripherals

The aim of this project was to create a functional prototype to demonstrate:

1. This project helped to connect multiple haptic devices through IoT framework.
2. It shows many sensors to interact based on a common gesture library.
3. Using middleware system sensing the user distance and velocity and calculate as a factor to determine the next listening haptic controller.

At the end of the project, a final system prototype was created with three haptic controller devices integrated into the middleware service that supports the scene perception.

Table 5.2. 1: Haptic controllers complementing their strengths over other controller's weaknesses

Device	Distance Detection	Euler's Angle	Fingers Detection	Hand Detection	Body Detection	Operating Distance
Leap Motion	☼		☼	☼		0 - 30cm (Reverse cone)
MS Kinect	☼			☼	☼	1 - 5.0m (Seated mode)
MYO		☼	☼			10m Radius
Result	☼	☼	☼	☼	☼	**Coverage**

A working prototype of the Haptic Middleware Software was designed and developed to allow for identification, management and visualisation of data received from several types of haptic hardware for which these specialised services were implemented. Initially, the requirements were to have the capability of sensing and servicing the users within 10 meters range. The type of functions that have been tested as follows: browsing multimedia presentation; pointing and selecting items, changing scenes and triggering objects in the class with the coverage distance as shown in the table 5.2.1. As a result, testing was completed by creating a Haptics user interface to test the middleware services.

Figure 5.2. 4: Haptic User Interface Testing

5.2.7 Experiment Analysis

The project achieved its aim towards creating an interactive teaching and learning environment by introducing a middleware system which is robust and scalable with multiple devices.

A working prototype was created to show proof of concept. There is currently no other middleware to knowledge that can share and handle common gesture interfaces with smart switching between devices based on distance.

The core of this project was to design and create the initial framework for the middleware. Below are a few key areas which improved the middleware framework:

- Implementing additional devices to expand compatibility of the middleware
- Adding additional gestures to the existing common library
- Adding other devices such as sensors
- Integrating the network service into cloud, which in turn connected to IoT peripherals
- Improve smart algorithm to device switching process

5.2.8 Summary

The new approach makes teaching and learning more effective compared to the current classes system. The new prototype demonstrates an interactive classroom that enhances the users' interest and attention in teaching and learning process in a novel way. The increased gestural interaction we saw stimulated curiosity in gaining or transferring the information. The objective here was to create teaching and learning in an interactive space that promotes real life interaction of scene perception. This may support learning objectives and the course learning outcomes. In addition, physical arrangement enables the teacher to know the status of each student in order to adjust the learning activities to suit the learners, which leads to an improvement of academic performance and their outcomes. The developed system shows the effectiveness of multiple haptic integration. Moreover, it works to enhance variant teaching and learning approaches, and is more engaging, student-centred, interactive, reflective and promotes a collaborative environment (Yang & Huang 2015).

5.2 Conclusion

As shown in this chapter, Augmented Reality can be integrated within the learning environment to support learning processes, creating a meaningful interactive learning platform. As such AR can play a key role in raising motivation levels in the education environment. The equation that increased activity equals curiosity, is a common sense notion; from this we assume, that haptic integration helps to improve knowledge acquisition and retention among learners. This is for further consideration in future research.

The project implemented AR within an overlay Smart Grid into the remote-lab for monitoring and selecting scene events (scene perception). The development of this application associated with the AR Smart Grid in remote-labs has demonstrated the possibility of leveraging existing technology for the purpose of monitoring and controlling. There is also future opportunities to extend the monitoring capabilities of the application to include face detection, for example, and other features that could be possible to enhance the learning process.

The approach showed the implementation of haptic technologies. These were integrated into the architecture of the learning environment by designing components of service oriented software middleware, achieved through proper architectural development and design. As a result, the functional prototype shows an innovative way of utilising haptic devices within a smart learning environment context.

As a result, both projects validate the system architecture design as modelled by ETAM, introducing the visualisation and haptic nodes proposed and designed in Chapter 4, reflecting as well the teaching and learning scenario.

The AR smart grid and haptics middleware system using various platforms show the possibility of integrating advanced ICT tools into new smart learning environment. The following Chapter 6 validates the introduced solution reflecting the level of acceptance among users.

Chapter 6

ETAM Validation

This chapter evaluates the acceptance of the newly developed system in context of Extended Technology Acceptance Model (ETAM). As ETAM was a guide for the introduction of ICT advanced tools into the education process, the modified model was assessed and validated based on users' experience and their acceptance. The assessment reflected well developed system architecture that introduced ICT tools into the new Smart Classroom setting.

6.1 Investigation Procedure: Method

A survey was conducted to investigate and measure specific concepts, such as behaviour, behavioural intentions and attitudes to predict technology acceptance at a statistically significant level. Therefore, oriented study is able to produce investigation results that are both understandable and relevant to practitioners (Pihlanto 1994). The sample population consists of tertiary academics who are using ICT tools in their learning practices.

In order to design and conduct survey, a practical application was tested through the development process to minimise system deficiency. In this respect, the study was conducted through pre experimental tests to validate the feasibility of the ICT tool before the actual system was run by the practitioners. After that, the survey was launched to measure users' reflections. The responses were based on pre-acknowledged about the system functionality and its benefits into the education system by running intuitive observable learning scenarios. After engaging the participants within experiment, the survey was established and conducted.

Some aspects of conducting outcomes used universal values and were very specific; and thus, it may have some local limitations which contain universal observation related to the academic perception. The limitation of this study is restricted to the samples collected from the academic staff at King Saud University in the Preparatory Deanship and cannot be able to take from the wider population. Though it is restricted, future research may be conducted to investigate the introduction of reviewed ICT tool into the advanced technology acceptance model (ETAM) in other educational and technological sectors to prove its wider acceptance.

The questionnaire consists quantitative and qualitative methods. The questions used for analysis were 5 point Likert scale questions where the participant was required to tick the appropriate options, such as: like 1- strongly disagree; 2- disagree; 3-neutral; 4-agree; and 5- strongly agree. The questions also were open-ended asking participants to come up with their own responses allowing the researcher to document the opinions of the respondent in his or her own words. These questions were useful for obtaining in-depth information, opinions, attitudes and suggestions, or sensitive issues. Completely open-ended questions allowed the researcher to probe more deeply into issues, thus providing new insights, bringing to light new examples or illustrations allowing for different interpretations. Moreover, the qualitative responses were converted into a quantitative form to facilitate and unify the result (see Appendix 9.C.1).

6.2 ETAM Parameters

The reviewed ICT advanced tool has a significant positive impact on the following factors:

- Perceived usefulness
- Perceived ease of use
- Attitude towards using ICT advanced tool
- Behavioural intention towards using ICT advanced tool

Assertion 1, perceived ease of use and perceived usefulness lead to a positive influence on attitude and behavioural intention towards using the reviewed ICT advanced tool.
Assertion 2, expectation, understanding of scene partitioning, and the reviewed ICT advanced tool have a positive impact among users when experience the tool towards the introduced the smart teaching and learning environment.

These parameters and related assertion underline in depth the research aim and objectives towards the acceptance of the new Smart Classroom development.

6.3 The Candidate Questions and Question Type

The survey is constructed in such a way that the questionnaire employed is easy to understand and fill so that the participants can fulfil it in under 15 minutes. Questionnaire consists as form which is completed and submitted by respondents. The statements or questions follow the BRUSO criteria (Converse & Presser 1986); they are Brief, Relevant, Unambiguous, Specific, and Objective.

6.4 Results

6.4.1 Quantitative Analysis

Descriptive data analysis has been taken into consideration for this particular case to evaluate the reliability of the data used for this specific case. This analysis procedure helps to identify the key variables that need to be taken care of while preceding the inferential study. Further, it has also seen that the descriptive analysis lend a hand towards the researcher to short data in a sequential manner and to understand the deviation of the data. In short, this section of the study has demonstrated the scattered nature of the data.

A. Demographic Information

Data was collected from a total of 220 participants among the academic staff at King Saud University in the Preparatory Deanship were given the questionnaire and will address the acceptance & influence factors through the introduction of advanced ICT tool. The Table 6.1 shows demographic data of the respondents, 87% (n = 191) were males and 13% (N = 29) were females among the total 220 participants. The majority of participants with the academic grade of Tutor or Trainer with 65% (N =144) followed by Lecturer with 26% (N=57) and 6% holds the Assistant professor. The Saudi nationalities are 10% (N = 21) and most of the participants are non-Saudis 90% (N=199).

Table 6. 1: Demographic Characteristics of Participants

		Frequency (N)	Percentage (%)
Gender	Male	191	87
	Female	29	13
Academic Position	Professor	3	1
	Assistant	15	6
	Lecturer	57	26
	Tutor or Trainer	144	65
	Lab Assistant	1	0.5
Nationality	Saudi	21	10
	Non Saudi	199	90

Table 6. 2: Cross Tabulation of the qualification and teaching experience

			Teaching Experience					
			>0 Year <1 Year	>1 Years <5 Years	>5 Years <10 Years	>10 Years <15 Years	> 15 Years	Total
Qualification	Bachelors	N	4	30	25	3	5	67
		%	6 %	44 %	37 %	5 %	8 %	
	Masters	N	9	44	43	15	15	126
		%	7 %	35 %	34 %	12 %	12 %	
	Doctorate	N	3	5	8	6	5	27
		%	9 %	22 %	35 %	17 %	9 %	

B. Cross Tabulation

A cross tabulation is made between the qualification and teaching experience of the participants .As shown in Table 6.2, The total 67 participants were Bachelor degree holders and the majority of participants were Master degree holders (N=126). Out of that, 12% (N=15) of the participants had reported with more than 15 years teaching experience. The doctorate holders with >10 years' experience were 17 %(N=6) and Bachelor degree holders with >15 years' experience were 8% (N=5). The figure 6.1 shows the graphical representation of the results received from the cross tabulation.

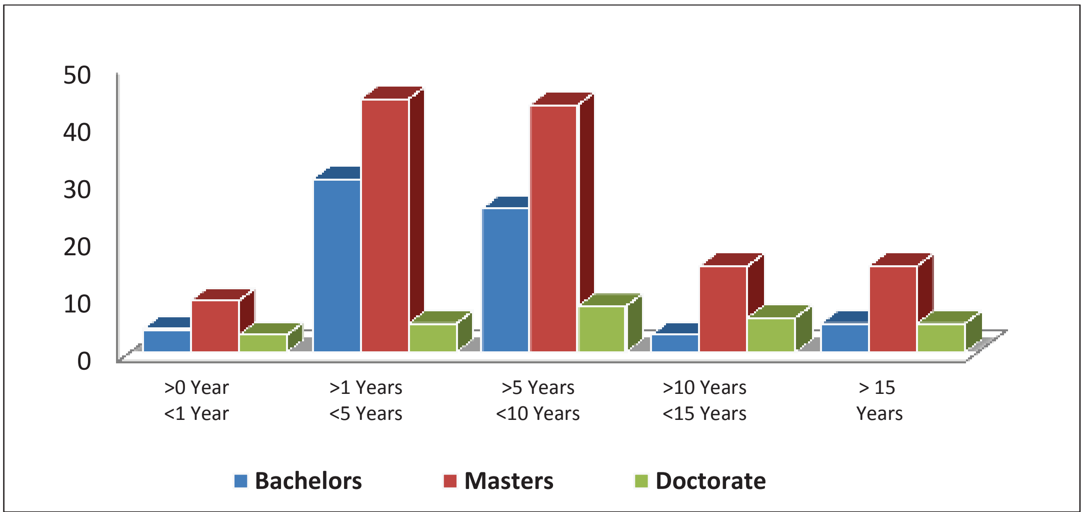

Figure 6. 1: Graphical Presentation of Cross Tabulation

C. Software Preference

Involvements of participants are very necessary in this aspect to analyse the collected data and information from the descriptive analysis procedure. As ICT learning software are used for advanced classroom activities, academics are considered as the respondents.

The Table 6.3 highlights the ICT learning application /software used in the classroom. According to it, the Microsoft Office was reported with the highest used software used in the classroom 85% (N=186) followed by YouTube with 67% (N=147). The CMS blackboard with 26%, Google applications 34%, Adobe reader 62% , Social media applications 27% and cloud storage with 49%. Figure 6.2 shows the graphical representation of ICT learning application/software used in the classroom.

Table 6. 3: ICT Learning Application / Software used in the Classroom

	Applications	Frequency(N)	Percentage (%)
1	CMS Blackboard	56	26
2	YouTube	147	67
3	Social Media Network Applications	60	27
4	Google Application	76	34
5	Microsoft Office	186	85
6	Adobe Reader	137	62
7	Cloud Storage (Google Drive, Dropbox)	108	49

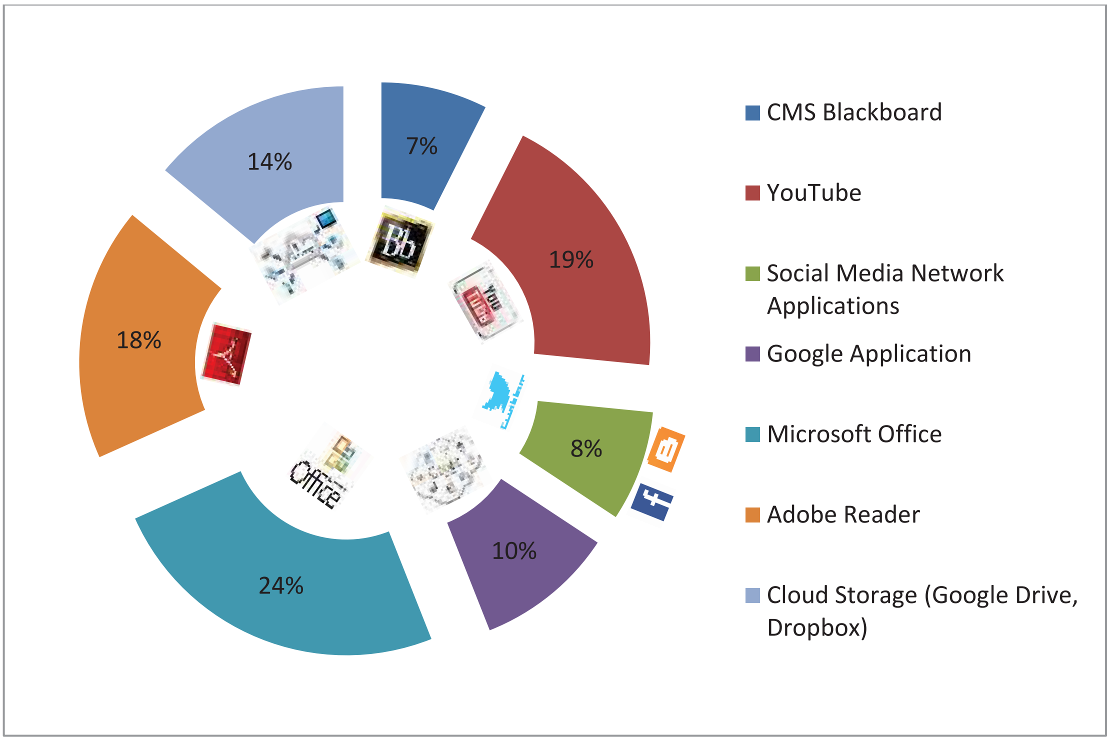

Figure 6. 2: ICT Learning Application / Software used in the Classroom

On the other hand, the ICT learning tools used in the classroom was depicted In Table 6.4 and it reveals that , the Smart-board and Computer desktop had reported with major ICT learning tools used in the classroom 81% (N=179). The smart pointer pen shows a 27% (N=60) which is the least ICT learning tools compared to other tools. The laptops with 42%, Tablet with 20%, projector with 76% are the other ICT tools used in the classroom. In Figure 6.3, the ICT learning tools used in the classroom are presented in Pie chart.

Table 6. 4: ICT learning tools used in the Classroom

	Devices / Peripherals	Frequency (N)	Percentage (%)
1	Computer Desktop	179	81
2	Laptop	92	42
3	Tablet	45	20
4	Projector	168	76
5	Smart Board	179	81
6	Smart Pointer Pen	60	27

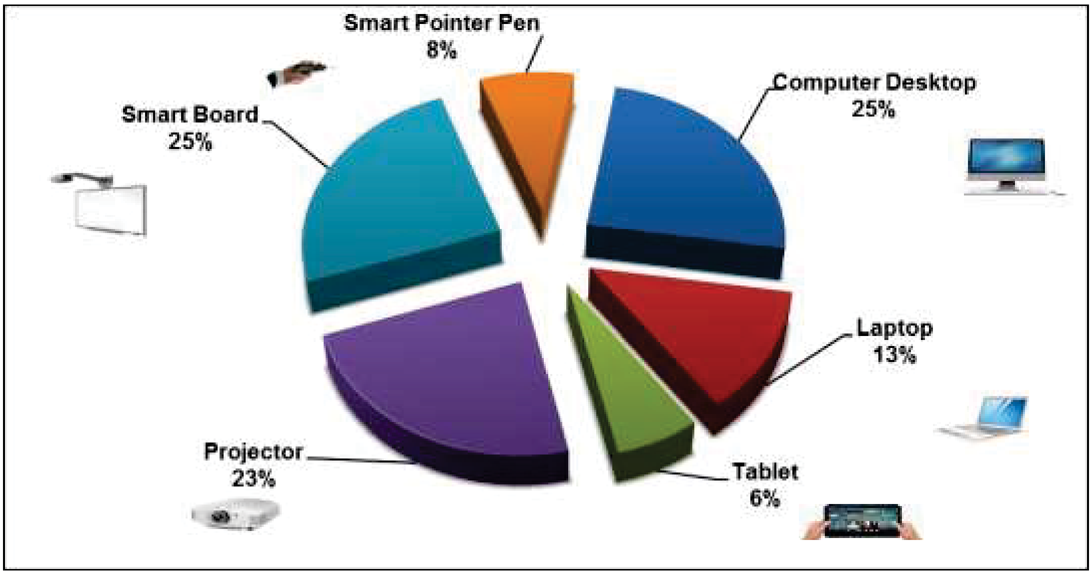

Figure 6. 3: Graph shows the ICT leaning tools used in the classroom

D. ICT Learning Tools Effectiveness

ICT tools are very effective to help the students to achieve academic excellence in their educational fields. This can be useful for the academics also as it helps them to provide proper and advanced knowledge to the learners.

The figure 6.4 shows the percentage of effectiveness perceived by the participants when using ICT learning tools. The red coloured bar item shows that 64% of them recorded effectiveness as "Very Much" and "Sometimes" as 27% and the least reported was 1.4% "Not at all".

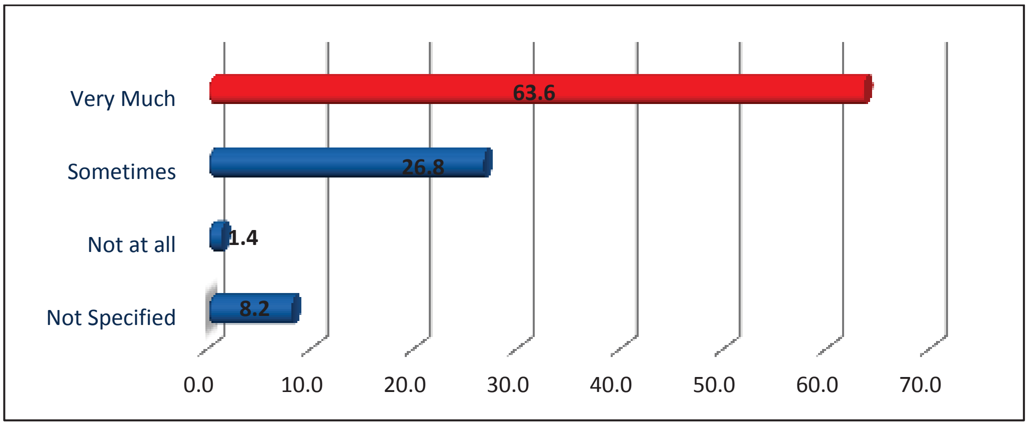

Figure 6. 4: the Percentage of Effectiveness Recorded by the Participants when Using ICT Learning Tools

E. Use of ICT Tools in Teaching

Use of advanced ICT tools in the teaching purpose can help to gain lots of knowledge of this advanced world. ICT tools like computer programs, smart board, web applications tools helps to gain outside knowledge instead of bookish knowledge, therefore students are able to achieve best academic performance.

The figure 6.5 shows the percentage of responses from the participants about the use of ICT tools in their teaching and learning methods. From the above figure, 93% of them recorded as "YES" and 7% of them as "NO".

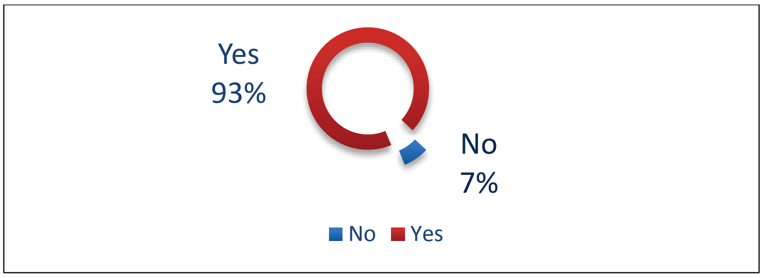

Figure 6. 5. Percentage Responses of ICT Tools Used by the Participants

F. Rating of ICT Skill

ICT tools must be rated as per their performance to enhance the performance of the learning styles in the educational institutes. This ranking will help to know which toll is useful for effective learning system.

ICT tools were rated as per their performance to enhance the learning styles.

The figure 6.6 shows the percentage of rating given by the participants based on their ICT skills. The rating of specialist shows a 12%, the expert with 36% and functional application and awareness holding the rating of 45% and 7% respectively and 7% of the participants not rating their ICT skills.

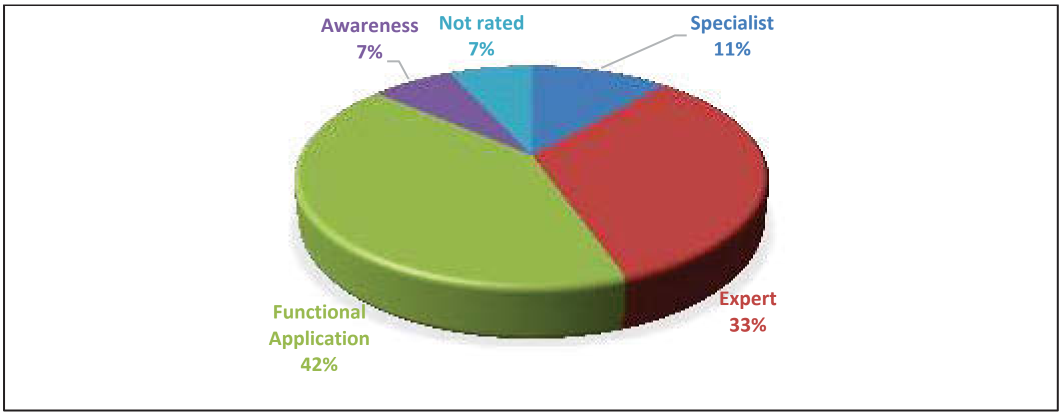

Figure 6. 6: Percentage of Rating Given by the Participants According to their ICT Skills

G. Descriptive Analysis of Key Categories

A formative questionnaire is constructed by the data and information collected from descriptive analysis technique. Key categories were:

- Perceived Usefulness (PU) Perceived Ease of Use (PEoU)
- Attitude Toward ICT advance tool Use
- Behavioural Intention to Use
- Understanding of Scene Partitioning in ICT advanced tool
- Understanding and Expectation of Scene Partitioning and ICT advanced tool in general

The Table 6.5 shows the descriptive analysis of mean and standard deviation of the questionnaire constructs. The overall results were positive with a high mean score on Perceived Usefulness (PU) and Attitude towards ICT advance tool Use, except the non-understanding of scene partitioning activating the system.

Table 6. 5: Descriptive Analysis of Constructs

Particulars	(N=220)	
	Mean	SD
Perceived Usefulness (PU)		
Using ICT advanced tool will improve my work	4.25	0.764
Using ICT advanced tool will enhance my learning and teaching effectiveness	4.28	0.689
Using ICT advanced tool will increase my teaching and learning productivity	4.25	0.756
Perceived Ease of Use (PEoU)		
I find it easy to get ICT advanced tool to do what I want it to do	3.98	0.779
Interacting with ICT advanced tool does not require a lot of mental effort	3.84	0.887
I find ICT advanced tool easy to use	4.00	0.814
Attitude Toward ICT advance tool Use		
ICT advanced tool makes work more interesting	4.29	0.767
Working with ICT advanced tool is exciting	4.24	0.675
I look forward to those aspects of my learning and teaching methods that require me to use ICT advanced tool.	4.24	0.747
Behavioural Intention to Use		
I will use ICT advanced tool in future	4.27	0.809
I plan to use ICT advanced tool occasionally	3.87	0.929
I plan to use the ICT advanced tool regularly	4.10	0.819
Understanding of Scene Partitioning in ICT advanced tool		
I found it clear and ease to understand the role of Scene Partitioning in activating the ICT advanced tool	3.82	0.893
I found it somewhat clear to understand how Scene Partitioning is able to activate the system	3.78	0.855
I could not understand or see how Scene Partitioning is able to activate the system	4.24	0.839
Understanding and Expectation of Scene Partitioning and ICT advanced tool in general		
Scene Partitioning software tool is a critical factor in the ICT advanced tool for Teaching and Learning process	3.86	0.822
I plan to use Scene Partitioning software tool for Teaching and Learning extensively.	3.81	0.874
I hope to use Scene Partitioning software tool for Teaching and Learning process in the future.	4.00	0.914

PU	Perceived Usefulness (PU)
PEoU	Perceived Ease of Use (PEoU)
ATT	Attitude Toward ICT advance tool Use
BI	Behavioural Intention to Use
USP	Understanding of Scene Partitioning in ICT advanced tool
UESP	Understanding and Expectation of Scene Partitioning and ICT advanced tool in general

H. Measurement Model Acceptability

In this study, the acceptability of the measurement model was evaluated according to reliability as well as convergent and discriminant validities which includes the following:

i. *Internal consistency*

The adequacy of the measurement model was measured using Cronbach's alpha. This is typically a measure based on the correlation between different items on the same test. It measures whether several items that propose to measure the same general category produce a similar score. The values which are substantially lower indicate an unreliable scale as presented in table 6.6.

A commonly accepted rule of thumb for describing internal consistency is as follows:

Table 6. 6: Cronbach's Alpha (Gliem & Gliem 2003)

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Table 6. 7: Internal Reliability of the Constructs

	Internal Reliability of the Constructs	
Constructs	Questionnaire Items	Cronbach α
Factor 1	**Perceived Usefulness (PU)**	
PU1	Using ICT advanced tool will improve my work	0.900
PU2	Using ICT advanced tool will enhance my learning and teaching effectiveness	0.903
PU3	Using ICT advanced tool will increase my teaching and learning productivity	0.900
Factor 2	**Perceived Ease of Use (PEoU)**	
PEOU1	I find it easy to get ICT advanced tool to do what I want it to do	0.901
PEOU2	Interacting with ICT advanced tool does not require a lot of mental effort	0.905
PEOU3	I find ICT advanced tool easy to use	0.900
Factor 3	Attitude Toward ICT advance tool Use	
ATT1	ICT advanced tool makes work more interesting	0.899
ATT2	Working with ICT advanced tool is exciting	0.900
ATT3	I look forward to those aspects of my learning and teaching methods that require me to use ICT advanced tool.	0.899
Factor 4	**Behavioural Intention to Use**	
BI1	I will use ICT advanced tool in future	0.901
BI2	I plan to use ICT advanced tool occasionally	0.908
BI3	I plan to use the ICT advanced tool regularly	0.902
Factor 5	**Understanding of Scene Partitioning in ICT advanced tool**	
USP1	I found it clear and ease to understand the role of Scene Partitioning in activating the ICT advanced tool	0.902
USP2	I found it somewhat clear to understand how Scene Partitioning is able to activate the system	0.904
USP3	I could not understand or see how Scene Partitioning is able to activate the system	0.918
Factor 6	**Understanding and Expectation of Scene Partitioning and ICT advanced tool in general**	
UESP1	Scene Partitioning software tool is a critical factor in the ICT advanced tool for Teaching and Learning process	0.904
UESP2	I plan to use Scene Partitioning software tool for Teaching and Learning extensively.	0.903
UESP3	I hope to use Scene Partitioning software tool for Teaching and Learning process in the future.	0.903

Regarding to the study investigation, table 6.7 shows that the alpha values of selected items range from 0.899 to 0.918. Therefore, all categories (in table 6.8) in the research model demonstrated high levels of reliability.

Table 6. 8: Questionnaire Items Constructs for the Factors

	Questionnaire Items Constructs
Constructs	Questionnaire Items
Factor 1	**Perceived Usefulness (PU)**
PU1	Using ICT advanced tool will improve my work
PU2	Using ICT advanced tool will enhance my learning and teaching effectiveness
PU3	Using ICT advanced tool will increase my teaching and learning productivity
Factor 2	**Perceived Ease of Use (PEoU)**
PEOU1	I find it easy to get ICT advanced tool to do what I want it to do
PEOU2	Interacting with ICT advanced tool does not require a lot of mental effort
PEOU3	I find ICT advanced tool easy to use
Factor 3	**Attitude Toward ICT advance tool Use**
ATT1	ICT advanced tool makes work more interesting
ATT2	Working with ICT advanced tool is exciting
ATT3	I look forward to those aspects of my learning and teaching methods that require me to use ICT advanced tool.
Factor 4	**Behavioural Intention to Use**
BI1	I will use ICT advanced tool in future
BI2	I plan to use ICT advanced tool occasionally
BI3	I plan to use the ICT advanced tool regularly
Factor 5	**Understanding of Scene Partitioning in ICT advanced tool**
USP1	I found it clear and ease to understand the role of Scene Partitioning in activating the ICT advanced tool
USP2	I found it somewhat clear to understand how Scene Partitioning is able to activate the system
USP3	I could not understand or see how Scene Partitioning is able to activate the system
Factor 6	**Understanding and Expectation of Scene Partitioning and ICT advanced tool in general**
UESP1	Scene Partitioning software tool is a critical factor in the ICT advanced tool for Teaching and Learning process
UESP2	I plan to use Scene Partitioning software tool for Teaching and Learning extensively.
UESP3	I hope to use Scene Partitioning software tool for Teaching and Learning process in the future.

ii. Convergent Validity

In regard to item reliability (IR), composite reliability (CR) and the average variance extracted (AVE) were figured to measure the convergent validity of the questionnaire items (Cunningham, Preacher & Banaji 2001). In order to make sure the item was reliable for a well-defined structure, the factor loading should be 0.5 or > 0.5 of the item reliability of each measure. According to the table 6.9, the entire factor loading was greater than 0.5 that surpasses the standard level. To ensure adequate composite reliability (CR), the CR value of 0.7 or > 0.7 was recommended and the Composite reliability (CR) with results ranging from 0.822 to 0.950 exceeds the critical value of 0.7. The AVE (Average variance extracted) should be a minimum of 0.5 and the results are all above 0.5 ranging from 0.611 to 0.863. To conclude, the overall measurement model revealed appropriate convergent validity as well.

Table 6. 9: Convergent Validity

Convergent Validity				
Items	Constructs	Factor Loading	Composite Reliability	Average Variance Extracted
PU1	Perceived Usefulness (PU)	0.913	0.903	0.758
PU2		0.883		
PU3		0.812		
PEOU1	Perceived Ease of Use (PEoU)	0.752	0.840	0.639
PEOU2		0.724		
PEOU3		0.910		
ATT1	Attitude Toward ICT advance tool Use	0.906	0.886	0.723
ATT2		0.877		
ATT3		0.760		
BI1	Behavioural Intention to Use	0.834	0.843	0.642
BI2		0.728		
BI3		0.837		
USP1	Understanding of Scene Partitioning in ICT advanced tool	0.905	0.950	0.863
USP2		0.892		
USP3		0.987		
UESP1	Understanding and Expectation of Scene Partitioning and ICT advanced tool in general	0.856	0.822	0.611
UESP2		0.848		
UESP3		0.618		

iii. Discriminant validity

A Pearson product-moment correlation coefficient was computed to assess the relationship between the variables; and thus table 6.10 highlights the positive correlation between the variables. There is a positive correlation between The Perceived Usefulness (PU) and Perceived Ease of Use (PEoU) $r = .501$, $n = 220$, $p = < 0.01$. The figure 6.7 represents the linear relationship between the variable.

The Correlation between Perceived Ease of Use (PEoU) and Attitude towards ICT advance tool use shows a positive correlation, $r = .576$, $n = 220$, $p = < 0.01$. The figure 6.8 reflects the linear relationship between the variable.

Figure 6.9 also shows a positive linear relationship between Behaviour intention to use and Understanding of scene partitioning in ICT advanced tool was found, $r = .314$, $n = 220$, $p = < 0.01$.

In the last Figure 6.10 shows a positive Correlation between Behaviour intention to use and Understanding and Expectation of scene partitioning and ICT advanced tool in general. $r = .292$, $n = 220$, $p = < 0.01$

Table 6. 10: Correlations Matrix

Correlations Matrix

	PU1	PU2	PU3	PEOU1	PEOU2	PEOU3	ATT1	ATT2	ATT3	BI1	BI2	BI3	USP1	USP2	USP3	UESP1	UESP2	UESP3
PU1	1																	
PU2	.741**	1																
PU3	.806**	.716**	1															
PEOU1	.501**	.360**	.552**	1														
PEOU2	.251**	.291**	.327**	.543**	1													
PEOU3	.402**	.331**	.466**	.685**	.659**	1												
ATT1	.607**	.505**	.679**	.576**	.391**	.590**	1											
ATT2	.530**	.565**	.537**	.471**	.378**	.505**	.689**	1										
ATT3	.588**	.508**	.669**	.527**	.425**	.622**	.795**	.666**	1									
BI1	.599**	.480**	.540**	.553**	.355**	.463**	.715**	.553**	.611**	1								
BI2	.199**	.197**	.239**	.305**	.232**	.261**	.326**	.294**	.273**	.404**	1							
BI3	.457**	.381**	.440**	.426**	.330**	.493**	.436**	.479**	.477**	.575**	.408**	1						
USP1	.383**	.334**	.331**	.362**	.343**	.422**	.329**	.397**	.353**	.314**	.266**	.323**	1					
USP2	.318**	.260**	.277**	.294**	.157*	.330**	.279**	.297**	.306**	.199**	.270**	.298**	.628**	1				
USP3	.042	.062	.027	.103	.274**	.126	.037	.036	.080	.000	.143*	.032	.203**	.195**	1			
UESP1	.325**	.212**	.202**	.252**	.239**	.349**	.308**	.371**	.284**	.303**	.208**	.325**	.532**	.437**	.177**	1		
UESP2	.345**	.238**	.306**	.296**	.173*	.374**	.291**	.369**	.363**	.271**	.254**	.369**	.500**	.494**	.124	.524**	1	
UESP3	.384**	.339**	.362**	.218**	.136*	.356**	.350**	.457**	.453**	.276**	.205**	.292**	.549**	.527**	.098	.530**	.727**	1

. Correlation is significant at the 0.01 level (2-tailed).

***. Correlation is significant at the 0.05 level (2-tailed).**

❖ The Correlation between PU and PEoU

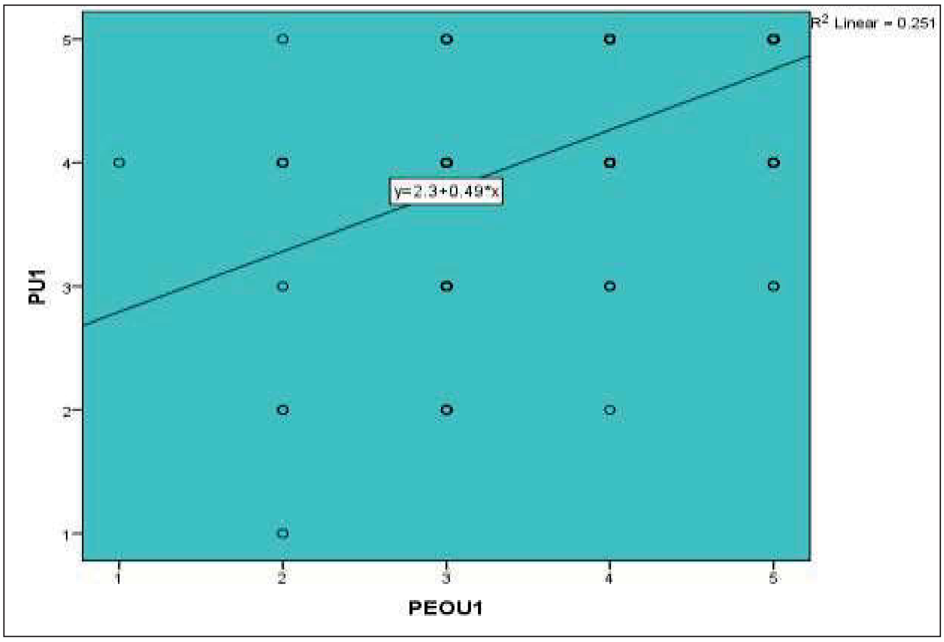

Figure 6. 7: Linear Graph shows Positive Correlation between Perceived Usefulness and Perceived Ease of Use

❖ The Correlation between PEoU and Attitude Toward ICT advance tool Use

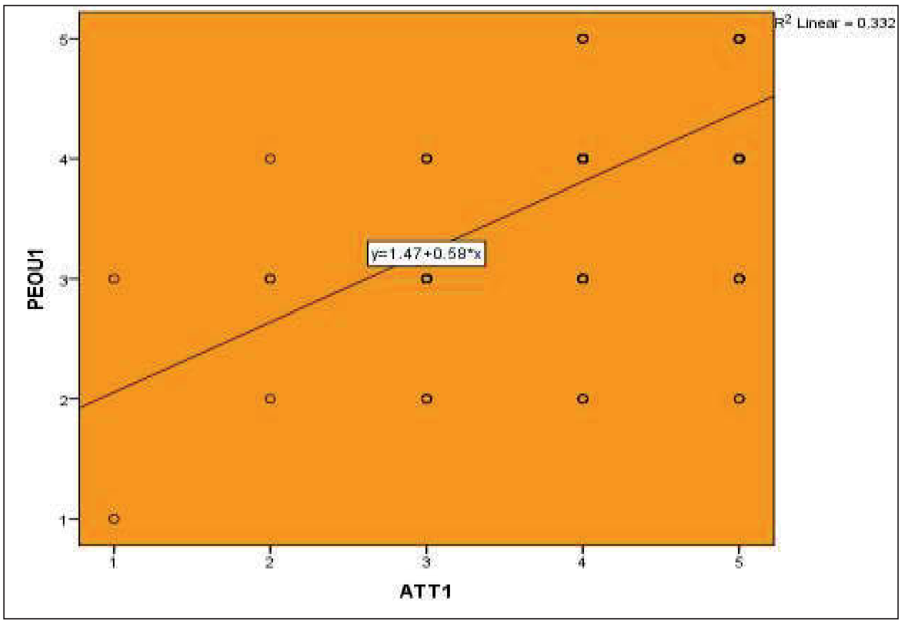

Figure 6. 8: Linear Graph shows Positive Correlation between Perceived Ease of Use and Attitude towards ICT advance tool Use

❖ Correlation between Behaviour intention to use and Understanding of scene partitioning in ICT advanced tool.

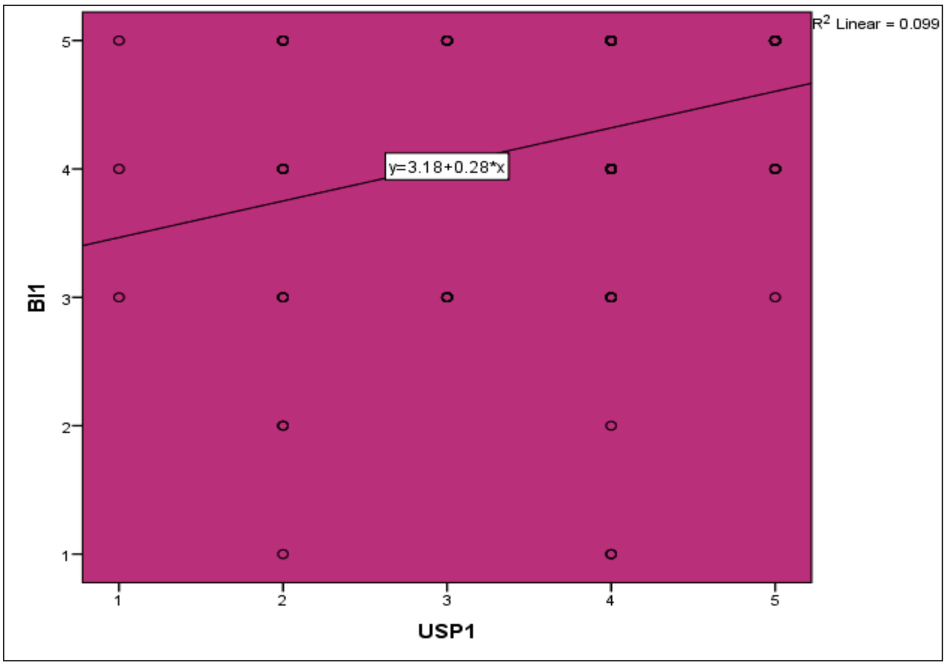

Figure 6. 9: Linear Graph shows Positive Correlation between Behaviour intention to use and Understanding of scene partitioning in ICT advanced tool.

❖ Correlation between Behaviour intention to use and Understanding and Expectation of scene partitioning and ICT advanced tool in general.

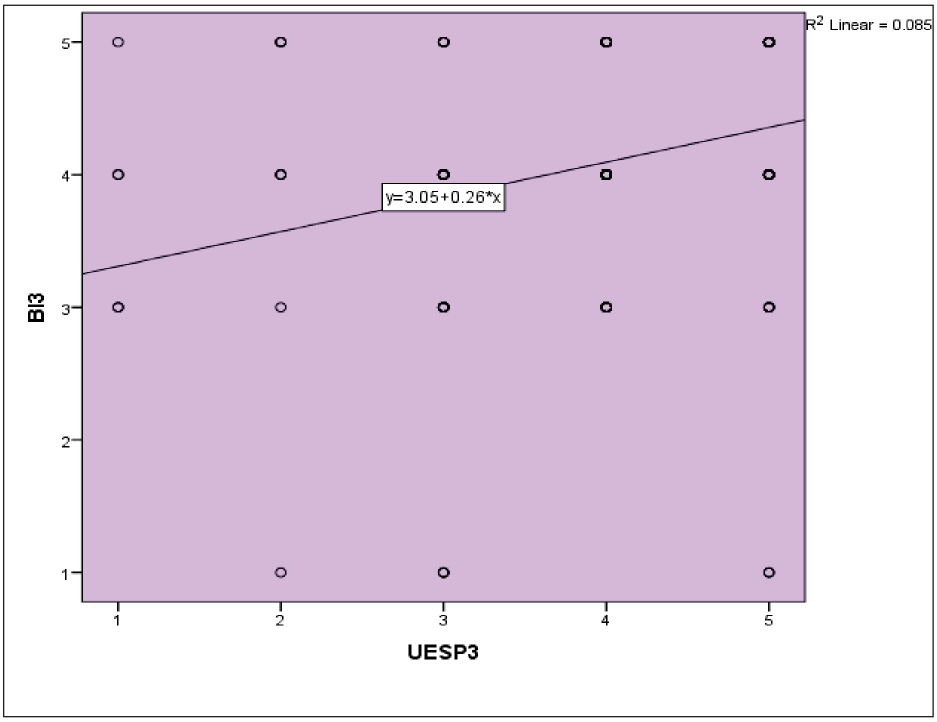

Figure 6. 10: Linear Graph shows Positive Correlation between Behaviour intention to use and Understanding and Expectation of scene partitioning and ICT advanced tool in general.

I. Structural Model

In the data analysis, a confirmatory factor analysis (CFA) using IBM SPSS AMOS 21.0 (Arbuckle 2010) was used to test the general measurement model. The overall model fit was assessed by seven goodness-of-fit indices. The Items of scale (PU, PEoU, ATT, BI) are Adopted from Davies (1989) and Thompson et al. (1991) cited in Compeau & Higgins (1995). The last construct represents the advanced technology that can play a vital role for enhancement. The factor items USP and UESP measure the effectiveness and reliability of the developed application system that implicated into the ETAM Model as an example of the integrated advanced ICT tool into the TAM model towards ETAM effectively. Each of the factors is measured by three items.

Two models were executed and are portrayed in Figures 6.11 and 6.12 respectively. Figure 6.11 brings out the combined model fit of ETAM (Extended technology Acceptance Model) and the Table 6.11 presents the fit indices of the measurement model, all of which met the recommended guidelines and suggested a good model fit. Statisticians have been indicated that the fit indices suggested a good model fit base on these measurement values RMSEA = 0.081, CFI = 0.928, GFI = 0.875 and AGFI = 0.820 (Bagozzi, Yi & Phillips 1991; Hooper, Coughlan & Mullen 2008; Jöreskog & Sörbom 1993). The significance test of individual parameters including standardised path coefficients and *t*-values with its significance are shown in Table 6.12. The coefficients represent the advanced technology which is a core of the study are statistically significant at the $p < .001$ level; and thus indicating good item reliability for the scale used in this study.

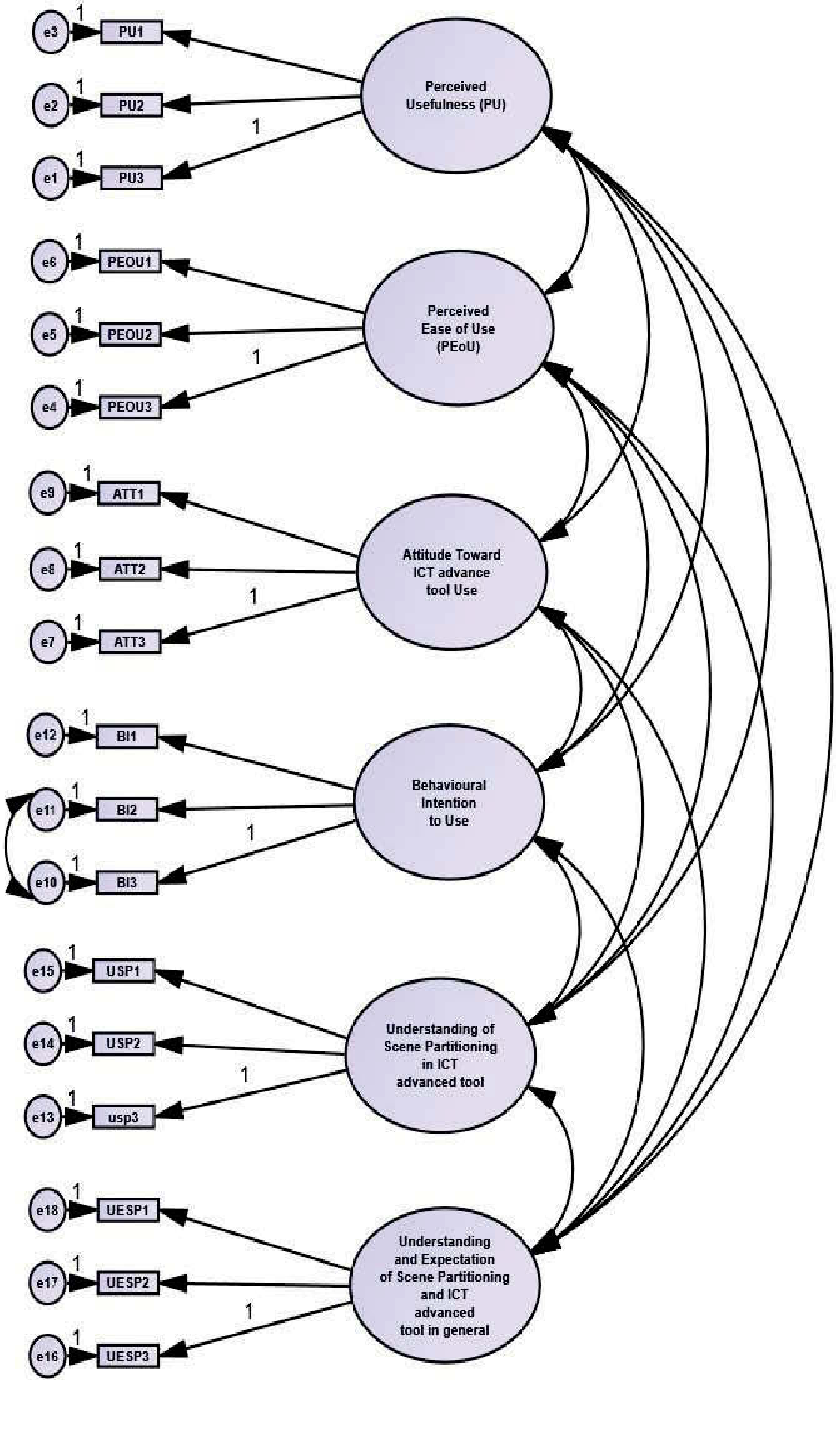

Figure 6. 11: Path Diagram of ETAM Model

Table 6. 11: Model Fit Evaluation (Combined Model)

Model Fit Evaluation(Combined Model)		
Fitness Indices	Recommended Value	Value
$\chi 2$/d.f	≤ 3.00	2.430($\chi 2$=289.18, df=119)
Goodness-of-fit index (GFI)	≥ 0.90	0.875
Adjusted goodness-of-fit index (AGFI)	≥ 0.80	0.820
Tucker Lewis index (TLI)	≥ 0.90	0.907
Comparative fit index (CFI)	≥ 0.90	0.928
Root mean square residual (RMSR)	≤ 0.10	0.036
Root mean square error of approximation (RMSEA)	≤ 0.10	0.081

a) Model Evaluations:

The model which is described in the above sections is well fitted in this case and uses a variety of indices. In the internal consistency table, seven different fit indices have been shown which consists of the comparative fit index, chi-square test, adjusted goodness of fit index, goodness of fit index, root mean square error approximation (RMSEA), standardised root mean square residual (RMSR) and the Tucker-Lewis index (TLI). Values resulted from these indices reflects the good fit on the index. It can be said that the model is a good fit for the data as the values are slightly lower than the recommended value .90.

i. Model chi-square ($\chi 2$)

In order to evaluate the entire model fit and to assess the discrepancy magnitude between fitted matrices and sample, Chi-square value model is used (Hu & Bentler 1999). Chi-squared test model overcomes the problems of irrelevant results at .05 threshold values. However, there are some limitations present in this model also. At the initial stages, severe deviation normality and multivariate normality can be assumed from this model which results in model rejection (McIntosh 2007). As chi-square test follows core statistical model, most of the times it rejects large sample size model after proper specifications (Bentler & Bonett 1980; Jöreskog & Sörbom 1993). On the other hand, when small samples are used, due to the lack of power, this model is unable to differentiate between the poor fitting model and good fitting model (Kenny & McCoach 2003). Researchers have discovered alternative indices models to overcome the limitations of Chi-square model. Wheaton et al's (1977) proposed relative chi-square model ($\chi 2/df$) which helps mitigate sample size impacts. Daire Hooper et.al (2008) opined that as there is no agreement with acceptable ratio statistic recommendations has been set from high 5.0 (Wheaton et al. 1977) to low 2.0 (Tabachnick, Fidell & Osterlind 2001).

ii. Goodness-of-fit statistic (GFI) and the adjusted goodness-of-fit statistic (AGFI)

Joreskog and Sorbom had introduced Goodness of Fit statistic model in the year 1993 as an alternative to the chi-square test to calculate the variance proportions. This variance is needed for estimated population covariance to replicate the observed covariance matrix (Tabachnick, Fidell & Osterlind 2001). The ranges vary from or to with larger sample size (Hooper, Coughlan & Mullen 2008). When there are a comparatively large number of degrees present, this model works as downward bias (Sharma et al. 2005). As the number of parameters are increased, GFI also increases (MacCallum & Hong 1997) and also works as an upward bias when large samples are used (Bollen 1990; Shevlin & Miles 1998). .90 omnibus cut off point has been recommended for this model (Hooper, Coughlan & Mullen 2008).

iii. Tucker-Lewis(TLI) index

This model holds the value equal to or greater than .90 which reflects that this can be fit into the accepted model. Some of the researchers have used cut off .80, as this model runs zero, which is much lower than GFI model. As this model is not related to the sample size, and relatively intensive, it can be used for continuous purposes (Hu & Bentler 1999).

iv. CFI (Comparative fit index)

By considering the sample size, CFI model has been introduced by Bentler 1990 which can perform very well even with smaller sample sizes (Byrne 2013). All the latent variables of this model are uncorrelated and compare the sample matrix with null model (Tabachnick, Fidell & Osterlind 2001). Initially, .90 cut off variance has been set for this model. In order to make sure the acceptance of unspecified model, the value greater than .90 is required (Hu & Bentler 1999). In the recent days, this model is used by almost every small and medium organisation, as this is very popular in the fit index model and does not affect by the sample size (Fan, Thompson & Wang 1999; Hooper, Coughlan & Mullen 2008).

v. Root mean square residual (RMSR)

RMSR helps to find out the square root difference between hypothesised convergence model and sample covariance matrix (Hooper, Coughlan & Mullen 2008). In order to fit this model, values range from 0 to 1. Values less than .05 is recommended for this model (Byrne 2013; Diamantopoulos, Siguaw & Siguaw 2000). However, a value of .08 is also acceptable. From the above model, 036 values are considered as the good fit model (Hu & Bentler 1999).

vi. Root mean square error of approximation (RMSEA)

The effectiveness of the model can be better determined by optimising the parameters for population covariance matrix (Byrne 2013). It is considered as one of the most informative fit index models due to its sensitivity towards the parameters (Diamantopoulos, Siguaw & Siguaw 2000). It is based on parsimony principle to choose less number of parameters. In the last fifteen years, cut-offs been reduced for this model (MacCallum & Hong 1997). From .05 to .10, was considered as the good fit model; however values of above .10 was considered as a poor fit model. After that, the value below .08 has been recommended for this model (MacCallum & Hong 1997).

Table 6. 12: Significance Test of Individual Parameters

Significance Test of Individual Parameters			
Construct Items	Standardized Path Coefficient	Critical Ratio (t-values)	Significance
PU1	0.903	18.972	***
PU2	0.803	15.459	***
PU3	0.899	---	
PEOU1	0.781	13.227	***
PEOU2	0.708	11.622	***
PEOU3	0.896	---	
ATT1	0.901	18.454	***
ATT2	0.769	14.020	***
ATT3	0.877	---	
BI1	0.878	9.769	***
BI2	0.437	6.262	***
BI3	0.661	---	
USP1	0.842	1.031	0.302
USP2	0.747	1.031	0.303
USP3	0.076	---	
UESP1	0.647	10.057	***
UESP2	0.816	13.256	***
UESP3	0.871	---	
*Note : *** P < 0.001*			

b) *Model Evaluation of the Reviewed Advanced ICT tool*

The Figure 6.12 shows the model fit for advanced technology and fit of the model was tested using a variety of indices. The table 6.13 shows seven different fit indices: the chi-square test ($\chi 2$/degree freedom (d.f.)), the comparative fit index (CFI), the goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), the Tucker Lewis index (TLI), the standardized root mean square residual (RMSR), and the root mean square error approximation (RMSEA) respectively. The values reflect a good fit for the above mentioned index.

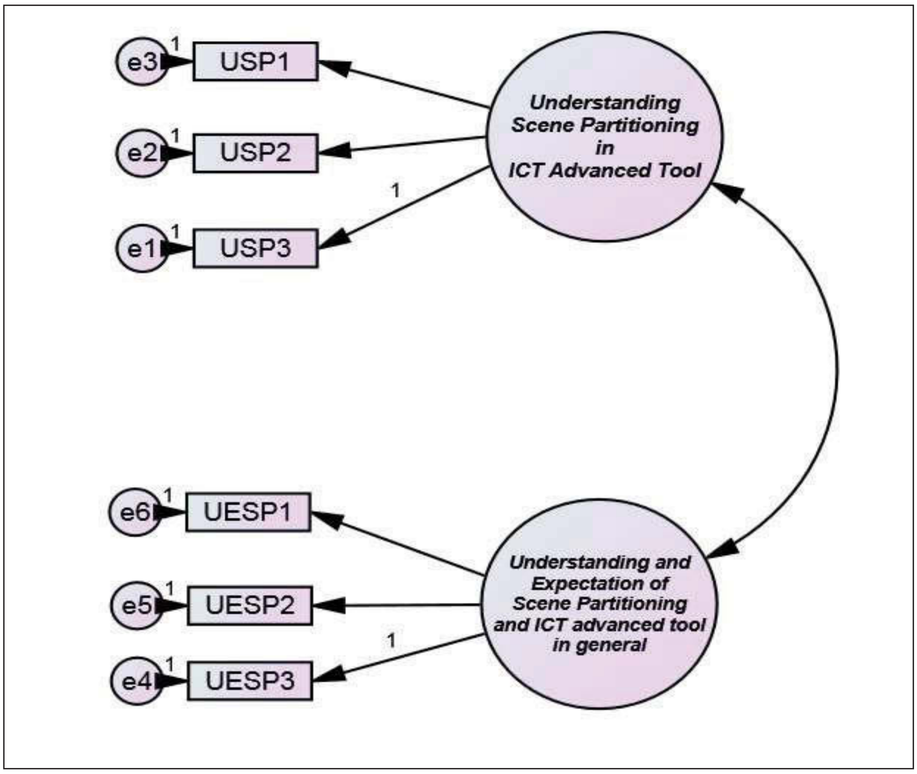

Figure 6. 12: Path Diagram of ETAM Model

Table 6. 13: Model Fit Evaluation(The reviewed advanced ICT tool)

Model Fit Evaluation(Advanced Technology)		
Fitness Indices	Recommended Value	Value
$\chi 2$/d.f	$\leq$ 3.00	2.271($\chi 2$=18.166, d.f=8)
Goodness-of-fit index (GFI)	$\geq$ 0.90	0.972
Adjusted goodness-of-fit index (AGFI)	$\geq$ 0.80	0.927
Tucker Lewis index (TLI)	$\geq$ 0.90	0.960
Comparative fit index (CFI)	$\geq$ 0.90	0.979
Root mean square residual (RMSR)	$\leq$ 0.10	0.027
Root mean square error of approximation (RMSEA)	$\leq$ 0.10	0.076

c) Results: The significant Original contribution

In this particular report, each parameter equally contributed in this particular report, which helps to give appropriate result as per the analysis techniques.

The significance of individual parameters were analysed by conducting path analysis using AMOS 21.0. According to the Table 6.12, it provides the results such as construct items, the standardised path coefficients (β,γ), the critical ratios (*t*-values) as well the *p*-values. Out of the eighteen constructs, ten of the individual constructs were showing the significance value P<0.001 and it is supported for the acceptance of ETAM model. Perceived usefulness had significant positive effect on ICT advanced tool **(ß =0.903, t=18.972, p< 0.001**), (**ß =0.803, t=15.459, p< 0.001**) **supports assertion 1**. Perceived ease of use was found by a significant positive effect on ICT advanced tool (ß=0.781, t=13.227, P<0.001), (ß=0.708, t=11.622, P<0.001) which is also **supports assertion 1**. Attitude toward ICT advanced tool had a significant positive effect (ß=0.901, t=18.454, p<0.001), (ß=0.769, t=14.020, p<0.001). Behaviour intention to use had a significant positive effect on ICT advanced tool (ß=0.878, t=9.769, p<0.001), (ß=0.437, t=6.262, p<0.001), while it had no significant effect on understanding of scene partitioning USP2 and USP3 items (p>0.05) because the questions used for this constructs are negative oriented and the participants are scored low scores which depicts that they understand well the scene partitioning in ICT advanced tool. The last factor represents the advanced technology that can play a vital role for enhancement, the factor items measure the effectiveness and reliability of the developed application system, where it gets the satisfaction among users had a significant positive effect (**ß=0.647, t=10.057, p<0.001**) and (**ß=0.816, t=13.256, p<0.001**) **supports assertion 2**.

6.4.2 Qualitative Analysis

The qualitative analysis technique is very useful to add perceptions of subjective judgement which can then be quantified.

In Table 6.14, the results portray the qualitative analysis of data responses given by the participants. The responses are recorded into 5 point likert scale being "5 = Very positive", "4 = Positive", "3=Without comments", "2= Negative" and "1=Very Negative". Some of the selected comments are taken out and placed in to the positive as well negative responses. The overall response shows that participants had given a positive comment towards the questionnaire items. The figure 6.13 shows the bar chart of the responses being received for each factor items in the questionnaire.

Table 6. 14: Qualitative Analysis

Particulars	N	%	Brief Description of Comments
Perceived Usefulness (PU)			
Positive Comments	74	34	1) Actually, students in present time are pretty much influenced with advanced technology tools in learning process which provide sufficient liberty in learning.
			2) ICT advance tools allows learners and teachers to have a better way of understanding how learning is achieved. Technology is part of our lives hence therefore it should be used with learning and teaching. Advance tools allows learners to engage with the material being taught and hence gain a better insight into what they are learning. As a teachers advance tools can allow me to create a better learning environment and therefore encourage the learners to be more interested.
Negative Comments	7	3	I do not strongly agree that ICT tools influence the teaching strategies. The reason is that according to the connectivism model (By George Simens)- knowledge resides in network entities. Learning may reside in non-human appliances. The capacity to know more is more critical that what is currently known.
Without Comments	139	63	
Perceived Ease of Use (PEoU)			
Positive Comments	48	22	"The ICT advanced tool is pretty straightforward and intuitive in terms of

Particulars	N	%	Brief Description of Comments
			usability provided you can navigate around most commonly used computer software”
Negative Comments	11	5	“It becomes too difficult and complex for the students to use on a daily basis. Different students have different IT levels.”
Without Comments	161	73	
Attitude Toward ICT advance tool Use			
Positive Comments	50	23	1) “It is very useful for students who want to become engineers, doctors or students who want to pursue a career that requires extensive research. The model allows students to conduct their own experiments at home. Important in creating importance and autonomy.”
			2)“They say, "A picture is worth 1,000 words." Using ICT technology in the classroom can generate an infinite number of images, both still and moving, to render in a clearer fashion what I am trying to communicate to my students than my words or white board writings alone.”
Negative Comments	3	1	“I do not strongly agree that ICT tools influence the teaching and learning strategies. The reason is that according to the connectivism model (By George Simens)- knowledge resides in network entities. Learning may reside in non-human appliances. The capacity to know more is more critical that what is currently known.”
Without Comments	167	76	
Behavioural Intention to Use			
Positive Comments	31	14	1)”Integrating the workbook or student book in classes with extra activities using mobile phone apps or smart-board apps.”
			2)”Perhaps linking the ICT to a tablet device will help the teacher to interact with the board without being at the board.”
			3)” i want it to use the latest tech in mathematics department. ICT is very helpful for mathematicians. “
			4)” It's not to use and not to use the tool occasionally, before ICT tools classes taught by our teachers had made attractive by using home-made tools. Now with the advancement in the technology we have to move with it. However if you add face detection or more accurately retina detection tools in order to reduce the time that

Particulars	N	%	Brief Description of Comments
			are taking while taking student attendance etc.. so that we will utilize this time in teaching. "
Behavioural Intention to Use			
Negative Comments	3	1	"the curriculum constraints of the institutions in question may be a hindrance to the regular use of ICT tools"
Without Comments	186	85	
Understanding of Scene Partitioning in ICT advanced tool			
Positive Comments	29	13	1)"Yes, because it activates the attention of the students and helps to keep them engaged."
			2)" Yes, it would be a valuable addition in relation to teaching and learning. In today's society, I believe ICT and Teaching are both synonymous with each other. In some ways ICT complements Teaching, and vice versa. Scene Partitioning is a great example of that, as it revolves around the students learning experience through an interactive method. The push message is also somewhat unique."
			3)" Yes I think it can be useful. But the issue maybe with timing. Do we have enough time to adopt this to an already fully utilized schedule. "
Negative Comments	13	6	"I wasn't sure exactly how it would add value to the teaching and learning process. It may be complicated for some teachers and may disrupt the flow of the lesson"
Without Comments	178	81	
Understanding and Expectation of Scene Partitioning and ICT advanced tool in general			
Positive Comments	26	12	1)" yes, especially if it provides some additional features, such as face recognition or sound detection as well."
			2)" Yes, I do. I can see where Scene Partitioning software can be used to help students who have learning disabilities, such as dysgraphia or dysphasia. I can also see myself using Scene Partitioning to help students who simply had difficulties understanding what I was trying to teach."
Negative Comments	5	2	"For the students in KSA with language barriers.. remote lab wont be good option... teacher needs to be always with the students...but other technologies are good for them."
Without Comments	189	86	

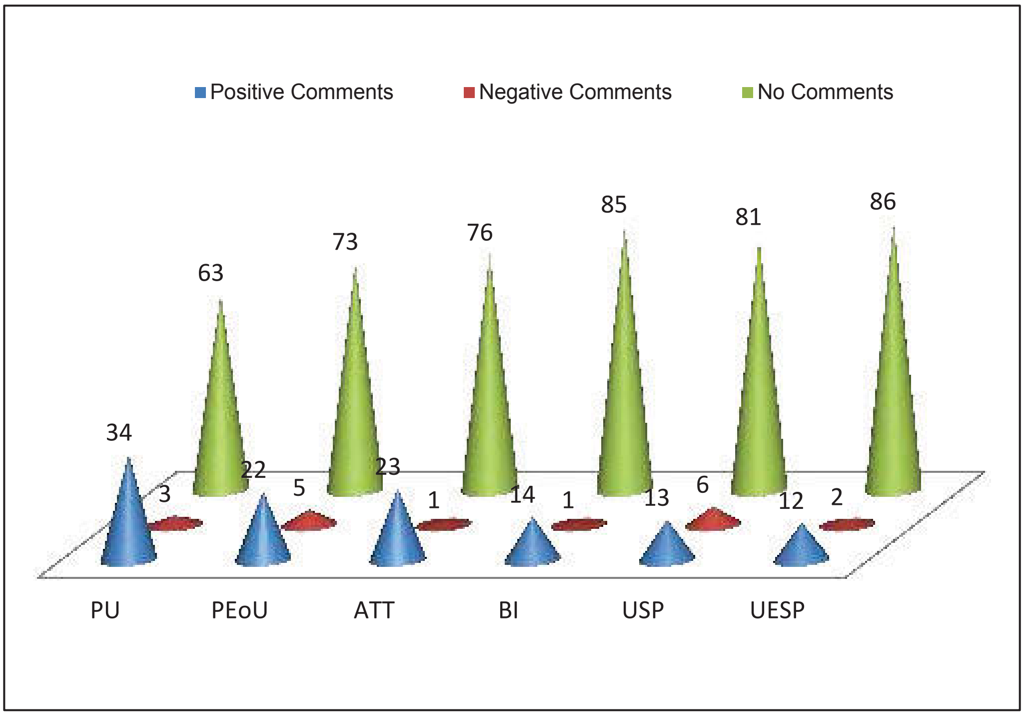

Figure 6. 13: Graph Showing the Qualitative Analysis Report

6.5 Discussion

Findings of this study insight into the acceptance of ETAM (Extended technology acceptance model) by introducing advanced ICT tool among the academic staff at King Saud University in the Preparatory Deanship and also the developed software system application AR – Smart Grid and Haptics. The correlations between the factors are showing a statistically significant positive correlation. The model fit indices of the measurement model met the recommended guidelines and suggested a good model fit. Moreover, the structural equation model results reveal that advanced ICT tool had a significant positive impact on the factors like perceived usefulness, perceived ease of use, attitude toward using ICT advanced tool and behaviour intention to use. Understanding and Expectation of Scene Partitioning and the reviewed ICT tool in general which is the core of the study factor item. It measures the effectiveness and reliability of the developed application system, where it gets the satisfaction among users had a positive effect and its impact among users to experience this sort of advanced tool.

6.6 Conclusion

Information and communication technology (ICT) relates to many fields and adds essential values to these areas. In the last decade, technology has been introduced to the education system as a useful, and motivation tool for practicing educators.

The acceptance of advanced technology should serve to narrow the gap as well as to improve the relationship between the appropriate use of technology and the accompanying advantages. This study specifically highlights the introduction of smart gridding learning monitoring approaches, such as an advanced ICT tool, with the adaptability of the learning process to enhance the concept of the extended model. Some aspects of conducting outcomes used universal values and were very specific; and thus, it may have some local limitations which contain universal observation related to the academic perception.

Chapter Seven

Conclusion

This chapter aims to highlight the key points of the thesis. It summarises the main concepts, contributions, limitations and observations, as well as considering future work.

7.1 Research Contributions

The reason for using technologies in the classroom is to enhance users' attention and activity towards teaching and learning objectives. Current attempts to introduce such advanced technologies into the classes for enhancement reduced the ICT tool value as it worked unconnectedly with peripherals (Huang et al. 2015). As such, the use of technology in the Smart Classroom is often congested and difficult. In this regard, the approach of integrating technologies requires an account of usability with effective technology design (Zualkernan 2012). Therefore, building the valuable advanced Smart Classroom needs to consider the system architecture design for the newly equipped teaching and learning environment.

The key goal of this study was to develop a theoretical model that can guide usability and acceptability for 21st century classroom; ETAM, which is a modification of TAM, acts as a reference guide for developing system architecture in conjunction with the particular selected advanced ICT tools. The developed model works to propose possible solutions to the problem in two main ways; firstly to develop a system architecture design; secondly to select innovative tools that are ideally adaptable to the software architecture. In Chapter 4, the system architecture was effectively designed by considering the selected developed experiments (later shown in Chapter 5) reflecting the reliability, versatility and feasibility of the entire system. Moreover key features such as controller, database and middleware (Lee, Park & Cha 2013) in conjunction with the layered architecture of educational technology (Bouslama & Kalota 2013) were integrated into the design.

To prove the hypothesis, two tools were used to validate the referenced system architecture which include Augmented Reality and Haptics; these were used to focus on specific tasks enabling users and the system architecture design of Smart Classroom. To measure the effectiveness of the approach, a survey was conducted involving a total of 220 academic participants. Based on ETAM elements, the survey was conducted to evaluate behaviour, behavioural intentions and attitudes to predict technology acceptance at a significant level. The survey results showed an acceptance of innovative ICT tools (see Chapter 6). Results also showed acceptance for the proposed software system applications of Haptics and AR Smart Grid. The correlations between these factors showed a positive correlation.

The model fit indices of the measurement model suggested a good model fit. Furthermore, the results of structural equation model demonstrate that innovative ICT tool had a significant positive impact on factors such as attitude, perceived usefulness and perceived ease of use, utilisation of innovative ICT tool, and intention to use. Moreover, understanding and expectation of scene partitioning and the reviewed ICT tool measured the reliability and effectiveness of the developed application system. Satisfaction among users was positive to experience the advanced tool.

In summary, the result reflected a positive impact of the new Smart Classroom system design among stakeholders. The experiments of the system architecture in conjunction with AR and Haptics delivered perceived improvement in Smart Classroom performance. From this we can conclude that the developed system architecture was an important factor in Smart Classroom design. Similarly, the reports on AR and Haptics use were mostly positive with interest shown by the participants. A key factor is the participants' positive attitude towards the acceptance of the new Smart Classroom design that introduced advanced tools, such as AR and Haptics, with the level of interaction offered by these tools. Consequently, *the attributes of the new Smart Classroom system architecture enhancement include: acceptability; usability; interactivity; and scene perception. This offers support for multi-mode and ad hoc teaching and learning approaches*.

As it comes to issues related to linking the components of hypothesis with sections of report, the following actions were executed:

- Best practices were defined and applied for modelling and designing by using modelling and designing tools addressed in Chapter 4.
- Experimentation tasks were designed, executed and validated using a testbed of the reference system. The testbed allowed to evaluate the performance and versatility as described addressed in Chapter 5.
- A survey was conducted to validate the system acceptance and usability qualities. Abroad spectrum of academics and ICT practitioners were involved in the investigation and final survey as indicated in Chapter 6.

7.2 Discussion

Considering the fact that ICT technologies are developing at such as a tremendous pace, it is possible to create a vision of the Smart Classroom base on the availability of very advanced technologies and tools. These technologies and tools evolve continuously exploiting many aspects and types of users' perception and interaction. The main purpose of this work is to provide a vision for a flexible architecture and reusable frameworks for the development of the Smart Classroom.

The architectural flexibility attribute is a design driver that projects the solutions of Smart Classroom needs to accommodate ever developing new technologies. Also, it is vital to sense needs attitude education practitioners what like to see or expect from ICT solutions. In that sense, it is essential that we are able to assess the real value of technology in the teaching and learning process. The influencing factors for the development of new model of system architecture needs to be highlighted. The focus of this work is not to just explore a particular technology, but also to investigate how the technology can be fitted into the educational goals of the Smart Classroom (as shown in Chapter 4).

The study indicates that the developed work has been accepted by the practitioners for an effective teaching and learning process. In this work, it has been defined and developed a new concept of the interactive oriented system architecture that involves an introduction of smart middleware and scene perception components (Alenazy, Chaczko & Tran 2015; Wael Alenazy, Zenon Chaczko & Chan 2016). The main contribution is to provide a new model for the system architecture of the 21st century classrooms. The perspective of the work is that there was never a participated focus on technology alone, but rather to show how the new technologies can be incorporated into user behaviour. This approach leads to the definition of a new extended model (ETAM) that is capable of supporting the design of the new system architecture for the Smart Classroom.

The developed system architecture is focused on two important nodes: visualisation; and haptic. First of all, the visualisation node is entirely based up on the augmented reality (AR) along with the introduction of Smart Grid technique for controlling and monitoring different objects. The developed system utilises video stream and web based cloud integration to perform its functionality. Augmented Reality (AR) allows the establishment of collaborative environments through teacher's and students' interaction within virtual objects leading to the creation of various interactive scenarios in the classroom environment as a substitute for the traditional classroom environment where static devices dominate (Alenazy, Chaczko & Tran 2015; Zarraonandia et al. 2013).

The association of virtual information with objects or events in the real world provides three key novel aspects: new ways of perceiving and interacting with the environment; it enables a better understanding of reality; and offers the possibility of experiences with great educational potential. The three aspects transform a classroom using augmented reality. It is a technology that allows the integration of the real world with virtual elements and content by creating a mixed environment for viewing with real time interaction. Specifically, these include a physical location, virtual content (image, video, text, etc.) and the technology that makes it possible to view and interact with content. The AR Smart Grid implementation is beneficial in that it monitors captured scenes for studying purposes i.e. scene perception, such as a video streaming. In addition, the significant objective was to investigate the AR framework capabilities and Software Development Kits (SDK) for selection and determination of particular cell(s). Therefore, the proposed program was implemented by utilising augmented reality (AR) smart grid elements in context of the smart learning environment known as UTS Remote-Lab.

AR gives learners a taste of both worlds i.e. real world and virtual reality. It mixes real world experience with virtual reality with the latter enhancing the former. However, there are also some challenges associated with use of AR that should be properly considered. These challenges include the various learning needs, personalities of the users and Smart Classroom setting (Van Krevelen & Poelman 2010). Generally, AR plays a key role in raising motivation levels by presenting students with a more interactive, exciting and familiar environment for learning. It elevates learning to a higher level and enables customised learning.

The approaches of haptic nodes were also incorporated which introduced innovative haptic ICT tools. The haptic nodes are used due to the current system scope in the Smart Classroom. The Smart Classroom s traditional learning and teaching interaction tools such as mouse and keyboard in order to interact. Thus, such types of interactions restrict the users' mobility across different points inside the Smart Classroom. As such, the research proposed the idea of integrating new peripherals into the Smart Classroom system with assistance of different haptic gesture devices as an extension to control these peripherals in the Smart Classroom. Thus, Haptics Middleware is developed to support interactions in the smart learning environment. The middleware defines a common gesture framework that led to multiple haptic and gesture peripherals to interact with the entire system consistently. The implementation and design of integrating haptic technologies in smart learning environment is done by utilising components of recognition algorithms, multi-sensors haptic devices and middleware system (Wael Alenazy, Zenon Chaczko & Chan 2016).

Such approaches maximise the interactivity as it replaces the traditional inputs on the system in order to simplify teaching and learning context. Moreover, to improve usability, different haptic sensors were cross implemented and connected through a central middleware framework by adopting the 'Internet of Things (IoT)' approach (Bouslama & Kalota 2013). Therefore, the effectiveness of AR and haptics used ensured a high level interactivity for Smart Classroom: the level of interaction is maximised by haptic nodes and augmented learning. The combination of system architecture that incorporates multiple nodes, such as visualisation and haptics is effective because the system architecture design provides an efficient platform for an active and dynamic Smart Classroom environment. In addition, they are implemented by using different platforms in order to maximise versatility and flexibility of proposed system architecture for Smart Classroom.

As stated in the hypothesis, the research results confirmed that the attitude of the user, particularly regarding acceptability, usability and interactivity, were in fact closely related to the system architecture. Moreover, the relationship between attitudes of interactive development system architecture's users was shown to be of positive and significant value to users of Smart Classroom technology. The statistical analysis shows a positive correlation supporting the proposed hypothesis. The proposed system architecture supports acceptability, usability and interactivity. Thus, the aim and objectives are successfully accomplished as the research proposes the model that is interactive and designed in conjunction with software in promotes improved learning. The proposed system architecture is suitable for the future generation of Smart Classrooms as it supports interactive configurations which then would lead to a dynamic teaching and learning environment. However, there is still area for future improvement in terms of the computational performance of selected software components as indicated in the limitations and future work section.

Finally, the future application of the research findings has been encapsulated in the ETAM model. The ETAM model is an extension of TAM as it indicates the importance of including system architecture and up to date user devices for technology acceptance in pedagogical practice. ETAM reinforces that teacher training should occur in the use of latest technology. Such training is a critical factor owing to the rapid evolution of new technologies emerging from the commercial market (Alenazy & Chaczko 2014). The major objective of implementing ETAM was to highlight the need for technology acceptance among educators and students alike. ETAM basically acts as a guide to use the ICT tools in the new Smart Classroom. The ETAM model seeks to increase the ability of individuals to operate efficiently in any current or future Smart Classroom, thus improving the users' acceptance of advanced ICT tools in teaching and learning process (Alenazy & Chaczko 2014). The use of these technologies can inform innovative pedagogy.

Some ICT technologies are exceptional; they assist in both teaching and learning process and yet the acceptance level of these tools among teachers is usually low because many users may perceive technology as an obstruction and interfere with cognitive aspects. Thus, technology will have greater effect if high acceptance levels are achieved. Usefulness and acceptance are clearly connected; therefore, in this research, a developed model considered these aspects, an essential difference from other previous approaches that impose technologies into the educational environment.

7.3 Challenges, Limitations and Further work

The research achievements represent the essential system design architecture platform for the new Smart Classroom in conjunction with the ETAM model. However, as it is a dynamic work that support multimodal interactions in the Smart Classroom.

There are some limitations in the AR smart grid testbed that need to be overcome. These are summarised as follows:

- the partitioning of dynamic immersive scenes especially 3D objects in real time. The problem would be solved through smart gridding partitioning by applying sort of division algorithm. The algorithm should produce quick and real time response.
- In dynamic scenes, frequent obstructions of the occlusions could occur because of people moving or hiding part of the picture that leads to missing part. The solution is to implement AR to complete the actual hidden scene / the missing part.

The working prototype of middleware was developed in order to demonstrate the fact that there is not any middleware associated with promoting learning by managing gesture interfaces along with smart switching among different devices on the basis of distance (Wael Alenazy, Zenon Chaczko & Chan 2016). Thus, the fundamentals of Haptics provide a framework for middleware. Below are some key challenges that need to be addressed and future research should be focused on the following:

- Improvement of usability, scalability and performance of middleware framework for Smart Classroom application
- Implementation of additional devices to improve compatibility of middleware with a variety of devices including sensors, actuators and controllers
- Addition of a wider range of gestures to the existing library
- Improvement in algorithms in order to improve the process of device switching
- Integration of network capabilities into cloud that would lead to establish connections with IoT peripherals

A significant challenge represents the problem how the Smart Classroom ICT tools can assist in assessment of teaching and learning activities. Moreover, it has been considered that the future work will also involve industrial solutions of Smart Classrooms infrastructure. It is assumed that the Smart Classroom will be widely used according to advanced educational models, trends, standards and practices. Also, there is a need to develop further ICT solutions that support Smart Classroom infrastructure using IoT technology.

7.4 Conclusion

The approaches of Information and Communication Technology (ICT) are applicable to different fields and complement a variety of essential values. In the last decade, technology has been incorporated into educational institutions with the aim of maximising student learning. Such innovative tools motivate educators. The acceptance of advanced technologies should serve to improve the relationship between the appropriate use of technology and anticipated advantages.

The research specifically highlights a particular smart learning approach using the concept of the extended model (ETAM). Traditional design practices of learning environments have been evolved to fulfil the requirements of students and to support several important pedagogical goals. The research has proposed a system that is concerned with incorporating innovative technologies in education. The major focus of such systems is based on interactive learning methodologies. The new approach showed the way AR and haptic nodes could be integrated into the architecture of the smart learning environment by designing components of service oriented software middleware. It can be achieved through proper architectural development and design (Wael Alenazy, Zenon Chaczko & Chan 2016). The research proposed the model by using two important nodes visualisation and haptic tools in order to improve learning.

The research also adopted qualitative and quantitative approaches to validate the hypothesis that the proposed system architecture would ensure acceptability, usability, interactivity and observability. Statistical analysis was performed in order to analyse the results of survey. The survey results presents acceptance for the model as it demonstrate a positive correlation for the selected parameters. The work highlights the need of usefulness of technology, yet it has to be recognised that there are some significant limitations. Although, the research fills one gap – that of adopted modelling for effective teaching and learning environment - the project is still deficient and required to be done by considering the aspects of occlusion, dynamic, changing scenes and arranging objects detection.

AR and haptics may offer versatility that enables students to learn a wide range of topics and subjects without necessarily moving from one class or geographical location to another (Alenazy, Chaczko & Tran 2015). In addition, the survey results also demonstrate the fact that proposed system architecture also support dynamic modes of interactivity and visualisation. IoT and Cloud computing played a significant role in terms of improving connectivity and interactivity of the proposed system. In addition, the integration of haptics and AR based applications also possess dramatic impact in terms of maximising interactions. Therefore, proposed model is an effective tool to improve learning of students.

PART 3:

Bibliography and Appendix

8. Bibliography

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9. Appendix

In the section, three appendixes show in details further information

Appendix – Supplementary List of Figures

Appendix – Supplementary List of Tables

Appendix A: AR Smart Grid

9.A.1 Functional and Non-Functional Requirements

Table 9.A. 1: Functional Requirements

Requirement ID	Description
1	The app shall provide a “Smart Grid” overlay for segmenting and mapping of Augmented Reality components.
2	The default input feed shall be the device’s camera video stream.
3	The cells of the Smart Grid shall be customisable with different shapes.
4	The cells of the Smart Grid shall be customisable with different colours.
5	The cells of the Smart Grid shall be customisable with different dimensions.
6	The app shall be able to monitor movement within each cell.
7	The app shall be able to monitor light within each cell.
8	Each cell shall display the monitored data for itself within its borders.
9	The app shall have the ability to zoom in and out of the Smart Grid.
10	Each cell shall be selectable, which shall be represented by an outline.
11	The app shall have a menu, where settings and other app information will be centralised.
12	Monitoring events shall trigger alerts, which shall be represented by the alerting cell flashing.
13	The cell flashing colour shall be customisable.

Requirement ID	Description
14	A Pebble Smart Watch shall be able to traverse the cells of the Smart Grid.
15	The Pebble Smart Watch shall be able to select a cell.
16	The Pebble Smart Watch shall display appropriate information on the screen while traversing and selecting a cell.
17	The app shall be able to push notifications to the Pebble Smart Watch.
18	The Pebble Smart Watch shall be able to receive notifications and alerts, then displaying them on the watch screen.
19	The Smart Grid shall be able to be fixed to the screen or AR scene.
20	The app shall allow the AR scene input to be changed to a Web View.
21	The app shall allow the alerts to be reviewed and cleared.
22	The app should be able to monitor graph data, such as maximum and minimum points.
23	The app should be able to monitor movement within a 3D cell.
24	The display location of the data in each cell should be customisable.
25	The events shall be recorded with screenshots.
26	The events should be able to be accessed and viewed anytime.
27	The sensitivity of the monitoring types should be customisable.
28	The application should continue to monitor the scene in the background when minimised.

Table 9.A. 2: Non-functional Requirements

Requirement ID	Description
1	The application’s state shall be persisted.
2	The monitored information shall be real-time data.
3	The feed shall exhibit no visible lag when data is updated.
4	The user experience should be intuitive.
5	The user interface should be aesthetically pleasing.
6	The application should not crash while the user is operating it.

9.A.2 Swimlane Diagrams

The following use cases have been selected to be further analysed with Swimlane diagrams. Swimlane diagrams provide an overview of component responsibility of activities. The following figure is the Unified Modelling Language (UML) diagram notations relevant to the Swimlane diagrams that follow.

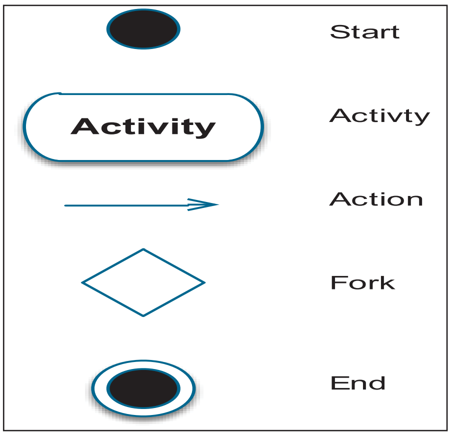


Figure 9.A. 1: Swimlane Notations

9.A.3 Execution Diagram

This section details the execution architecture view of the system. Figure 10.A.1 can be referred to for the UML diagram notations relevant to the conceptual architecture diagram that follows.

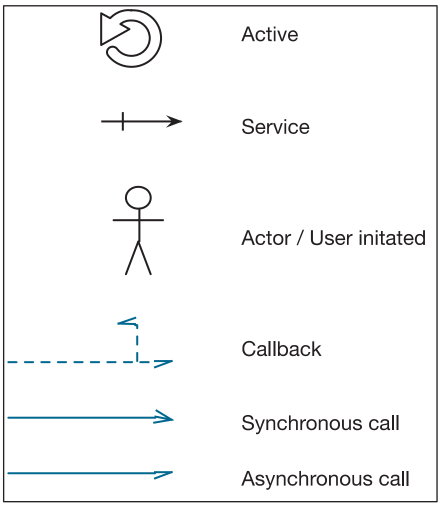


Figure 9.A. 2: Execution Architecture Notations

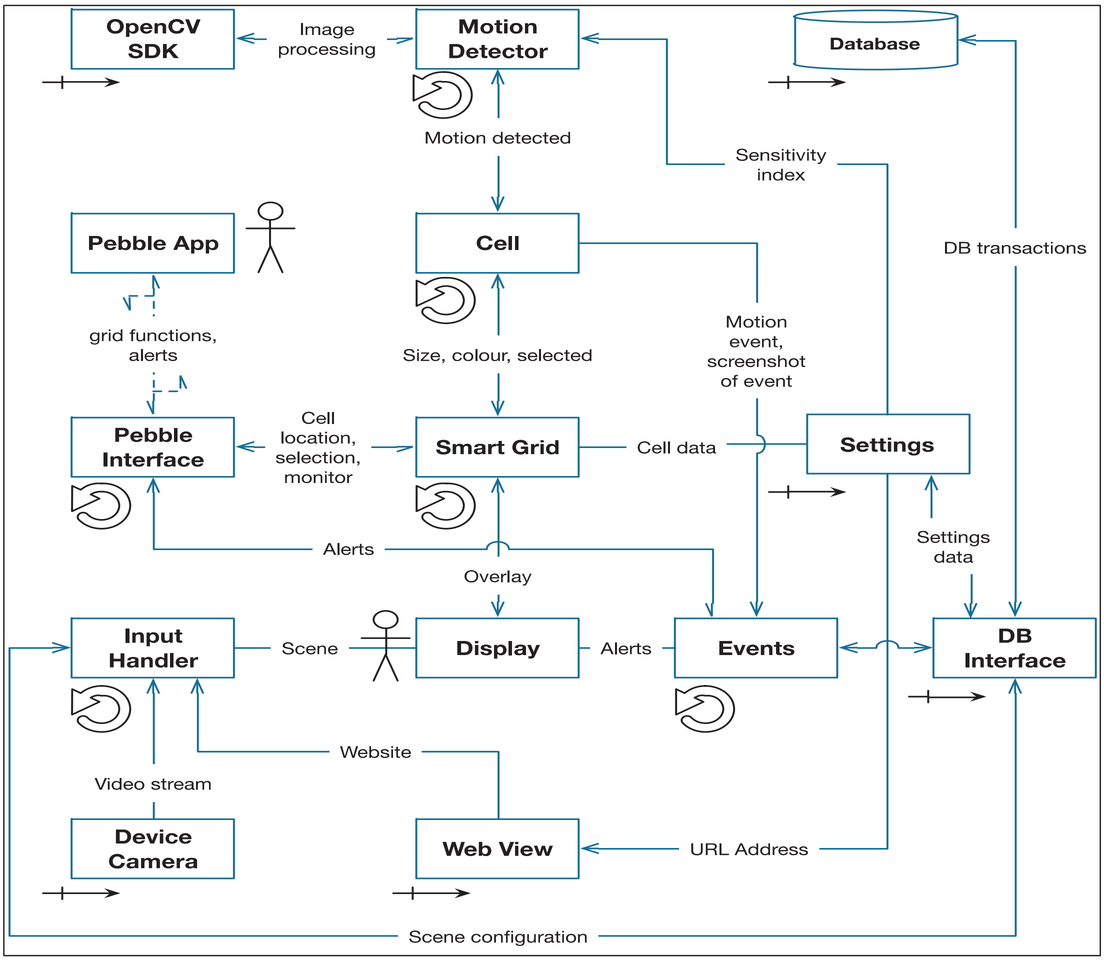


Figure 9.A. 3: Execution Architecture Diagram

9.A.4 Use Case Maps

The following use cases have been selected to be mapped against the execution view in order to validate the architecture.

a. Customising Settings

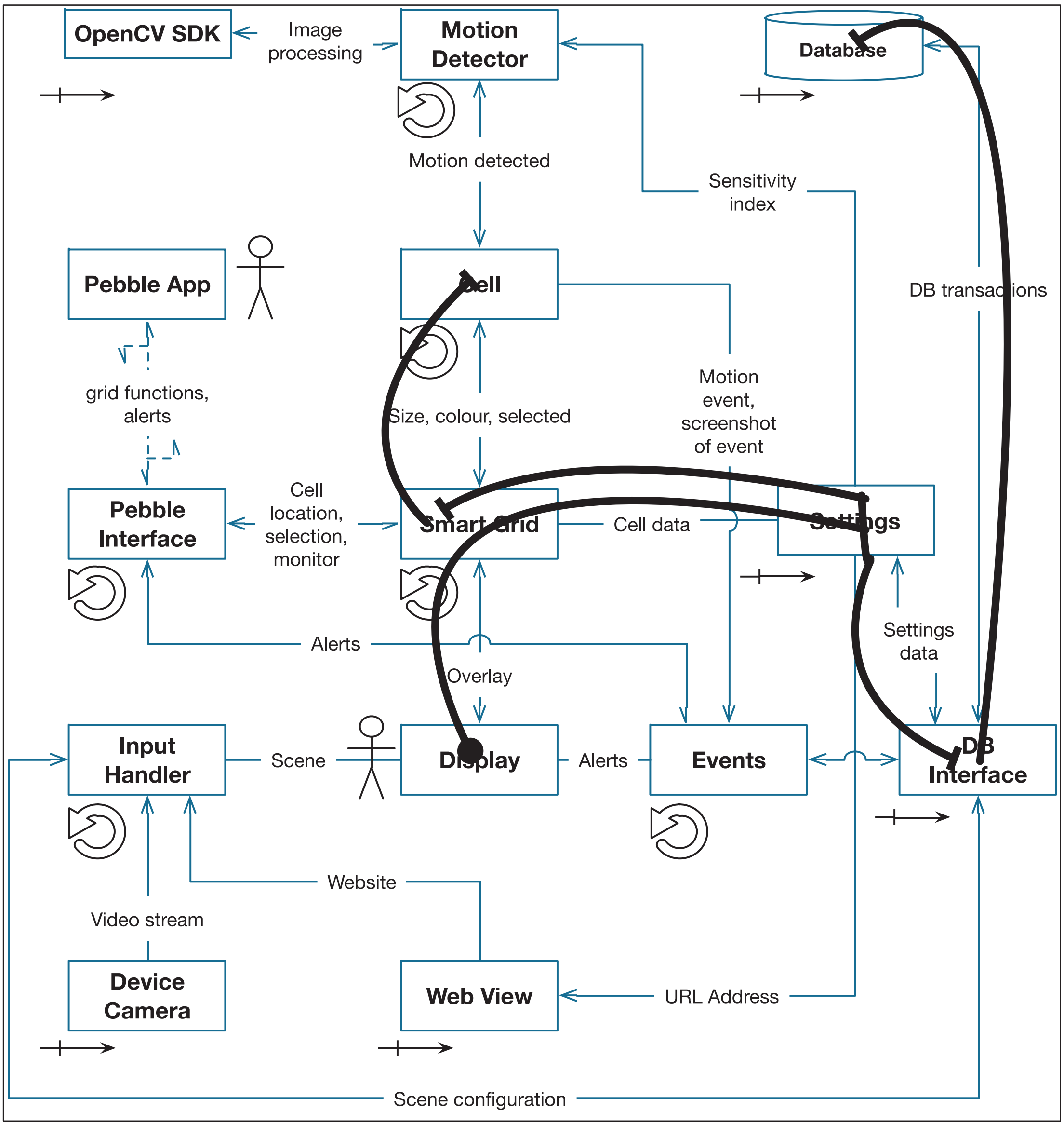


Figure 9.A. 4: Use Case Map: Customising Settings

b. Movement Monitoring

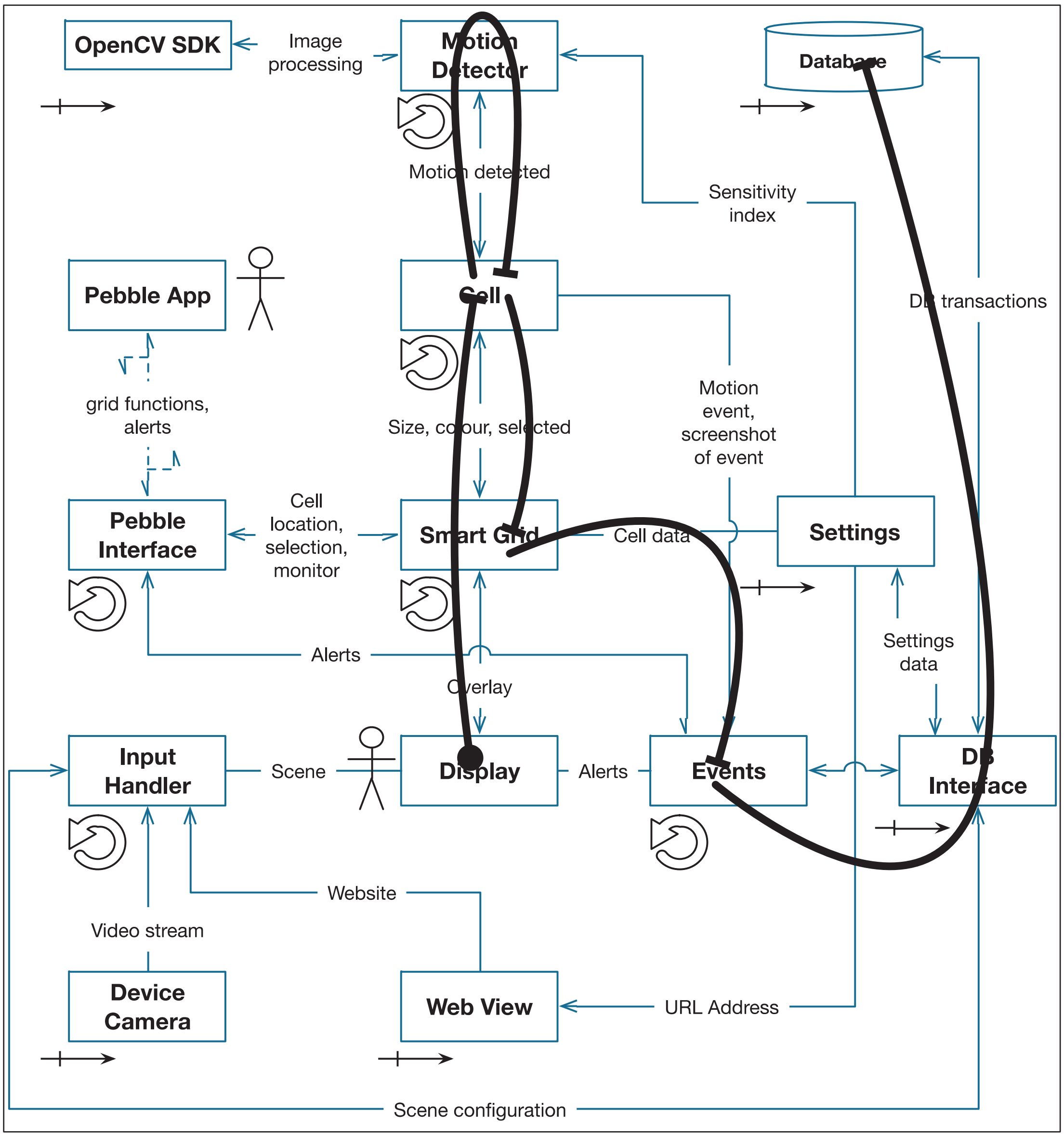


Figure 9.A. 5: Use Case Map - Movement Monitoring

c. Pebble Smart Watch Integration

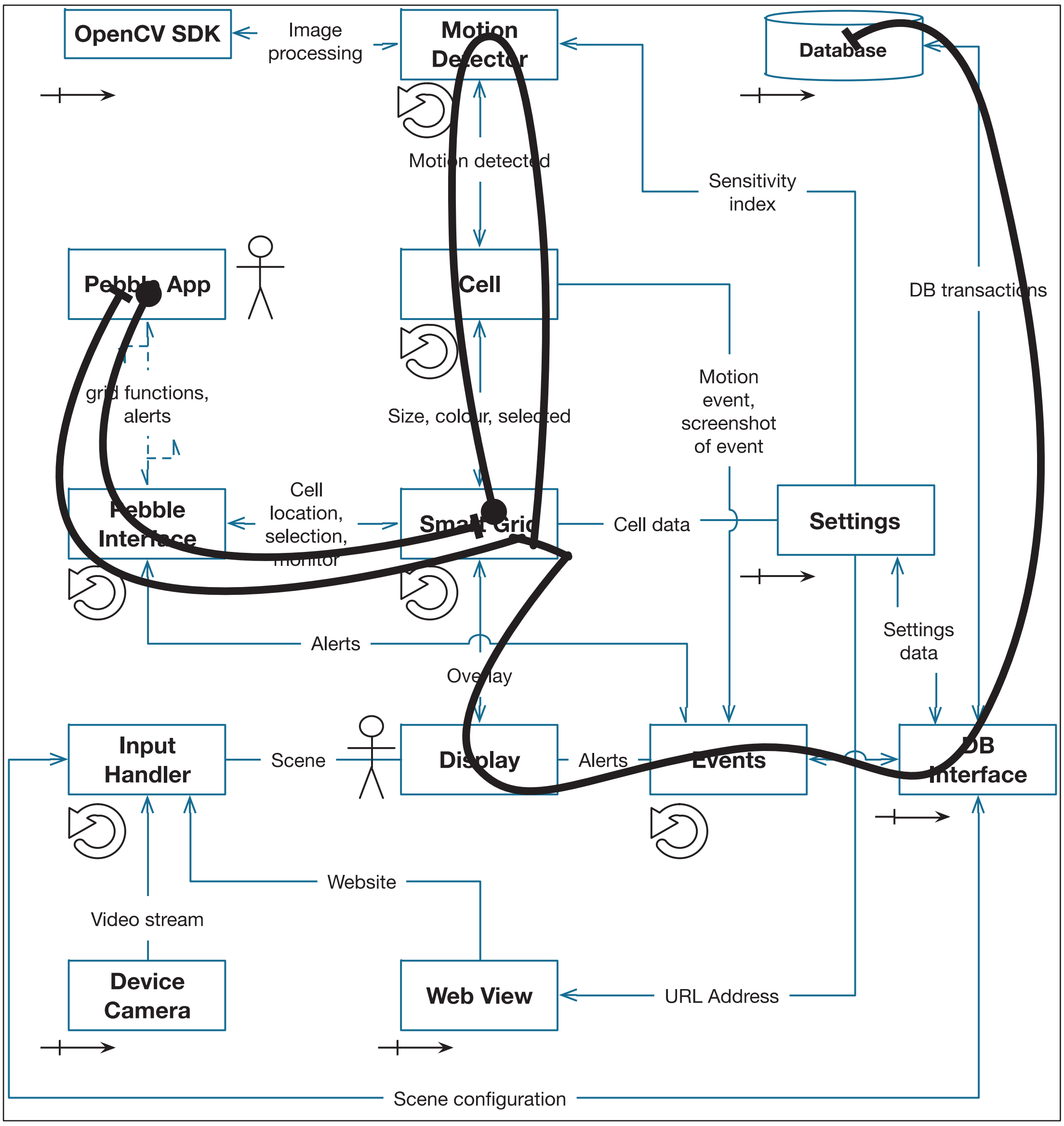


Figure 9.A. 6: Use Case Map - Pebble Smart Watch Integration

9.A.5 Class Diagram

The following diagram is the low-level class diagram of the AR Smart Grid application. Figure 10.A.5 can be referred to the UML diagram notations relevant to the class diagram that follows.

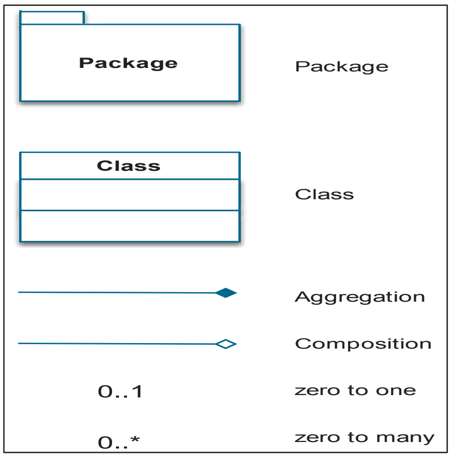


Figure 9.A. 7: Class Diagram Notations

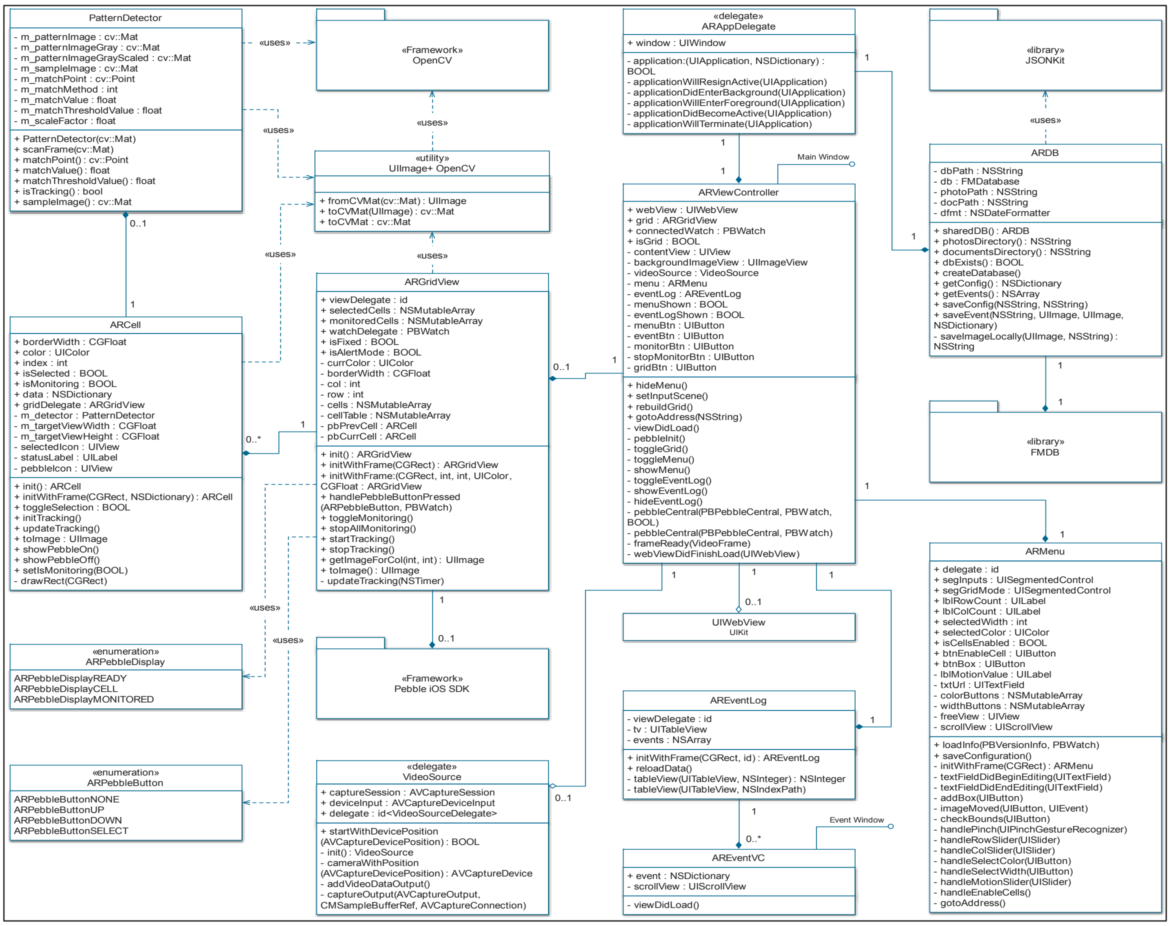


Figure 9.A. 8: Class Diagram

9.A.6 AR Smart Grid Application - Landing Screen

Figure 9.A. 9: Landing Screen

This is the default screen to load after the app is opened from the device home screen. The default scene input is Website and the default URL address is https://remotelabs.eng.uts.edu.au.

9.A.7 Configuration Menu of the AR Smart Grid

In figure 26, the AR Smart Grid menu is open. This is where the scene input can be changed from camera to a website and vice versa. Selecting the type of grid mode, either fixed or free. For fixed grid mode only, the sliders to adjust the number of rows and columns. Both rows and columns have a range from 1 to 10. Next is the colour palette to choose the colour of the grid, and then there is the width palette to choose the width of the cell borders. Note that the last colour of the palette is transparent mode. The Motion Detector Threshold slider controls the sensitivity of the motion detector. This ranges from 1 to 99, where 1 is the least sensitive and 99 is the most sensitive. The URL address bar is shown conditionally based on whether the input is set to Website.

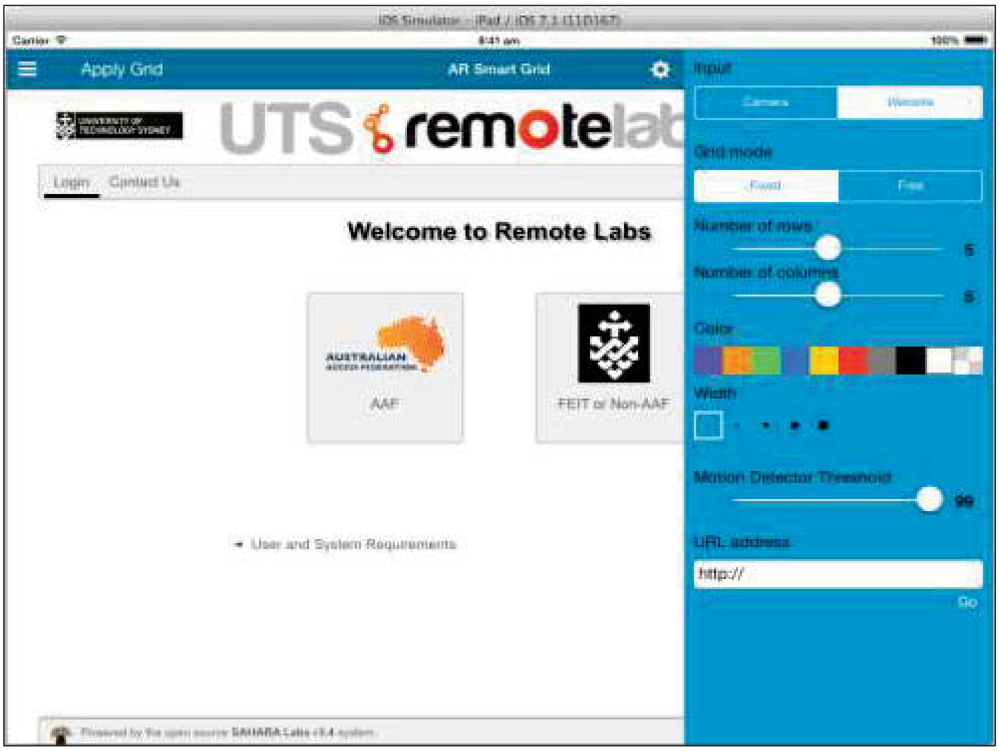


Figure 9.A. 10: AR Smart Grid Configuration Menu

a. Toolbar buttons

- **Event Log** – Shows and hides the event log table.
- **Apply Grid** – Apply/Remove the grid overlay.
- **Hide** – Hide/Show the working grid to allow manipulation of the scene, specifically a website, without loosing changes to the existing grid.
- **Stop All** – Stops all monitoring activities.
- **Monitor** – Starts monitoring of the selected cells, if no cells are selected, then the entire grid is monitored.
- **Menu** – Shows and hides the menu screen.

b. Menu

To access the menu, tap the menu button in the top right hand corner. The menu layout is detailed below.

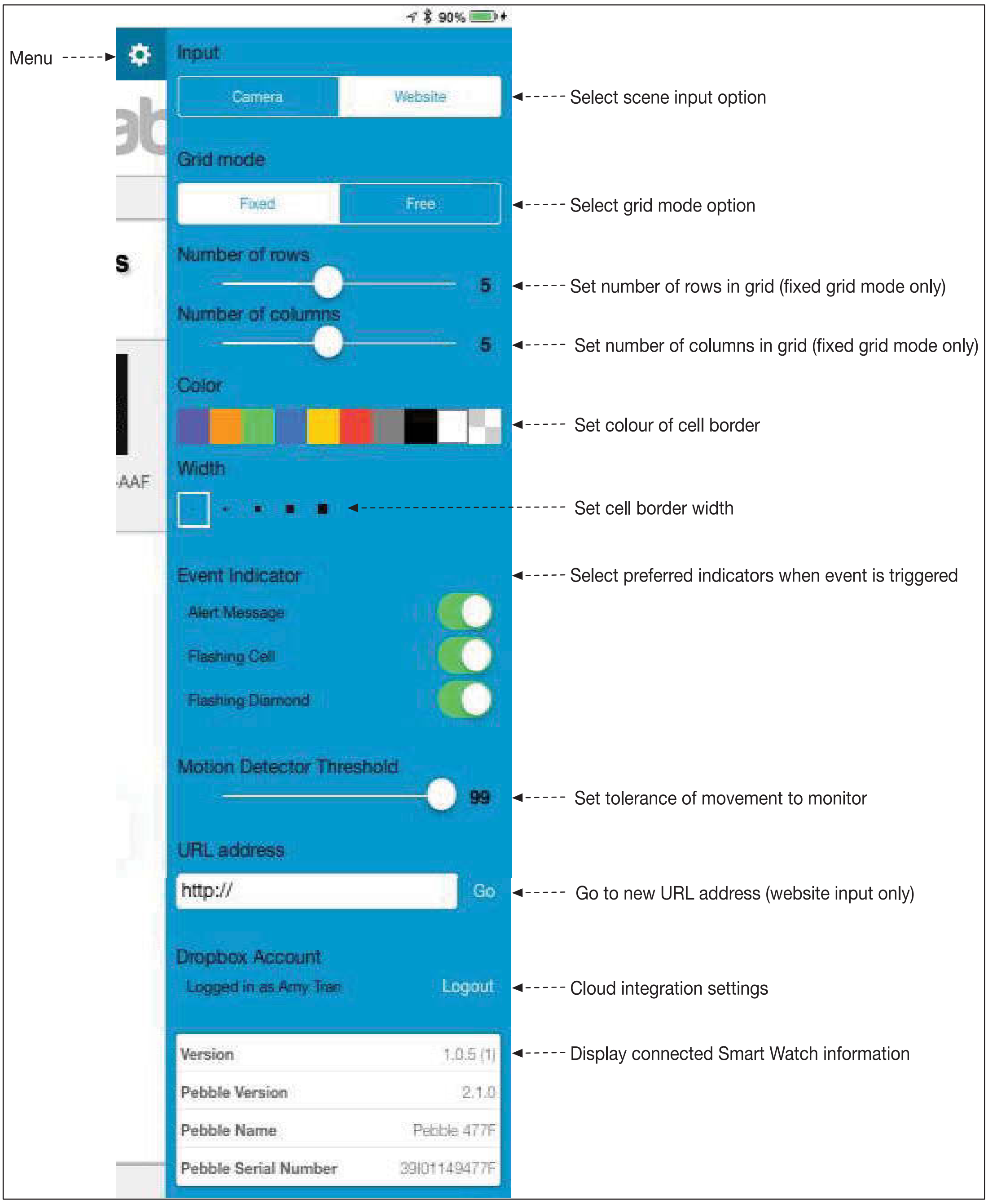


Figure 9.A. 11: Configuration Menu of AR Smart Grid Application

Selecting the Free grid mode will show the drag and drop cell instead.

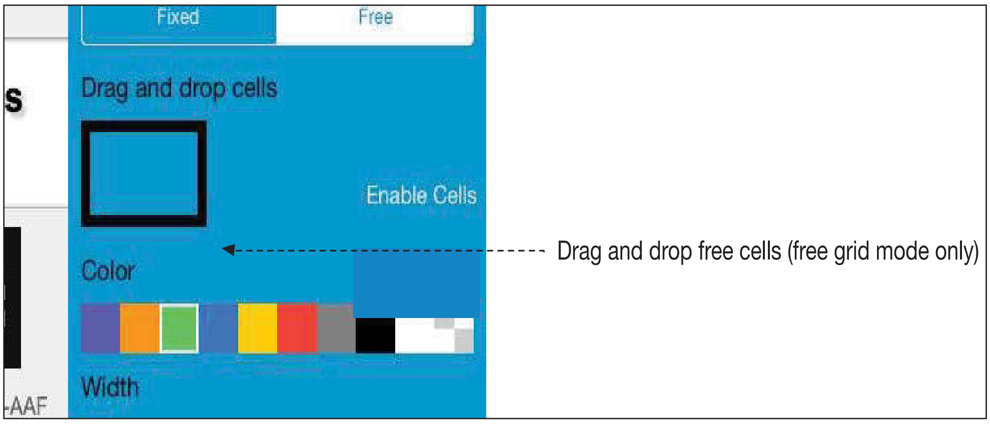


Figure 9.A. 12: Menu – The Free Mode Cell Configuration

9.A.8 Monitoring Services

In regard to the monitor service that represents the core of the system development, the following points show farther details of the system functionality include:

1. After configuring the grid as desired, apply the grid if not already applied.
2. Select the cells to be monitored, or leave all unselected to monitor the entire gird.
3. Tap the Monitor button on the top right, the selected cells will display a “Monitoring” label in bottom left if monitoring is enabled.
4. When movement is detected, an event is triggered.
5. To stop monitoring, tap the “Stop All” button on the top right. **Note**: it is recommended that each monitoring session should not last longer than 10 seconds.

9.A.9 Cell Components

Below are the components of a cell that consists the following notations:

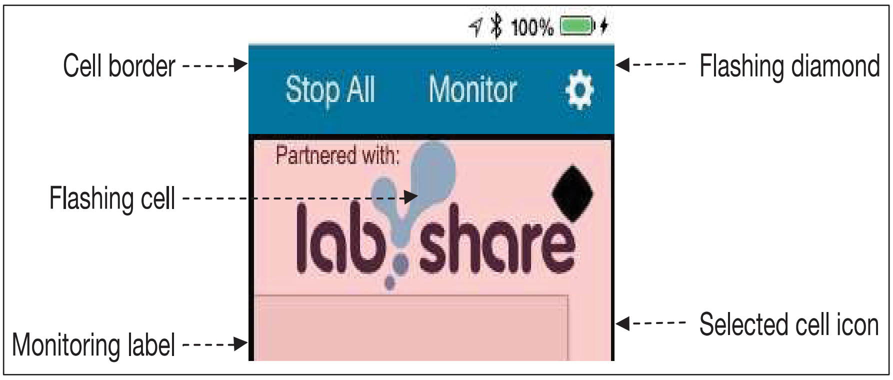


Figure 9.A. 13: Cell Components

9.A.10 Events Detection and Store

a. Event Indicators

The event indicator options are the visual cues that appear when an event is trigger. They are turned on or off with the switch to their right. The available event indicators are:

- **Alert Message** – An auto message dialog that appears near the bottom of the screen.
- **Flashing Cell** – The cell flashes a transparent red.
- **Flashing Diamond** – A flashing opaque black diamond in the top right corner of the cell.

b. Event Detection Scenario

When an event is triggered, the following processes occur in the app.

- Visually, the enabled Event Indicators will appear.
- A screenshot of the individual cells and the entire grid images are saved onto the device locally.
- An event record is saved to the local database.

- The app will attempt to upload the images to Dropbox. **Note:** for this reason, it is recommended that a Dropbox account is linked prior to performing monitoring activities.

c. Motion Event

In order to monitor cells, they must be select first. This is achieved by tapping on the desired cell or any number of cells. The cells indicate that they are selected by a blue tick in a circle on the bottom right of the cell, as observed in figure 10.A.12. When there are selected cells, the user can enable monitoring by tapping on the Monitor button. The cells indicate that they are being monitored, by a translucent label with the word "monitoring" on the top right of the cell, as shown in figure 10.A.12. If there are no cells selected, a popup dialog box informing the user will appear. When motion detection reaches the threshold specified, an event is triggered. This pops an alert on screen and the Pebble Smart Watch app. This event is also saved to the event log. The event is acknowledged by tapping the Clear button of the alert.

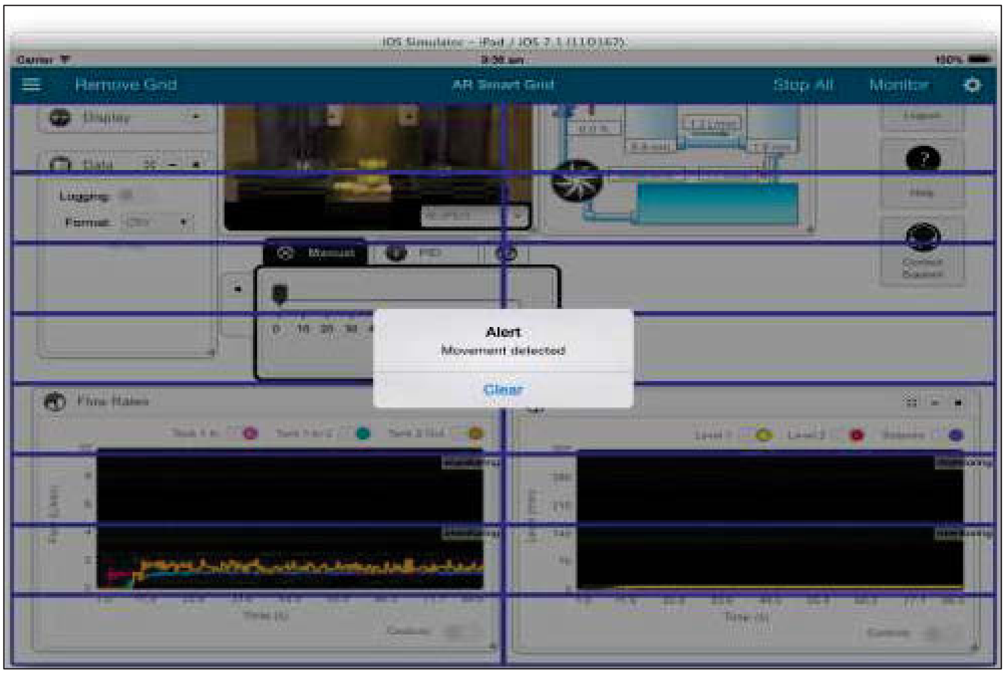


Figure 9.A. 14: Alert Event Message Detection

d. Event Log

The event log slides open when the bar shaped icon is tapped. The following figure shows the event log open. This is a table of events that have been saved. The information displayed for each event is a timestamp and the event type. Currently, AR Smart Grid only supports motion detection events, but this even property is included here to allow future scalability to include other types of events.

The event log is a table of all the event records in the local database. It can be accessed by tapping the icon in the top left corner. Tapping an event log row will open the screenshots of the individual cell and the entire grid image captured at the moment of the event. First image will be the cell, swipe left to view the grid image.

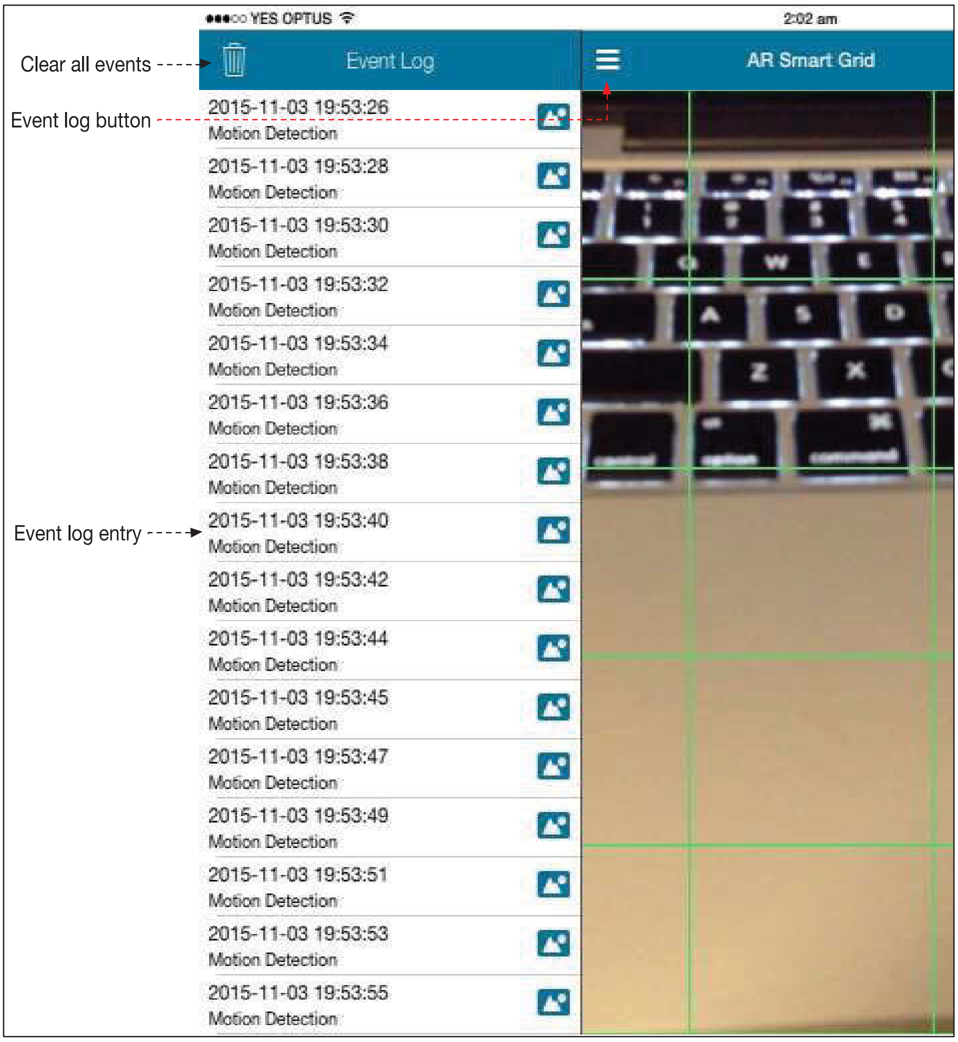


Figure 9.A. 15: AR Smart Grid Event Log

The clear all events button will delete all event records and their corresponding images locally. All images uploaded to Dropbox will remain.

9.A.11 Pebble – Smart Watch Integration

This section shall demonstrate the companion Pebble Smart Watch application. Figure 10.A.14 shows a Pebble watch with the AR Smart Grid app loaded. As it was described in chapter 5.A, In order for the Pebble to communicate with the iOS AR Smart Grid app, the watch must first be paired via Bluetooth to the iPad. When the Pebble app is first opened, the text on the screen will read "Waiting for app". When the iPad app is opened, the program will check if there are connected Pebble watches. If one is detected, text is pushed to the screen, in this case the text is "AR Smart Grid". After connection is established, the user may press any button on the right side of the Pebble. This will bring up the function button labels.

Figure 9.A. 16: Pebble Smart Watch

a. Navigation in Congestion with the Smart Watch

The Pebble can been used to traverse the cells of the grid. The cell which the pebble is currently positioned is indicated by the Pebble logo, as shown in figure 10.A.15. When the Pebble is positioned on a cell, the cell can be selected or unselected. The blue tick indicates its selection status, as usual.

Figure 9.A. 17: Pebble app position shown on AR Smart Grid

i. Interaction with the Smart Watch

Figure 10.A.16 is a screenshot of the Pebble interface. The left side displays information of the cell and the right side are the button labels. The screenshot indicates the Pebble is currently positioned on the cell forth column and second row.

Figure 9.A. 18: Pebble App Showing Current Cell Position

The following screenshots show the Pebble interface for the interactions of selecting and unselecting, and monitoring actions. The iOS application will behave in the same way.

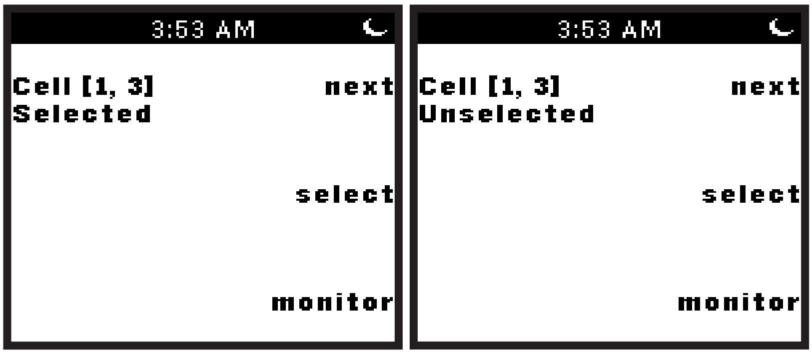


Figure 9.A. 19: (Left) Cell Selected and (Right) Cell Unselected

Figure 9.A. 20: (Left) Monitoring Toggled and (Right) Monitoring Stopped

9.A.12 OpenCV Experiments: Detection Test

a. Harris Corner Detector

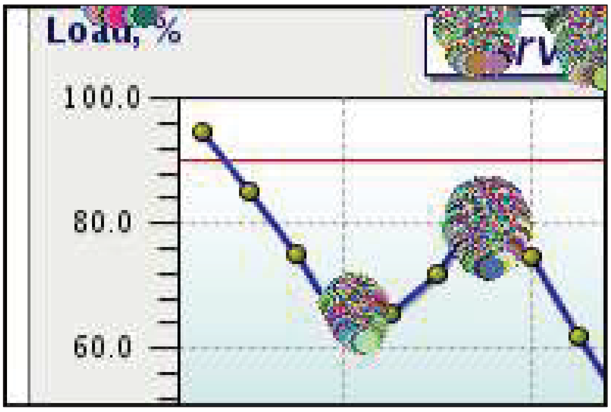


Figure 9.A. 21: Harris Corner Detector results

b. Hough Circle Detector

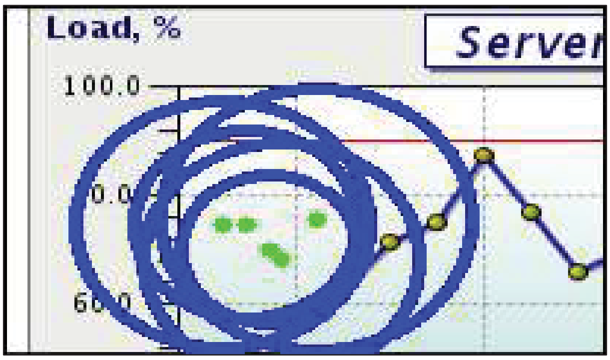


Figure 9.A. 22: Hough Circle Detector, first Attempt

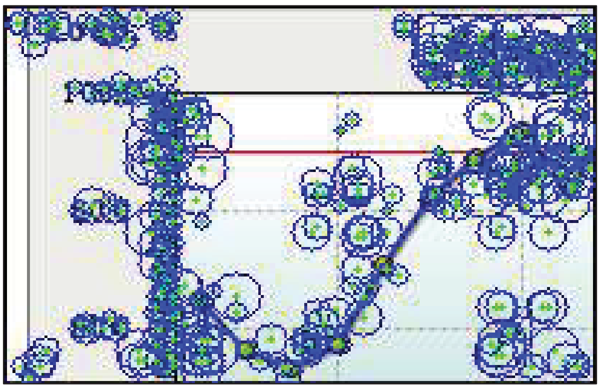


Figure 9.A. 23: Hough Circle Detector, Second Attempt

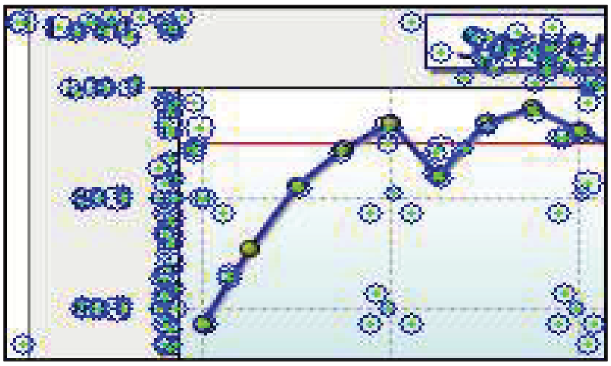


Figure 9.A. 24: Hough Circle Detector, Further Refinement

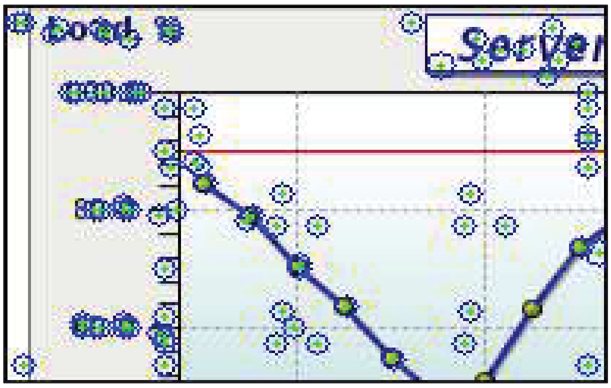


Figure 9.A. 25: Hough Circle Detector, Results

A demonstration of the project can be viewed by scanning the following QR code:

Figure 9.A. 26: QR Project Demo of AR Smart Grid

Appendix B: Haptic Middleware for Smart Peripherals Interactions

9.B.1 System Analysis

Initial System Requirements Analysis

Regarding the requirements for this project, the preliminary set of requirements had been defined through the demand of system development purposes; thus, the system will:

- Have the ability to connect multiple haptic control devices
- Each connected device can be connected to one or more clients within the network
- Haptic gestures captured from device can be interpreted by each individual client
- Be able to capture gestures from variable that is approximately 10 metres
- The user may have multiple haptic control devices connected to it where the gesture captured will be interpreted dependent on the distance from the client

List of potential applications:

- Operating theatres environment
- Smart Classroom environment
- Any potential systems that implements IOT framework

List of potential problems:

- Integrating multiple haptic controllers
- Detection gaps or overlapping virtual spaces (in distance) for each haptic controller
- Transitioning between haptic controller devices
- Limitations in hardware functionality

9.B.2 Software Tools

The table below outlines all the software tools utilised throughout this project.

Table 9.B. 1: Software Tools

Type	Software	Reasoning
Target System	Windows 7 (32/64bit)	As Microsoft ceased support of Windows XP. The expected minimal requirement by all business facilities would be Windows 7 and above at the point of project completion.
Development Platform	.NET Framework 4.5 (WCF Framework)	.NET 4.5 WCF Framework will be utilised to handle Endpoint communication for the network communication services for the middleware framework.
Development Environment	Visual Studio 2013	Commercial application available for free for students via Microsoft DreamSpark program.
Programming Language	C#	Fast, popular and well supported professional language. This is to aim at high level development and prototyping.
Version Control	GitHub & Sourcetree	A robust version control that has a tiny footprint with lightning fast performance. It outclasses SCM tools like Subversion, TortoiseSVN.
Document Control	DropBox	Cloud documentation control that could provide shared access between all devices. There are currently 50Gbs of available storage space for documentation and research purposes.
Word Processor	Microsoft Office Word 2013	Word processing tool that have been previously purchased and will be

Type	Software	Reasoning
		utilised in this project
Diagramming Tool	Rhapsody, Microsoft Visio 2013	It is planned to implement SysML for this project. It is known that piece diagramming tools will be able to provide the functionality to draw these diagrams.
Graphics	Adobe PhotoShop CS6	Although graphics may be minimal within the implementation of this project, however is time is available then portion of the time may be considered to design the graphical user interfaces to improve usability of system.
Middleware	IISU [2]	Complete open source platform to handle natural gesture development and deployment for haptic sensory devices. It is known to be compatible with a few major brands of haptic sensory devices such as MESA SwissRanger SR4000 [3] and SoftKinect [2] with a set of predefined gesture library.
Third-party Tools	External libraries and applications cannot be determined at this stage and will be assessed throughout each iteration of the spiral model	

9.B.3 System Prototyping

The selected software development approach have been taken with consideration into the original rational unified process within the development process section. These software development cycles involved the development of "prototypes" which would serve both for concept development and project development.

The diagram below outlines a high level design or an overview of the actual system. The system will be reciting within the application server where network service will be managing this off haptic controllers that are to be implemented on each of the Smart Classroom setting. The user would then be interacting with these network haptic controllers.

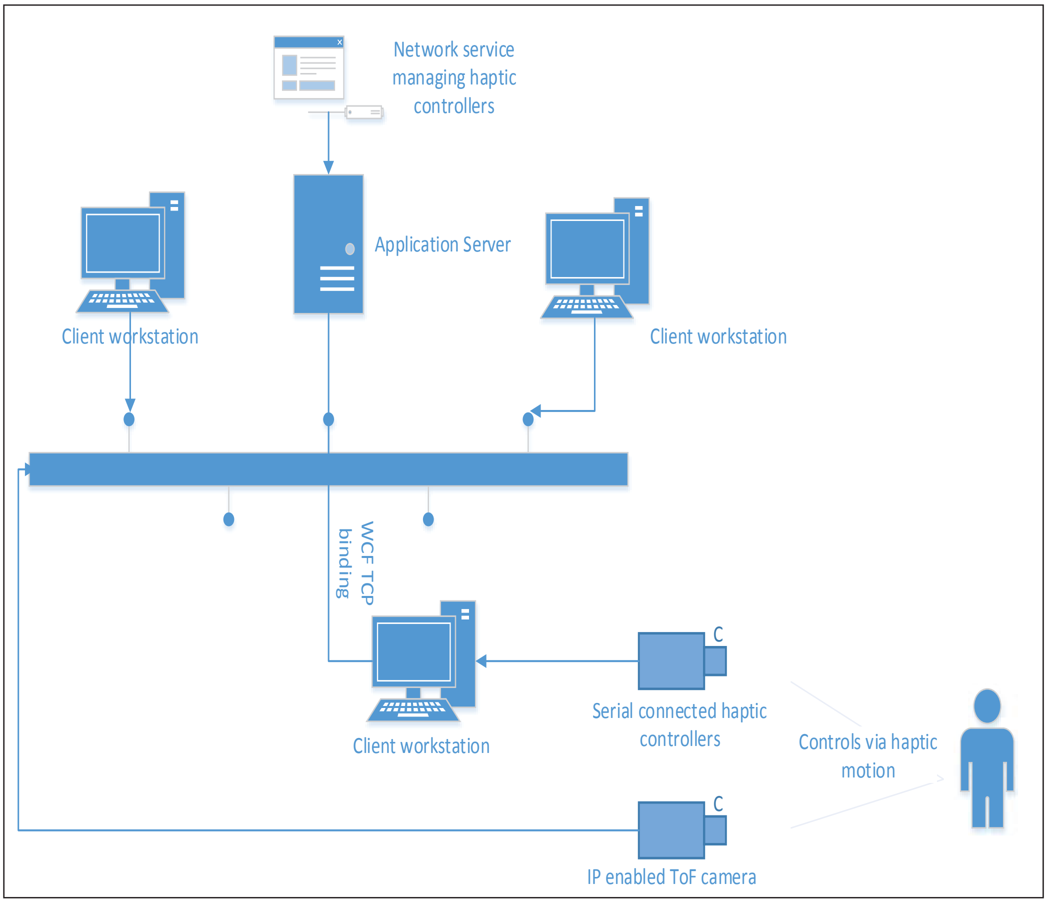


Figure 9.B. 1: Overview of the Haptic Control System

Below are screenshots of the graphical user interface from the prototype:

Figure 9.B. 2: Integrating MESA SwissRanger 4000 camera into system

Figure 9.B. 3: Integrating Leap Motion Device into System

Figure 9.B. 4: Integrating Depthsense DS325 into System

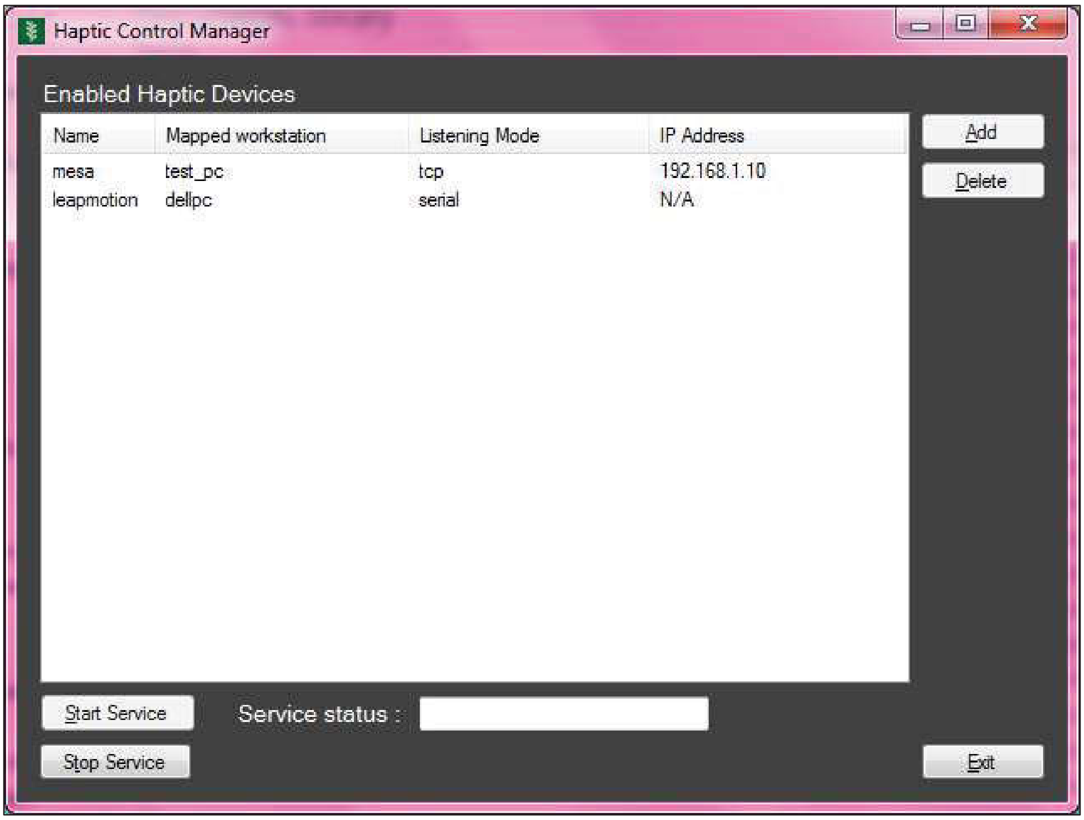


Figure 9.B. 5: Prototype of Haptics Control Manager

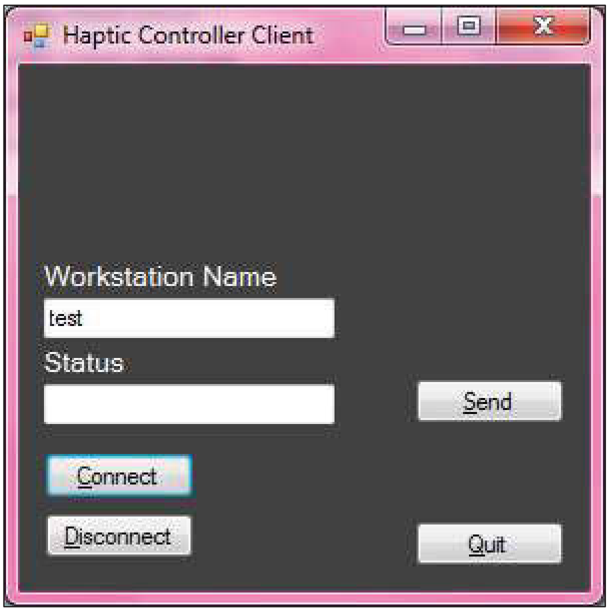


Figure 9.B. 6: Client Interface, Receiving Gesture Signals from the Server Application

Figure 9.B. 7: Prototype of Leap Motion, which Interpret Gesture, Signals to Control the Mouse

The prototype have to be carefully redesigned for each device to be initialised individually on the application server level to simply address to the hardware incompatibility issues. This will mean that for some devices that it will bypass the middleware layer and communicate directly to the application server.

9.B.4 System Requirements

The requirements analysis process for the new middleware system is defined through gathering raw requirements from multiple phases of prototyping as well as via discussion with the stakeholder. These raw requirements are then refined by extracting individual requirements on the core functionality of the middleware.

System requirements are to be classified into two major categories: functional requirements and non-functional requirements.

- **Functional requirements**: These are core requirements are mandatory for the baseline operation of the haptic control middleware service. These requirements are addressed in the "shall" statements within the requirements table. These statements indicate that the core requirements must be implemented and tested to ensure the functionality of the middleware. In the design phase, these requirements are given more priority over the non-functional requirements.

- **Non-functional requirements**: These are extension requirements that are specified as supplementary capabilities to support or improve the middleware service's performance. These requirements are addressed in the "should" statements. These statements indicate that the requirements are planned to be included in the system design but may be implemented and tested accordingly.

Table 9.B. 2: Initial Requirements

Requirement	Requirements Description
1	The middleware shall be able to handle a common set of gestures
2	The middleware shall be able to interface additional devices
3	The middleware shall be able to be used by a third party software
4	The middleware shall allow the user to interface with individual device using the same function calls
5	The middleware shall be able to track distance if detected
6	The middleware shall be able to determine velocity if detected
7	The middleware shall be able to choose between devices when user is in range
8	The middleware shall have the capability to add new common libraries
9	The middleware shall provide an API that can be implemented and used
10	The middleware shall allow any sensors to be added and implemented
11	The middleware should be able to send out gestures via network
12	The middleware should capture finger coordinates if possible
13	The middleware should capture hand coordinates if possible
14	The middleware should capture live video feed of the device if possible
15	The middleware should be able to switch devices when in range
16	The middleware should be able to guess the device a user is moving towards

9.B.5 System Design

The aim of the systems design cycle is to define how the system should be implemented to match to the requirements defined during the system analysis phase.

The requirements are then reviewed and analysed, key aspects of architectural qualities are then identified to create designing components for the overall design of the middleware system.

Different architectural patterns are analysed and reviewed, as showed in chapter 5, to meet the design of the middleware system. A high level design will be developed using SysML which will then be decomposed into lower level design, which determines the functionalities of which component block.

An implementation design has been also be created to provide a better overview of the implementations process.

9.B.6 Middleware Implementations

The middleware framework is implemented and displayed utilising Layered Service Oriented Architecture would be beneficial for the haptic control middleware, as the middleware framework will need to provide communication between integrations between new system developments to add new libraries.

Low Level Design:

- Haptics Middleware API

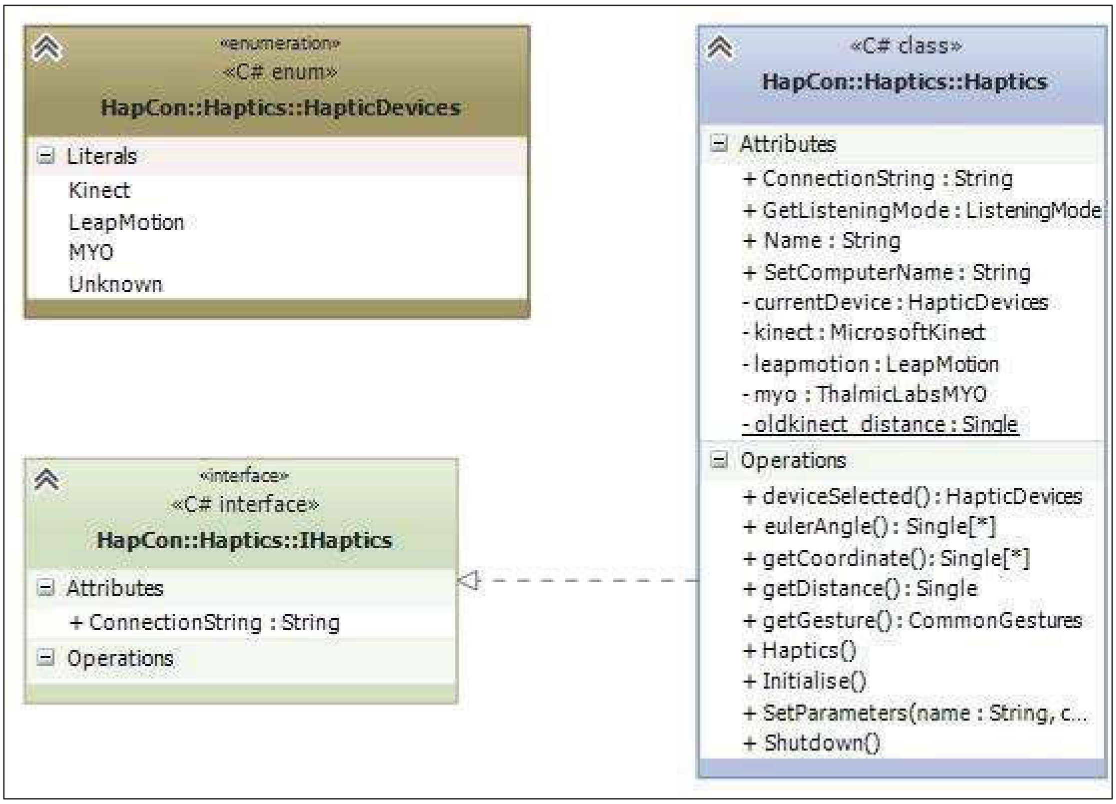


Figure 9.B. 8: Haptics Class Diagram

- **Haptic Devices**

This is a device enumerator representing the devices implemented within the project. There are three devices in total: Microsoft Kinect camera, Thalmic Labs MYO arm band and LEAP motion haptic controller

- **IHaptics**

This is an interface which hooks onto the main hardware interface to obtain data from all devices.

- **Haptics**

This implement the IHaptics interface. This class handles the resource distance service on selecting devices depending on distance as well as containing the main methods for the middleware API:

- ***deviceSelected()*** *– Returns information on which device is currently selected to read its output data.*
- ***eulerAngle()*** *– Returns additional information of the MYO reading on the gyroscope. The data returned will contain the roll, yaw and pitch of the Thalmic Labs MYO arm band.*
- ***getCoordinate()*** *– For camera devices, provides the live coordinates of the hand in x, y and z axis.*
- ***getDistance()*** *– Returns the distance of the user's hand from the camera devices. The data return is in centimeters.*
- ***getGesture()*** *– Returns the gesture detected from the selected listening device. The gesture is defined within the common gestures library*
- ***Initialize()*** *– Initializes all connected devices;*
- ***Shutdown()*** *– Shutdown all connected devices;*

- Common Hardware Interface

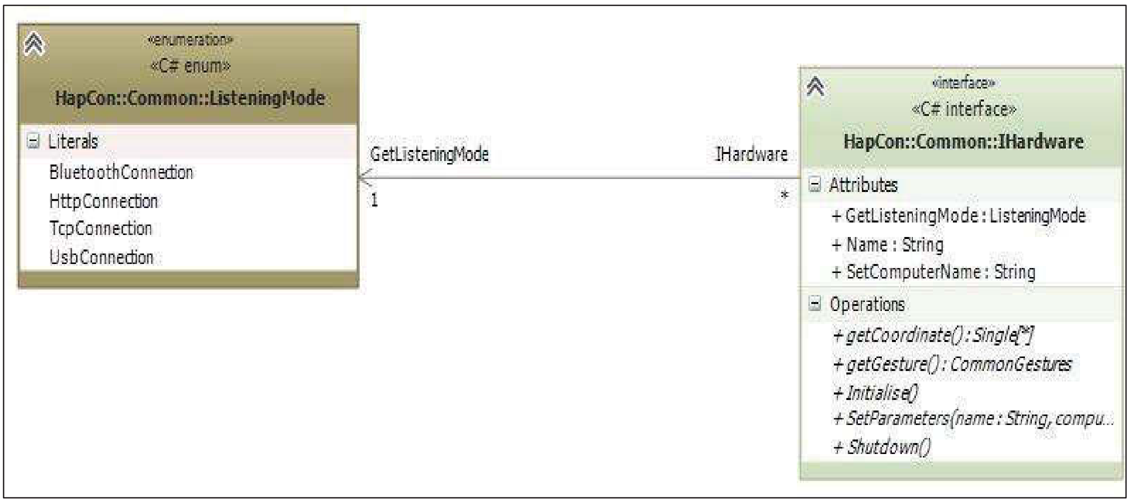


Figure 9.B. 9: Common Hardware Interface Class Diagram

- **Common::ListeningMode**

This is a part of the common hardware library which defines all haptic controllers and sensors. This enumerator contains all supported connection methods for devices implemented within this project.

- ***BluetoothConnection*** *– Bluetooth connectivity of all device*
- ***HttpConnection*** *– Connectivity via HTTP endpoints*
- ***TcpConnection*** *– Connectivity via TCP/IP endpoints*
- ***UsbConnection*** *– Connectivity via USB connectivity*

- **Common::IHardware**

Defines the common hardware interface for this project, this implements the hardware service to handle all devices and sensors for the middleware framework:

- ***getCoordinate()*** *– If the device is defined as a camera device, then it will obtain the coordinates of the user's hand within the project.*
- ***getGesture()*** *– Obtains the gesture of the device. The gesture is defined within the common gesture library.*
- ***Initialize ()*** *– Initializes the haptic controller*
- ***SetParameters()*** *– Obtains the configuration data from the XML configuration files and setup the device for connectivity and communication.*
- ***Shutdown ()*** *– Shutdown the device*

- Common Gestures

Figure 9.B. 10: Common Gesture Class Diagram

- **Common::CommonGestures**

It defines the common gesture library for the middleware framework. Within this project, five common gestures were created for the devices. These are:

- ***Circular Anti-clockwise*** *gesture – hand moving anti-clockwise*
- ***Circular clockwise*** *gesture – hand moving clockwise*
- ***Okay*** *gesture – hand showing OK or an upper O shape in the air with both hands*
- ***Swipe Left*** *gesture – Hand swiping left*
- ***Swipe Right*** *gesture – Hand swiping right*
- ***Unknown*** *– An unknown gesture as a safety fall back if the device is unable to recognise the gesture made by the user.*

- **Leap Motion**

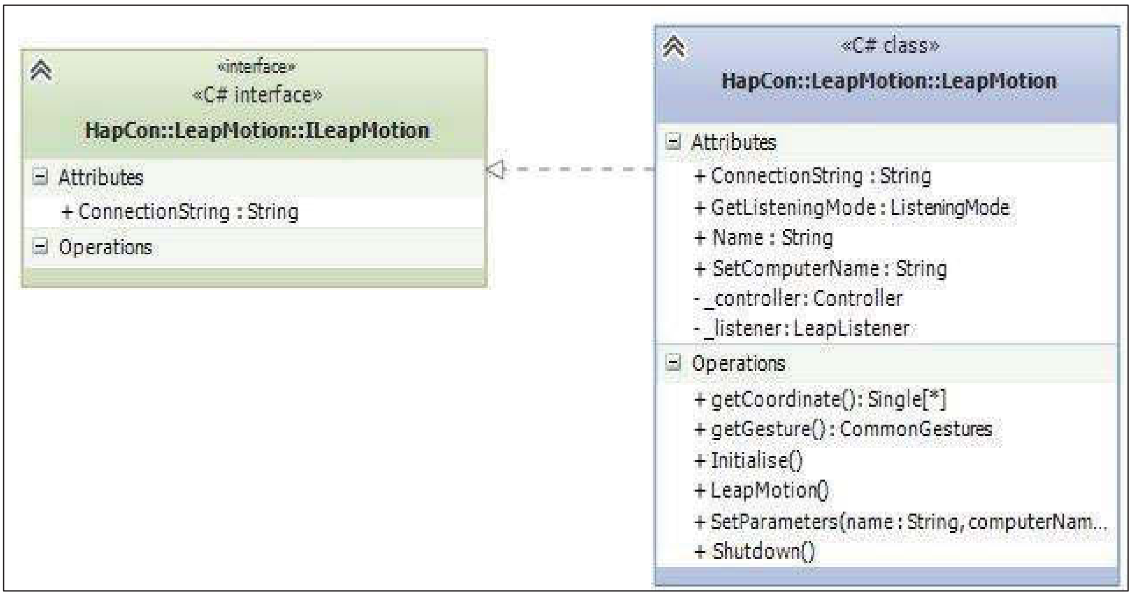


Figure 9.B. 11: LEAP Motion Class Diagram

This is the class implementation of the LEAP motion device. This connects to the main common hardware and gesture library to maintain consistency between device communications.

- **ILeapMotion** – Interface created to hook onto the common hardware library
- **LeapMotion** – Implements the common hardware interface with the following methods
  - ***getCoordinate()*** *–obtain the coordinates of the user's hand within the project. This is calculated by take an average of the coordinates of the finger tips.*
  - ***getGesture()*** *– Obtains the gesture of the device. The gesture is defined within the common gesture library.*
  - ***Initialize ()*** *– Initializes the haptic controller*
  - ***SetParameters()*** *– Obtains the configuration data from the XML configuration files and setup the device for connectivity and communication.*
  - ***Shutdown ()*** *– Shutdown the device*

- **Microsoft Kinect**

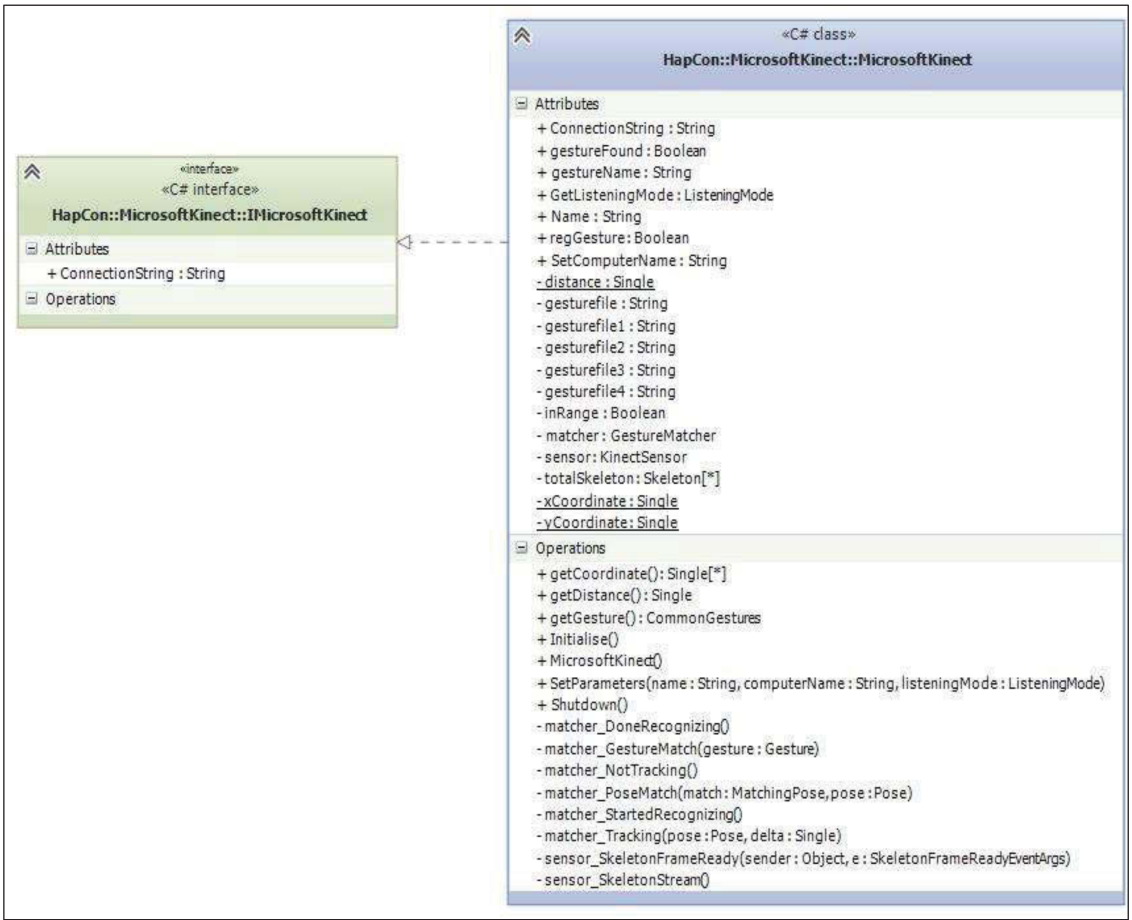


Figure 9.B. 12: Microsoft Kinect Class Diagram

This is the class implementation of the Microsoft Kinect device. This connects to the main common hardware and gesture library to maintain consistency between device communications.

- **IMicrosoftKinect** – Interface created to hook onto the common hardware library.
- **MicrosoftKinect** – Implements the common hardware interface by utilizing Microsoft Kinect SDK and Kinect Gesture library.

- ***getCoordinate()*** *–obtain the coordinates of the user's right hand within the project. This data is obtained from private sensor skeleton frames defined within the Microsoft Kinect SDK.*
- ***getGesture()*** *– Obtains the gesture of the device. The gesture is defined within the common gesture library. These are obtained from private matcher event calls as defined within the Kinect Gesture library.*
- ***Initialize ()*** *– Initialises the haptic controller*

- ***SetParameters ()** – Obtains the configuration data from the XML configuration files and setup the device for connectivity and communication.*
- ***Shutdown ()** – Shutdown the device.*

- **Thalmic Labs MYO**

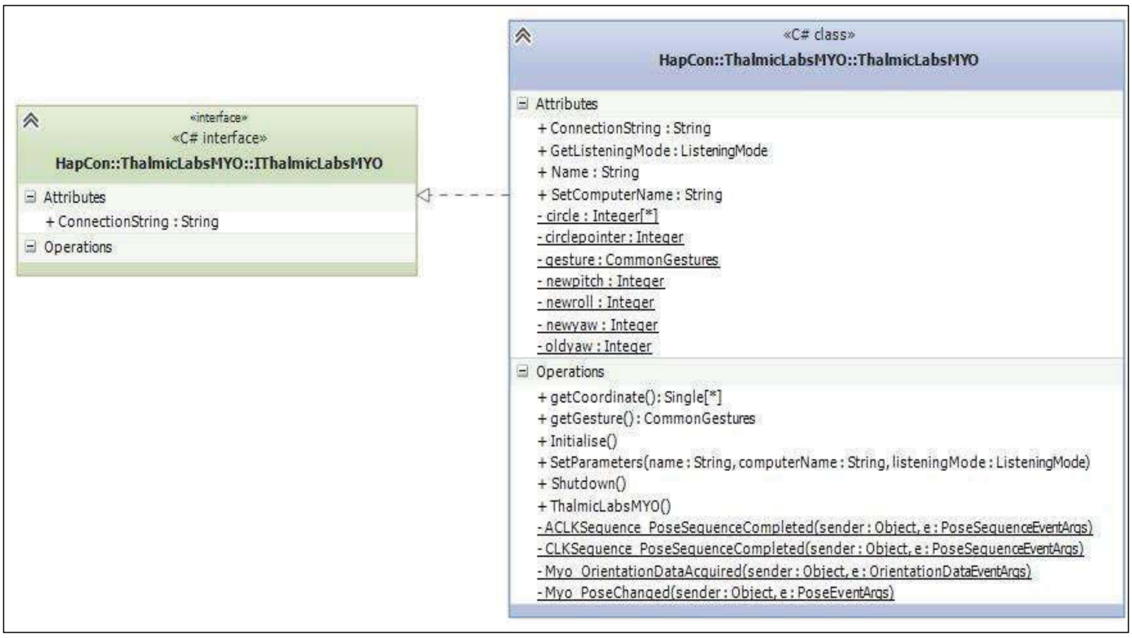


Figure 9.B. 13: Thalmic Labs MYO Class Diagram

This is the class implementation of the Thalmic Labs MYO armband device. This connects to the main common hardware and gesture library to maintain consistency between device communications.

- **IThalmicLabsMYO** – Interface created to hook onto the common hardware library
- **ThalmicLabsMYO** – Implements the common hardware interface by utilising Thalmic Labs class library and MYOSharp wrapper interops.

- ***getCoordinate()** –obtain the eulers angle of the MYO armband within the project.*
- ***getGesture()** – Obtains the gesture of the device. The gesture is defined within the common gesture library. These are obtained from private PoseSequence event calls as defined within the MYOSharp library.*
- ***Initialize()** – Initialises the haptic controller*
- ***SetParameters()** – Obtains the configuration data from the XML configuration files and setup the device for connectivity and communication.*
- ***Shutdown()** – Shutdown the device.*

- Haptics Control Manager

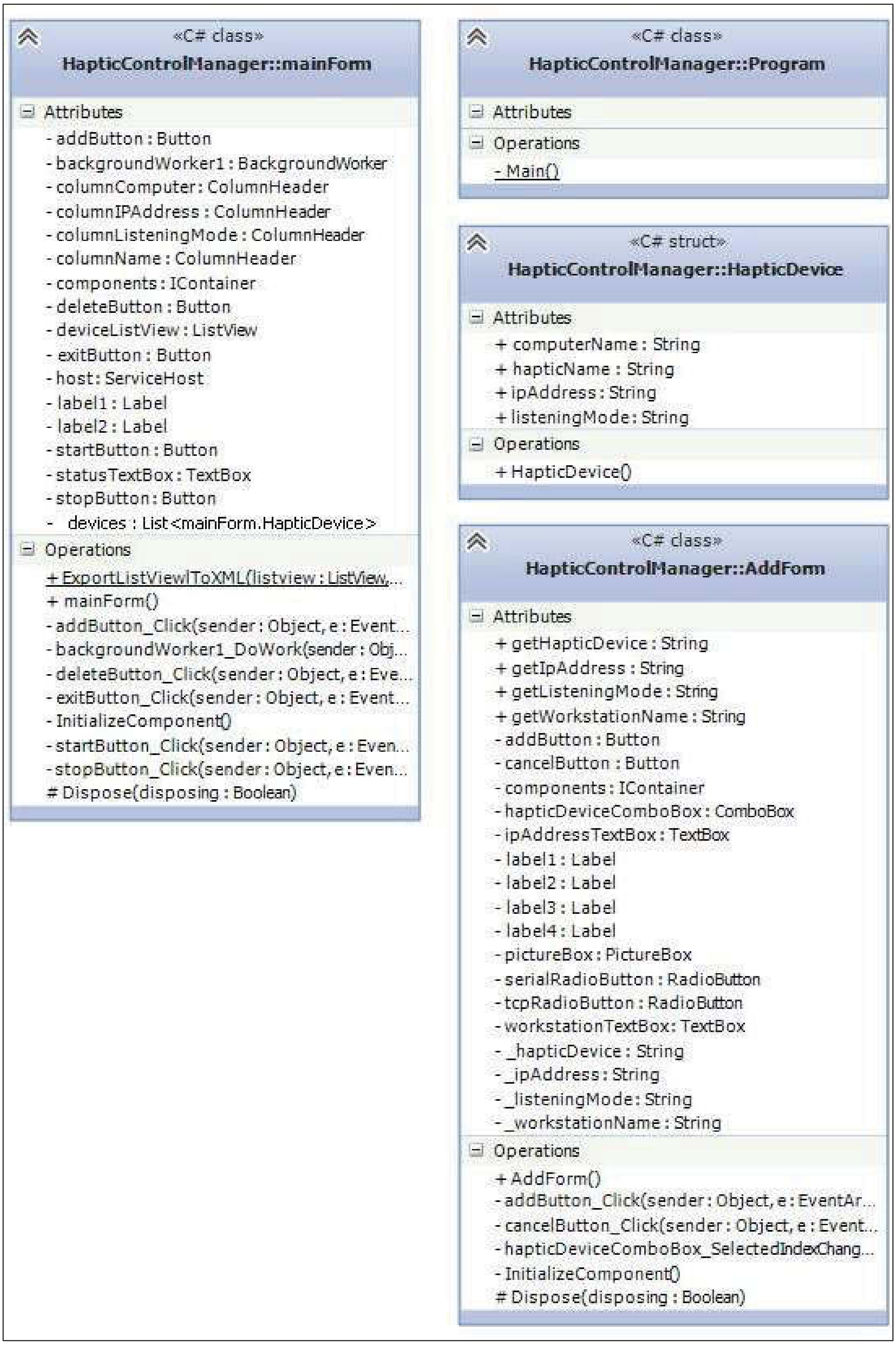


Figure 9.B. 14: Haptic Control Manager Class Diagram

- **Haptics Control Manager**

This is a user interface that is used to setup and configure haptic controllers and store within XML configuration files. This component is regarded as non-functional requirement hence the functionality is basic that has the potential for further development. The data stored and extracted from these configuration file can be used to handle the common hardware interface method as below:

- ***SetParameters()*** *– Obtains the configuration data from the XML configuration files and setup the device for connectivity and communication.*

This system implements the hardware configuration service as defined within the implementation architecture and uses an XML engine to define the storage structure as well as using the XML file for I/O purposes.

- Haptics UI

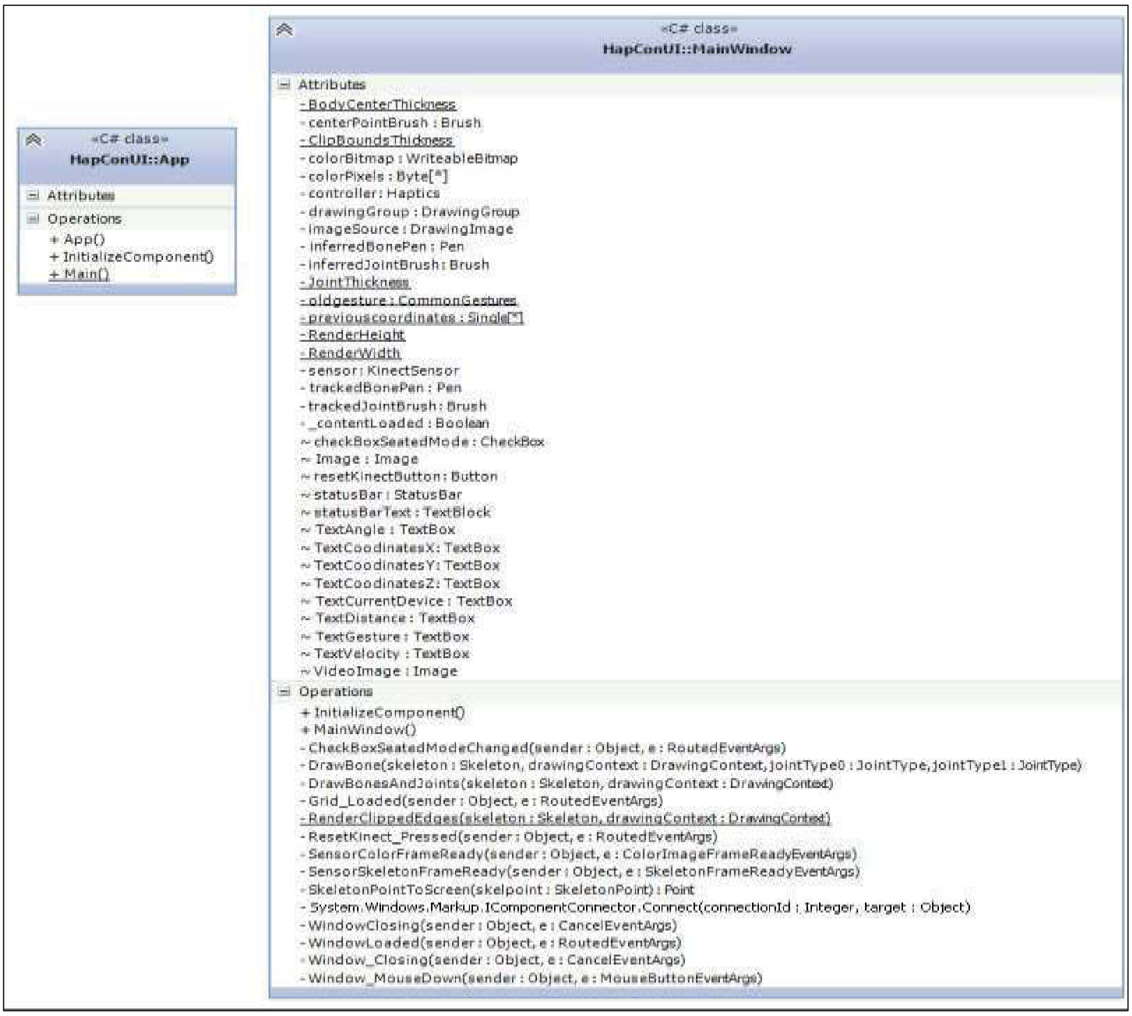


Figure 9.B. 15: Haptics User Interface Class Diagram

- **HapticsUI**

This is a demo user interface which implements the middleware framework. This implements the middleware API and generates live sample data to display and demonstrate the middleware functionality. A live feed of the Microsoft Kinect is also generated to show the system's current vision to show integration. This is achieved by generating a live video feed which overlaps with the current skeleton feed of the Microsoft Kinect.

- Middleware Service Result and Testing

Below are the functions tested for the API with the three hardware implemented into the middleware service.

- ***deviceSelected()*** *– Returns information on which device is currently selected to read its output data.*
- ***eulerAngle()*** *– Returns additional information of the MYO reading on the gyroscope. The data returned will contain the roll, yaw and pitch of the Thalmic Labs MYO arm band.*
- ***getCoordinate()*** *– For camera devices, provides the live coordinates of the hand in x, y and z axis.*
- ***getDistance()*** *– Returns the distance of the user's hand from the camera devices. The data return is in centimeters.*
- ***getGesture()*** *– Returns the gesture detected from the selected listening device. The gesture is defined within the common gestures library*
- ***Initialize()*** *– Initialises all connected devices;*
- ***Shutdown()*** *– Shutdown all connected devices;*

9.B.7 System Architecture Quality

Below are the architectural qualities that are consider to be important through requirement analysis:

Table 9.B. 3: Architectural Qualities Description

Name	Description
Performance	This architectural quality is the measure describing the system's performance. Performance could be expressed in several ways but within this project is the accuracy of analysing the data received by the sensors and camera. The speed in switching the device on detect is required to be completed within minimal time delay The quality of the received gesture and its confidence ratio from the middleware is considered a measure of the system's performance.
Scalability	This architectural quality is the measure of how the middleware handles additional sensors and devices. Being scalable means having the smooth capability to size up by either adding new device or increasing the general size of the middleware by any additional means.
Reliability And Availability	This architectural quality is the measure of duration that the middleware service can be up and running correctly; the length of time between failures and the length of time needed to resume operation after a failure.(Availability = MTTF / (MTTF + MTTR) where MTTF = Mean time to failure, MTTR = Mean time to repair the component). Availability can be categorised as the probability that the system will work as required during a certain period of the system's mission. It is particularly important for real time systems.

Name	Description
Usability And Maintainability	This architectural quality is the measure of how easy it is to implement the middleware to integrate with third party systems and how easy it is to keep the middleware running with the sensors and devices.

Thought these architectural qualities, architectural analysis is then carried out on the architectural models chosen as possible implementation candidates. It is normal to overlap multiple architectural models to fit to requirements and architectural qualities.

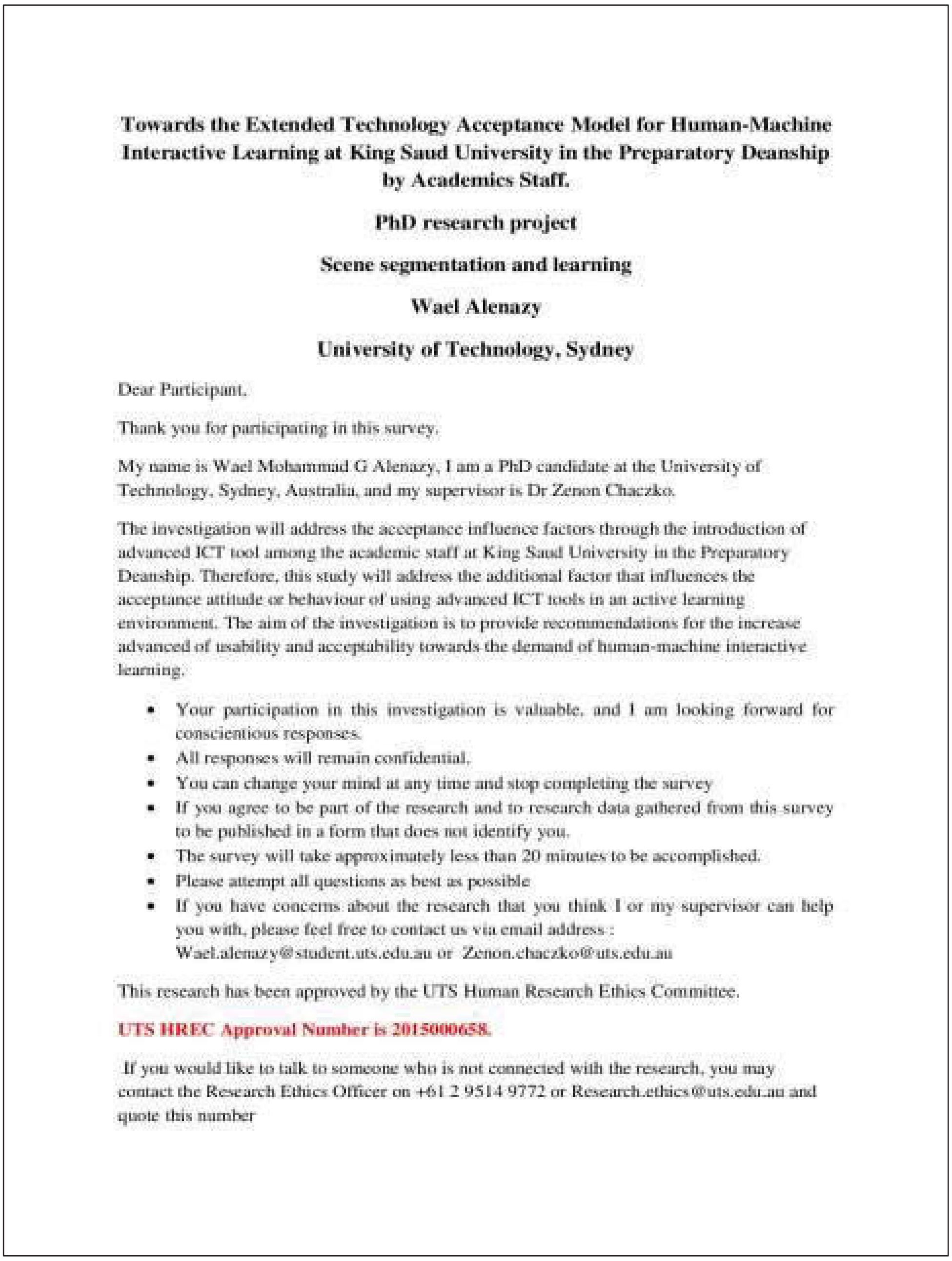
Analysis has been taken and reviewed for possible communication models for the middleware and the design had considered the following criteria for the comparison of architectural models:

- **Time Performance -** degree of timing feedback of data can be interpreted between sensors and how quickly information could be processed by the middleware.
- **Maintainability** - value showing the possible duration and cost of the middleware due to maintenance work and the degree of its complexity towards the logical interfacing between devices.
- **Modularity** - the ease with which middleware service components may be separated and recombined.
- **Usability -** value indicating how complex and time consuming the middleware service is to be implemented and to use by third party software developments. Also shows how difficult it is to learn to use the middleware framework.

Appendix C: Survey Structure

9.C.1 The Conducted Survey layout

The conducted survey contains the following details as shown in figures below:



Towards the Extended Technology Acceptance Model for Human-Machine Interactive Learning at King Saud University in the Preparatory Deanship by Academics Staff.

PhD research project

Scene segmentation and learning

Wael Alenazy

University of Technology, Sydney

Dear Participant,

Thank you for participating in this survey.

My name is Wael Mohammad G Alenazy, I am a PhD candidate at the University of Technology, Sydney, Australia, and my supervisor is Dr Zenon Chaczko.

The investigation will address the acceptance influence factors through the introduction of advanced ICT tool among the academic staff at King Saud University in the Preparatory Deanship. Therefore, this study will address the additional factor that influences the acceptance attitude or behaviour of using advanced ICT tools in an active learning environment. The aim of the investigation is to provide recommendations for the increase advanced of usability and acceptability towards the demand of human-machine interactive learning.

- Your participation in this investigation is valuable, and I am looking forward for conscientious responses.
- All responses will remain confidential.
- You can change your mind at any time and stop completing the survey
- If you agree to be part of the research and to research data gathered from this survey to be published in a form that does not identify you.
- The survey will take approximately less than 20 minutes to be accomplished.
- Please attempt all questions as best as possible
- If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us via email address : Wael.alenazy@student.uts.edu.au or Zenon.chaczko@uts.edu.au

This research has been approved by the UTS Human Research Ethics Committee.

UTS HREC Approval Number is 2015000658.

If you would like to talk to someone who is not connected with the research, you may contact the Research Ethics Officer on +61 2 9514 9772 or Research.ethics@uts.edu.au and quote this number

Figure 9.C. 1: Survey layout – Page 1

Section 1: Demographic Questions and General Technological usage

For each item, please select the most appropriate answer to yourself.

1.1) What is your position at the University?

□ Professor

□ Associate Professor

□ Assistant Professor

□ Lecturer

□ Tutor or Trainer

□ Lab assistant

1.2) What is your Department at the Preparatory Deanship?

□ Basic Science

□ Self-Development Skills

□ English Language Skills

1.3) What is your last earned degree ?

………

1.4) Kindly, indicate your teaching experience from the following:

□ 0 – 1 year

□ 1 – 5 years

□ 5 – 10 years

□ 10 – 15 years

□ More than 15 years

1.5) What is your nationality?

□ Saudi

□ Non-Saudi

1.6) Do you usually use ICT (Information Communications Technology) tool(s) in your teaching and learning method?

□ Yes

□ No

Figure 9.C. 2: Survey layout – Page 2

Section 2: ICT background

2.1) What ICT learning tool(s) do you use in the classroom? (Multiple choice)

□ Computer desktop

□laptop
□ tablet

□ Projector

□ Smart board

□ Smart pointer pen

□ Camera

□ Other Please specify:

2.2) What sort of ICT learning application(s)/software(s) do you use in the classroom?

□ CMS Blackboard

□ YouTube

□ Social Media Network Applications, Twitter, WhatsApp, Facebook, blogger

□ Google applications

□ Microsoft office, Word, PowerPoint, Excel.

□ Adobe Reader

□ Cloud storage, e.g. Google drive, Dropbox

□ Other Please specify:

2.3) How would you rate your ICT skills?

□ Specialist

□ Expert

□ Functional Application

□ Awareness

2.4) When using ICT learning tool(s) in the classroom do you find it effective?

□ Not at all

□ Sometimes

□ Very much

Figure 9.C. 3: Survey layout – Page 3

2.5) Do you have any kind of learning plan that apparently integrates ICT tool into the syllabus goals?

□ Not at all

□ Sometimes

□ Very much

2.6) Do you ever engage or seek ICT tool learning development of your skills?

□ Not at all

□ Sometimes

□ Very much

Figure 9.C. 4: Survey layout – Page 4

Section 3:

The following section is going to be answered based on the UTS-Remote lab experiment. In other word, the study will measure four main factors that could have a positive impact in user's attitude and behaviour to accept the adaption.

Please select the response that best describes your beliefs, feeling, or attitudes on the scale Strongly Agree to Strongly Disagree. Additional awareness and expectation factors are being stated to estimate the usability and acceptability, particularly in shown experiment ICT tool.

	Strongly Agree	**Agree**	Neutral	**Disagree**	Strongly Disagree
1. Perceived Usefulness (PU)					
Using ICT advanced tool will improve my work					
Using ICT advanced tool will enhance my learning and teaching effectiveness					
Using ICT advanced tool will increase my teaching and learning productivity					
Please provide a brief explanation that justifies your opinion. Give an example(s) how the ICT advanced tool may influence your work.					
2. Perceived Ease of Use (PEoU)					
I find it easy to get ICT advanced tool to do what I want it to do					
Interacting with ICT advanced tool does not require a lot of mental effort					
I find ICT advanced tool easy to use					
Give an example(s) what specifically effects usability.					
3. Attitude Toward ICT advance tool Use					
ICT advanced tool makes work more interesting					
Working with ICT advanced tool is exciting					
I look forward to those aspects of my learning and teaching methods that require me to use					

Figure 9.C. 5: Survey layout – Page 5

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
ICT advanced tool.					
Please provide an example(s) how the tool can, in your opinion, affect/influence the teaching and learning process?					
4. Behavioural Intention to Use					
I will use ICT advanced tool in future					
I plan to use ICT advanced tool occasionally					
I plan to use the ICT advanced tool regularly					
What type of other valuable functions could benefits the ICT advanced tool? OR, What other possible areas of use avoided you be willing to apply the tool for?					
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5. Understanding of Scene Partitioning in ICT advanced tool					
I found it clear and ease to understand the role of Scene Partitioning in activating the ICT advanced tool					
I found it somewhat clear to understand how Scene Partitioning is able to activate the system					
I could not understand or see how Scene Partitioning is able to activate the system					
Do you think using Scene Partitioning aspect and ICT advanced tool would be valuable/ interesting in the Teaching and Learning Process as shown in the experiment? Please provide an example(s).					

Figure 9.C. 6: Survey layout – Page 6

	Strongly Agree	**Agree**	Neutral	**Disagree**	Strongly Disagree
6. Understanding and Expectation of Scene Partitioning and ICT advanced tool in general					
Scene Partitioning software tool is a critical factor in the ICT advanced tool for Teaching and Learning process					
I plan to use Scene Partitioning software tool for Teaching and Learning extensively.					
I hope to use Scene Partitioning software tool for Teaching and Learning process in the future.					
Do you expect to use Scene Partitioning software tool in Teaching and Learning process? Please provide an example(s).					

Thank you for your participation

Sincerely

PhD Candidate, UTS

WAEL Mohammad G ALENAZY

Supervisor

Zenon Chaczko

Figure 9.C. 7: Survey layout – Page 7

9.C.2 ETAM Adopted Factors and Elements

Table 9.C. 1: List of Constructs and Corresponding Items

Factors Construction	Item	Measurement Questions	Reference information from
Perceived Usefulness Perceive Usefulness (PU)	PU1 PU2 PU3	1. Using the ICT advanced tool will improve my work 2. Using the ICT advanced tool will increase my learning and teaching effectiveness 3. Using the ICT advanced tool will improve my teaching and learning productivity	Adopted from Davies 1989
	PU4	4. If you agree/disagree with the ***Perceived Usefulness*** of the ICT advanced tool related statements, please provide a brief explanation that justifies your opinion. Give an example(s) how the ICT advanced tool may influence your work.	Open Discussion Question
Perceived Ease of Use (PEoU)	PEU1 PEU2 PEU3	1. I find it easy to get the ICT advanced tool to do what I want it to do 2. Interacting with the ICT tool does not require an extensive mental effort 3. I find the ICT advanced tool easy to use	Adopted from Davies 1989
	PEU4	4. If you agree/disagree with the ***Perceived Ease of Use*** of the ICT advanced tool, give an example(s) what specifically effects usability.	Open Discussion Question
Attitude Toward ICT advance tool Use	ATICTU1 ATICTU2 ATICTU3	1. The ICT advanced tool makes my work more interesting 2. Working with ICT advanced tool is exciting 3. I look forward to those aspects of my learning and teaching methods that require me to use	Adopted from Thompson et al. 1991; Compeau & Higgins 1995

Factors Construction	Item	Measurement Questions	Reference information from
		the ICT advanced tool.	
	ATICTU4	4. If you agree/disagree with the level of enthusiasm ***Attitude Toward the use of the ICT advanced tool***, please provide an example(s) how the tool can, in your opinion, affect/influence the teaching and learning process?	Open Discussion Question
Behavioural Intention to Use	BIU1 BIU2 BIU3	1. I will use the ICT advanced tool in future 2. I will use the ICT advanced tool if some functions are improved 3. I plan to use the ICT advanced tool regularly	Adopted from Davies 1989
	BIU4	4. If you agree/disagree to **intend to use the ICT advanced tool**, what type of other valuable functions could benefits the ICT advanced tool? OR, What other possible areas of use avoided you be willing to apply the tool for?	Open Discussion Question

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Perceived Usefulness (PU)					
Using ICT advanced tool will improve my work					
Using ICT advanced tool will enhance my learning and teaching effectiveness					
Using ICT advanced tool will increase my teaching and learning productivity					
If you agree/disagree with the ***Perceived Usefulness*** of the ICT advanced tool related statements, please provide a brief explanation that justifies your opinion. Give an example(s) how the ICT advanced tool may influence your work.					
2. Perceived Ease of Use (PEoU)					
I find it easy to get ICT advanced tool to do what I want it to do					
Interacting with ICT tool does not require a lot of mental effort					
I find ICT advanced tool easy to use					
If you agree/disagree with the ***Perceived Ease of Use*** of the ICT advanced tool, give an example(s) what specifically effects usability.					
3. Attitude Toward ICT advance tool Use					
ICT advanced tool makes work more interesting					
Working with ICT advanced tool is exciting					
I look forward to those aspects of my learning and teaching methods that require me to use ICT advanced tool.					

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
If you agree/disagree with the level of enthusiasm ***Attitude Toward the use of the ICT advanced tool***, please provide an example(s) how the tool can, in your opinion, affect/influence the teaching and learning process? ____________					
4. Behavioural Intention to Use					
I will use ICT advanced tool in future					
I plan to use ICT advanced tool occasionally					
I plan to use the ICT advanced tool regularly					
If you agree/disagree to **intend to use the ICT advanced tool**, what type of other valuable functions could benefits the ICT advanced tool? OR, What other possible areas of use avoided you be willing to apply the tool for? ____________					

9.C.3 E-Survey

Survey was conducted by using **Google Form** tool. Bellow some screen captured reflects the developed distributed survey.

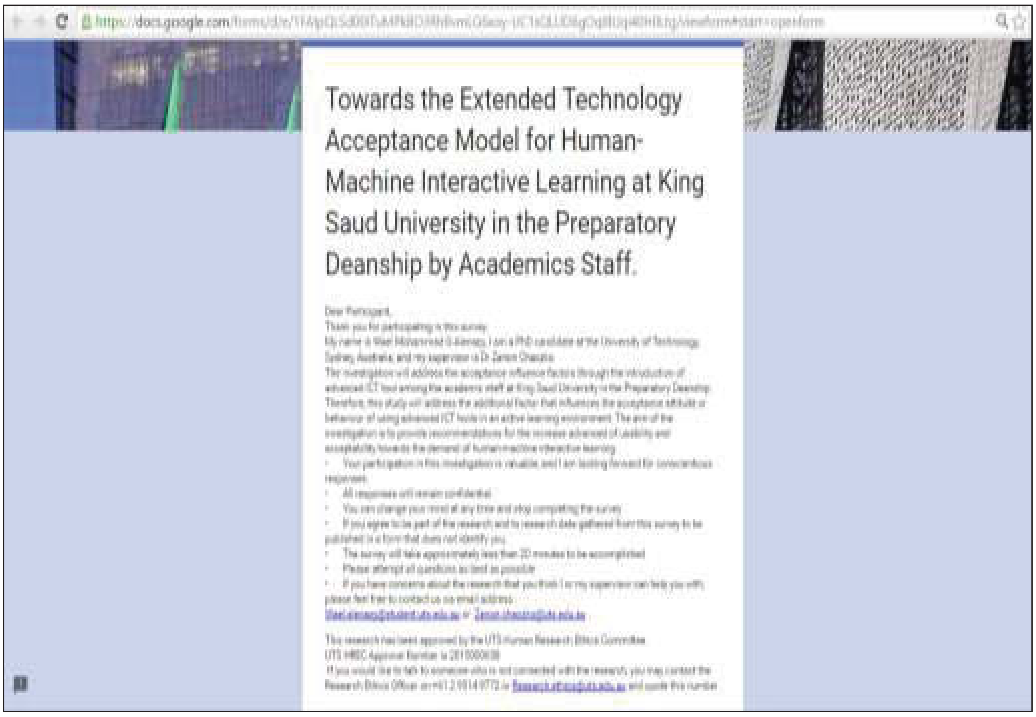


Figure 9.C. 8: Survey Screen Captured- Introduction Page

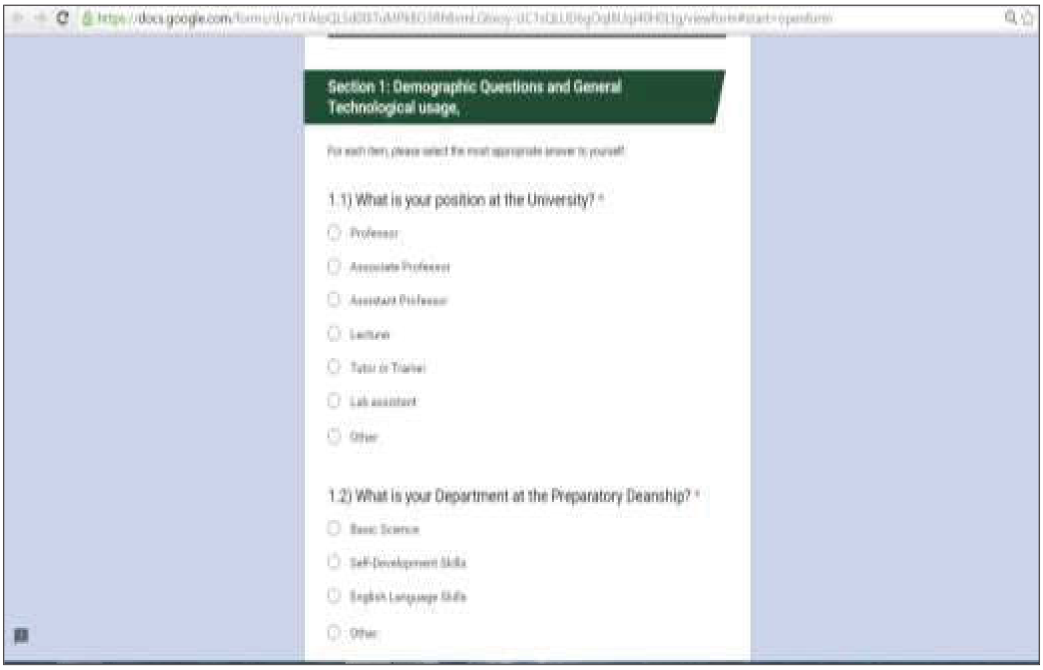


Figure 9.C. 9: Survey Screen Captured - Form 1

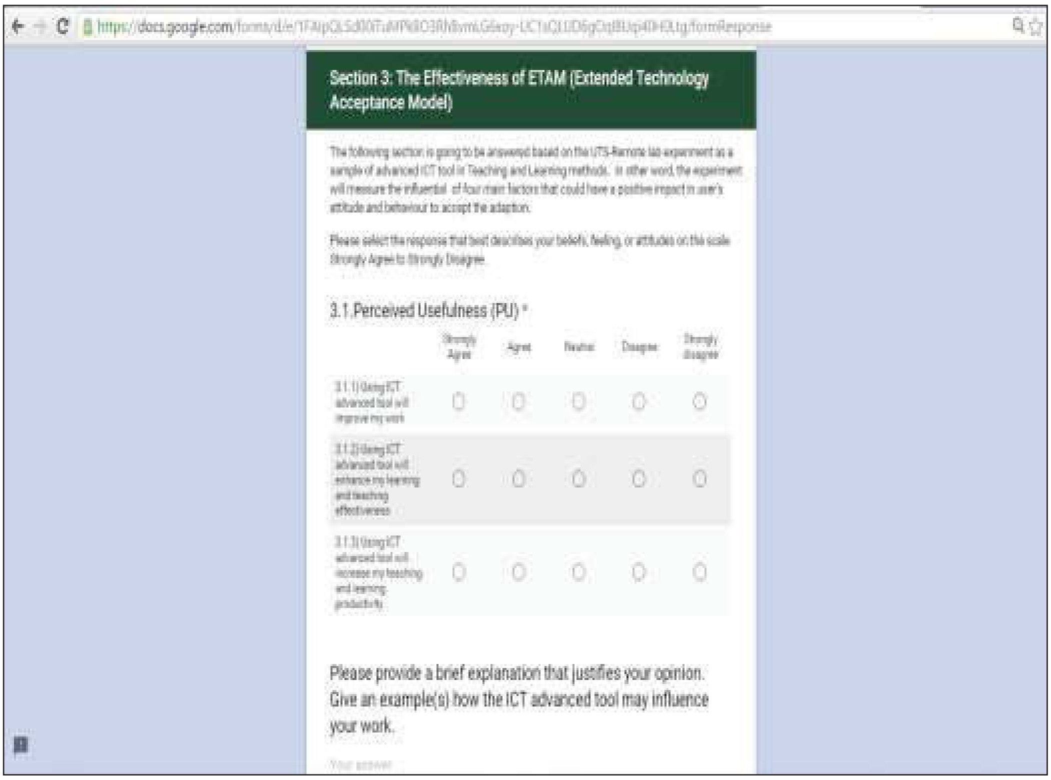


Figure 9.C. 10: Survey Screen Captured- Form 2

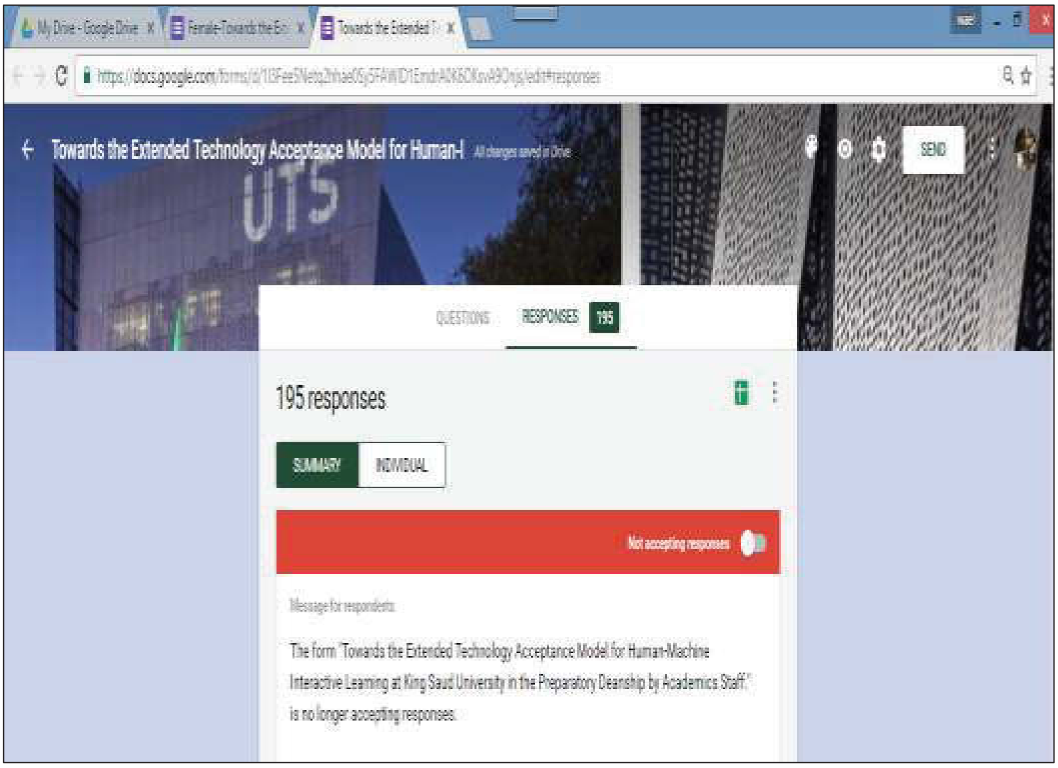


Figure 9.C. 11: Number of Male Participants

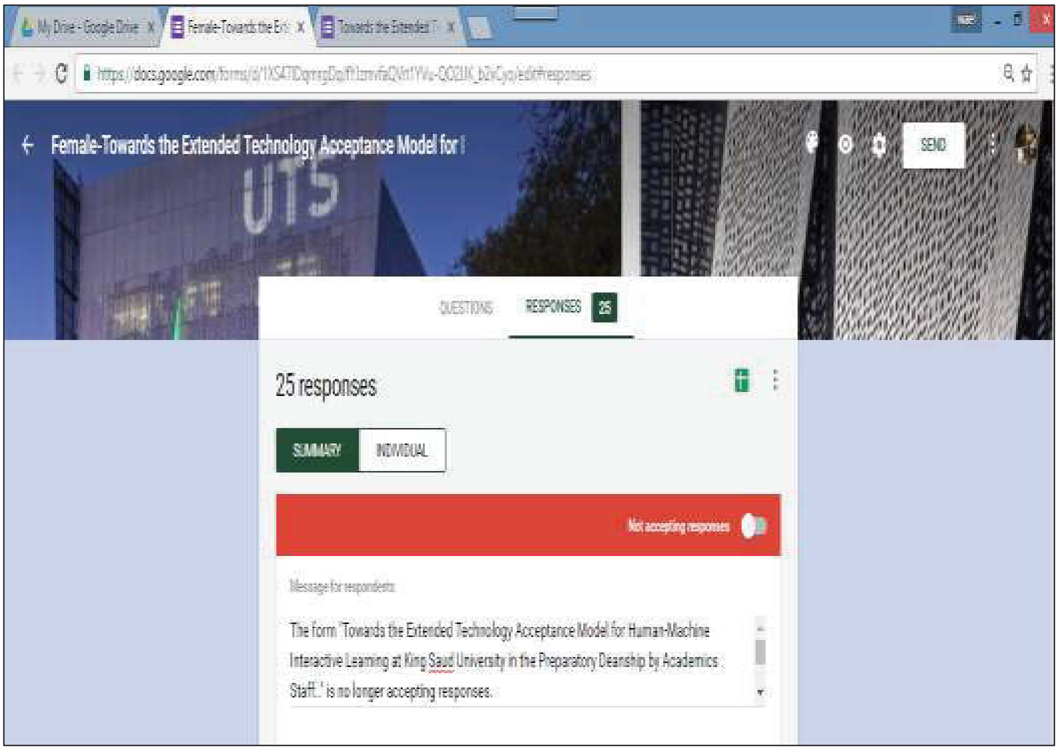


Figure 9.C. 12: Number of Female Participants

9.C.4 Scientific Trip Stages for Collecting Data

Table 9.C. 2: Data Collection Stages

Journey Scientific Trip in KSA at KSU			الخطة الزمنية للرحلة العلمية في المملكة العربية السعودية – جامعة الملك سعود		
		Stages Description	**شرح المراحل**		
Date	Stages	**Primarily and Preparation**	**التمهيد والاستعداد**	المراحل	التاريخ
From 08-12-2015 to 24-12-215	1st stage	- Arrival time into the research place - Show inclusive study plan to the exterior supervisor and obtain the primarily recommendations. - Addressing the nominated recommendation and find out the collaboration method. - Choosing the sample population technique collaborating with some experts. - Noticing scenes of the ICT tools usages in education environment at the preparatory deanship. - Documenting these scenes and impact of the ICT tools in classes. - Receiving some points of view from the exterior supervisor. - Doing general interviews to selected participants. - Sending a brief documented history, about the implemented operating system that is being used and run, to the primary academic supervisor in Australia.	- الوصول الى الجهة المشرفة للبحث - إطلاع المشرف الخارجي في المملكة العربية السعودية على الخطة الشاملة للدراسة وأخذ التوصيات الاولية. - أخذ بالتوصيات الأولية حول آلية البحث وطرق التعاون - وضع آلية اختيار عينه البحث من خلال التواصل مع خبراء بحث لدى الجهة المعنية - تدوين المشاهدات في كل ما يتعلق باستخدامات التكنولوجيا الحديثة في مجال التعليم في عمادة السنة التحضيرية - تسجيل مشاهدات تلك الاجهزة ومدى فاعليتها في القاعات. - اخذ الرأي من المشرف الأكاديمي ليتم التنسيق لبدء الدراسة الكمية "الإستبيان". - عمل مقابلات عامه مع المشاركين (اعضاء هيئة التدريس المدربين والفنيين) من جهتين التي توفر بيئة التعلم الإلكتروني ذو العلاقة الأكاديمي والتقني. - إرسال ملخص تلك المشاهدات عن الأنظمة المستخدمة الى المشرف الأكاديمي في الجامعة بأستراليا لتحديد نوع الانظمة التي سيتم البحث عليها بعد التشاور مع المشرف في المملكة.	المرحلة الأولى	من 1437-02-25 الى 1437-03-12هـ

		Applying Essential Concepts and Verification Stage	**مرحلة تطبيق المفاهيم الأساسية والتوثيق**		
From 27-12-2015 to 14-01-2016	2nd Stage	- Start to build the survey based on the suggested one within taking into account of the first stage considerations. - Translate the survey homogeneously. - Contacting at least 6 of survey's experts and meeting them to improve the quality of the prepared questionnaire. - Revising and considering the suggested feedback. - Revamping/ Amending/ Improving the last version of the survey. - Sending/ Sharing the last version of the survey with the primary supervisor in Australia and get his feedback as well. - Creating a channel between the exterior supervisor and the primary supervisor by establishing a video conference. - Start revising the latest survey version and state the principle of the investigation strategies with both supervisors during the meeting time. - Sending and sharing the verified/committed version to the supervisors to be declared. - Preparing the next stage.	- البدء في بناء الاستبانة وتنسيقها على ضوء الاستبانة المقترحة مسبقا مع الاخذ بعين الاعتبار المشاهدات والملاحظات التي تم تدوينها في المرحلة الأولى - ترجمة الاستبانة بما يتوافق مع المحتوى - التواصل مع محكمين عدد 6 ومقابلتهم لابداء الرأي حول فاعلية الاستبانه - المراجعة وأخذ بعين الاعتبار المقترحات من خلال التغذية الراجعة من المحكمين - إجراء التعديلات النهائية للإستبيان الخاص بجمع البيانات الكمية بناءاً على أراء الخبراء الذين تمت مقابلتهم في المرحلة السابقة. - إرسال المسودة النهائية للمشرف الأكاديمي بالجامعة واخذ المرئيات على النسخه النهائية للإستبانة. - التواصل مع المشرفين واجراء اجتماع من خلال ال Video Conference - البدء في مراجعة الاستبانة بالتنسيق مع المشرف الخارجي والداخلي. - مراجعة العمل وتدوين ما تم التوصل اليه من توصيات ومقترحات لسلامة الاستبانة. - ارسال ملخص والنسخة النهائية للمشرفين للاعتماد. - التمهيد للمرحلة الثالثة.	المرحلة الثانية	من 1437-03-15 الى 1437-04-03هـ
		Select and data collection	**مرحلة تحديد و جمع البيانات**		
From 17-01-2016 to 04-02-2016	3rd Stage	- Selecting the sample population and convenient time with exterior supervisor. - Printing out the hard copy of the survey and also developing electronic survey to insert the data immediately. - Communicating with at least 60 participants via emails to arrange the proper time and place to meet. - Scheduling meeting timeline based on the received mails. - The nominated participants will involve 30 academics and 30 trainers in the deanship. - Interviewing and instant data collecting will conduct the investigation process based on applied experiment application. - Considering that each participant will consume min 20 min (5 min experience the application and 15 min collect feedback) - Taking notes based on the reflected experience for future development. - This approach will guarantee the integrity of data and research ethics. - Keeping the exterior supervisor observed the entire procedure. - Preparing the next stage.	- تحديد عينة البحث و التوقيت لنشر الاستبانة مع المشرف لدى المملكة. - طباعة وتوزيع الإستبانة ورقياً و بإستخدام النظام الالكتروني لإدخال البيانات بشكل فوري. - التواصل مع المشاركين (عدد 60 أو أكثر) من خلال البريد الالكتروني لتحديد الزمان و المكان المناسب لهم - تنسيق الجدول الزمني بما ياتناسب مع كل مشارك - المشاركين هم 30 عدد من اعضاء هيئة التدريس و 30 عدد المدربين لدى عمادة السنة التحضيرية - اجراء الاختبار لهم من خلال المقابلة الشخصية و اخذ الاستجابات بشكل فوري و دقيق بعد التجربة العملية من خلال استخدام تطبيق محدد - الأخذ بعين الاعتبار 60 مقابلة بمدة لا تزيد عن 20 دقيقه لكل مشارك (5 دقائق تجربة التطبيق – 15 دقيقه اخذ الاستجابات) - تدوين الملاحظات الاضافية التي تصب في مصلحة البحث و البيانات - هذه الخطواه تسهم في الضمان و التأكد من جودة البيانات المراد جمعها في الإستبانات اللاحقة خلال عملية جمع البيانات الكمية, وهذا يتطابق مع متطلبات الكلية وأخلاقيات البحث - ابقاء المشرف لدى المملكة على اطلاع تام بالاجراء المتبع - التمهيد للمرحلة الرابعة	المرحلة الثالثة	من 1437-04-06هـ الى 1437-04-24هـ

		Combining and Auditor Stage	**مرحلة الجمع و التدقيق**		
From 07-02-2016 to 29-02-2016	4th Stage	- Gathering and classifying the surveys - Auditing and assure content integrity - Analysing and assure the results effectiveness of surveys for future work. - Sending primarily analytical results to the supervisors to be negotiated - Presenting the analytical results and informing the end of the study's investigation and data collection to exterior supervisor to gain the official reflected letter upon the study to be sent to the Saudi Culture Mission in Australia.	- جمع الاستبانات وتصنيفها - إجراء التدقيق الأولي على جميع الإستبانات للتاكد من سلامة المحتوى - إجراء تحليل اولي لعينة من الإستبانات للتأكد النهائي من إمكانية إجراء التحليل الكامل و لتجنب إعادة عمل نفس الدراسة مرة اخرى في المستقبل. - إرسال نسخة من نتائج التحليل الجزئي الأولي للمشرف الأكاديمي بالجامعة للتشاور وأخذ التوصيات بما هو مناسب طالما لايزال الباحث في المملكة العربية السعودية - إطلاع المشرف في المملكة على النتائج الأولية للتحليل, وإبلاغة بالإنتهاء من جمع البيانات والحصول على خطاب إنتهاء الرحلة العلمية لتزويدها للجامعة والملحقية.	المرحلة الرابعة	من 1437-04-27 الى 1437-05-20هـ
		Back to Australia, the headquarters of scholarship	**المرحلة الخامسة و الأخيرة**		
03-03-2016	5th stage	- Getting back to Australia to start the essential data analysis - Inserting the collected data and using particular program for that matter - Showing the result to the supervisor.	- العودة الى مقر البعثة للبدء بمرحلة التحليل للبيانات. - إدخال البيانات وتحليلها بإستخدام البرامج الخاصة بذلك - تسجيل النتائج النهائية للتحليل و عرضها على المشرف الاكاديمي.	المرحلة الخامسة	1437-05-23هـ

9.C.5 Initial Acceptance Statement to Conduct the Survey at the Preparatory Deanship – KSU

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King Saud University

السنة التحضيرية
مكتب العميد

To Whom It May Concern

This is to certify that the Preparatory Deanship at King Saud University in Riyadh has granted a place to the PhD Candidate at UTS in Australia Mr. WAEL MOHAMMD G ALENAZY (NID. ١٠٠٤٣٠٧٥٠٨) to do his research investigation in preparation for his PhD project in the Preparatory Deanship under the supervision of Dr. Adil Alaskar the assistant professor in the Deanship.

Moreover, Preparatory Deanship is committed to provide a notification letter upon that matter at the end of student's investigation.

لمن يهمه الأمر

تفيد عمادة السنة التحضيرية بجامعة الملك سعود بالرياض، بأن لا مانع لديها من إشراف الدكتور/ عادل العسكر – الأستاذ المساعد- في عمادة السنة التحضيرية و الذي سيتولى الاشراف على طالب الدكتوراه في جامعة سدني للتكنولوجيا- و المحاضر لدى العمادة الأستاذ / وائل بن محمد بن غازي العنزي صاحب هوية رقم (١٠٠٤٣٠٧٥٠٨) وذلك عند قيامه بإجراء رحلته العلمية للمملكة العربية السعودية خلال العام الدراسي ١٤٣٦ – ١٤٣٧ هـ لغرض البحث المتعلق بدراسته في مرحلة الدكتوراه.

وستقوم العمادة بعد انتهاء الطالب من عملية البحث بتزويد الملحقية بكتاب بهذا الخصوص.

عميد عمادة السنة التحضيرية

Dean of the Preparatory Year Deanship

6/9/2015

Production Note:
Signature removed prior to publication

Dr. Nami Aljehani

Figure 9.C. 13: Initial acceptance Letter for conducting Survey at KSU

9.C.6 Statement of Permission to Conduct the Survey at the Preparatory Deanship - KSU

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المكرم الباحث/ وائل بن محمد بن غازي العنزي الموقر

السلام عليكم ورحمة الله وبركاته

إشارة إلى اجتماع لجنة دعم الأبحاث العلمية بالعمادة بجلستها التاسعة والثلاثين المنعقدة بتاريخ ١٤٣٧/٣/٦هـ للنظر في طلبكم بتطبيق أداة الدراسة بعنوان "Towards the Extended Technology Acceptance Model for Human – Machine Interactive Learning at King Saud University in the Preparatory Deanship by Academics Staff" على عينة من أعضاء هيئة التدريس بعمادة السنة التحضيرية؛ نفيدكم بأن اللجنة أوصت بالموافقة على التطبيق على أن لا يكون التطبيق أثناء المحاضرات؛ وبإمكان الباحث التواصل مع سعادة الدكتور/نعيم كامل على جوال رقم: (٠٥٠٨٣٦٤٠٢٨)، أو عن طريق البريد الإلكتروني: nshiber.c@ksu edu.sa لإكمال الإجراءات.

وتفضلوا بقبول وافر التحية والتقدير

وكيل العمادة للشؤون الأكاديمية

د. عبد المجيد بن عبد العزيز الجريوي

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Figure 9.C. 14: Statement for Conducting Survey at KSU