

**DESIGN AND EVALUATION OF AN AUDIO-VISUAL ANIMATED  
TECHNICAL DRAWING APPLICATION AS A TEACHING AND LEARNING TOOL  
A CASE OF THE CIVIL AND BUILDING ENGINEERING DEPARTMENT OF  
KYAMBOGO UNIVERSITY**

MUTEBI RONALD

(15/U/14583/GMVP/PE)

A DISSERTATION SUBMITTED TO GRADUATE SCHOOL  
IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTERS DEGREE  
IN VOCATIONAL PEDAGOGY OF KYAMBOGO UNIVERSITY

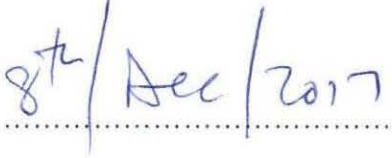
DECEMBER 2017

**DECLARATION**

I, Mutebi Ronald, declare that this research dissertation is my original work and that it has never been presented anywhere else for any academic endeavour

MUTEBI RONALD

Sign.....

Date.....

**APPROVAL**

This research dissertation entitled “**DESIGN AND EVALUATION OF AN AUDIO-VISUAL ANIMATED TECHNICAL DRAWING APPLICATION AS A TEACHING AND LEARNING TOOL**”, A CASE OF THE CIVIL AND BUILDING ENGINEERING DEPARTMENT OF KYAMBOGO UNIVERSITY has been done under my supervision. It has been submitted to the graduate school for examination with my approval as the student’s supervisor.

Sign .....  .....

Date ..... *07/12/17* .....

**Name:** KYAKULA MICHEAL (PhD)

**Dedication**

This research dissertation is dedicated to my parents Mr and Mrs J.K. Mutebi, My wife Mrs Mutebi Josephine and our children Nicholas Kiyaga Mutebi, Nichole Delaney Ndagire, and Ceaser Mutebi Kajjoba.

### **Acknowledgement**

Am profoundly grateful to the MVP program coordinator, facilitators, mentors, administrator and support staff for making my stay and studies for the last one and half years, comfortable and memorable.

I will forever be indebted to my supervisors Dr. Kyakula Michael and Dr. Opit Elizabeth for the tremendous support, encouragement and guidance that they have accorded me in the course of my action research study.

Special thanks go to all my cohort 5 colleagues for the invaluable knowledge I have acquired from them in the course of my study. The knowledge we have shared has made me a much better person who now appreciates the enormous advantages of teamwork.

Lastly but not least, I appreciate the support and sacrifices that my family has made to enable me spend what would be their time focused on my studies.

## TABLE OF CONTENTS

<b>Declaration.....</b>	<b>ii</b>
<b>Approval .....</b>	<b>iii</b>
<b>Dedication .....</b>	<b>iv</b>
<b>Acknowledgments .....</b>	<b>v</b>
<b>List of Tables .....</b>	<b>v</b>
<b>List of Figures.....</b>	<b>v</b>
<b>Acronyms .....</b>	<b>xii</b>
<b>Abstract.....</b>	<b>xiv</b>
<b>CHAPTER ONE: INTRODUCTION .....</b>	<b>1</b>
1.1 Chapter summary .....	1
1.2 Background of study .....	1
1.3 Situation analysis.....	3
1.4 Future workshop.....	4
1.5 Statement of the problem .....	6
1.6 Purpose .....	7
1.7 Specific objective .....	7
1.8 Justification of the study .....	8
1.9 Significance of the study .....	8
1.10 Scope of the study .....	9
1.10.1 Geographical scope .....	9
1.10.2 Content scope .....	9
1.10.3 Time scope.....	9
<b>CHAPTER TWO: LITERATURE REVIEW.....</b>	<b>10</b>
2.1 Introduction .....	10

2.2 Literature search strategy .....	11
2.3 Conceptual framework concerning animated tutorials and ICTs in learning.....	11
2.3.1 Design of e-learning applications .....	16
2.3.2 Implementation of e-learning applications in the teaching and learning process .....	19
2.3.3 Evaluation of e-learning applications as a teaching and learning tool .....	22
2.4 Literature Summary.....	23
<b>CHAPTER THREE: METHODOLOGY .....</b>	<b>24</b>
3.1 Introduction .....	24
3.2 Research design.....	24
3.3 Target population .....	24
3.3.1 Sample population.....	25
3.3.2 Sampling Technique .....	26
3.3.3 Sample size.....	27
3.4 Methods of data collection .....	28
3.4.1 Focus group discussions .....	28
3.4.2 Individual interviews .....	28
3.4.3 Observations .....	28
3.5 Instruments of data collection .....	29
3.5.1 Individual interview guide.....	29
3.5.2 Focus group discussion guide.....	29
3.5.3 Observation checklist .....	29
3.5.4 Questionnaire.....	30
3.6 Procedure of data collection .....	30
3.7 Data analysis .....	31
3.8 Implementation of action production objective .....	31

3.8.1 Work plan .....	32
3.8.2 Budget.....	33
<b>CHAPTER FOUR: ACTION IMPLEMENTATION RESULTS AND EVALUATION .....</b>	<b>34</b>
4.1 Introduction .....	34
4.2 Design of the AVATED application .....	34
4.2.1 Preliminary works phase .....	34
4.2.2 Functionality.....	36
4.2.3 Development of AVATED.....	37
4.2.4 Testing.....	39
4.3 Implementation of the AVATED application in the teaching and learning of ED .....	42
4.3.1 Collecting drawing background data.....	43
4.3.2 Installation of AVATED .....	46
4.3.3 Training of participants .....	48
4.3.4 Using AVATED as a learning tool .....	49
4.4 Evaluation of the AVATED application as a teaching and learning tool .....	51
4.4.1 Questionnaires.....	52
4.4.1.1 Design of AVATED.....	52
4.4.1.2 Implementation of AVATED.....	53
4.4.1.3 Effectiveness of AVATED.....	54
4.4.1.4 Efficiency of AVATED .....	55
4.4.1.5 General Comments .....	55
4.4.2 Evaluation Group Discussion.....	56
4.4.3 Interviews .....	59
<b>CHAPTER FIVE: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS.....</b>	<b>61</b>
5.1 Introduction .....	61

5.2 Interpretation of the findings .....	61
5.2.1 Interpretation of themes related to Design of AVATED .....	61
5.2.2 Interpretation of themes related to Implementation of AVATED .....	66
5.2.3 Interpretation of themes related to Evaluation of AVATED .....	70
5.3 Conclusions .....	76
5.4 Recommendations .....	77
5.4.1 Recommendations for Action.....	77
5.4.2 Recommendations for Future Research .....	78
References.....	80
Appendix B: Students Questionnaire 1 .....	85
Appendix C: AVATED Evaluation Questionnaire.....	87
Appendix F: Consent Form.....	90
Appendix G: Design work plan .....	93
Appendix H: Implementation work plan .....	94
Appendix J: Evaluation work plan.....	95
Appendix K: Evaluation interview guide .....	96
Appendix L: Evaluation Workshop Protocol.....	97
Appendix M: Minutes of Stakeholders Future Workshop.....	98
Appendix N: Minutes of Evaluation Group Discussion workshop .....	105

## LIST OF TABLES

Table 3.1 Sample Population and their Respective Purpose in the Study.....	25
Table 3.2 Different strata of the target student population.....	26
Table 3.3 Sample Size for the Study.....	27
Table 3.4 The Action Research Study Work Plan.....	32
Table 3.5 Estimated budget for the design, implementation, and evaluation of AVATED.....	33
Table 4.1 Software used to Design the AVATED Application.....	35
Table 4.2 Participants' Scores in the Pre-AVATED Intervention Drawing Exercise.....	43
Table 4.3 Participants' Gender, TD Background Information, and ED Learning Experience at University.....	45
Table 4.4 Device on which the participants installed the AVATED application.....	46
Table 4.5 The Quality of Participants' Weekly Drawing Work.....	50
Table 4.6 Participants' Responses to the Design of AVATED.....	52
Table 4.7 Participants' Responses to the Implementation of AVATED.....	53
Table 4.8 Participants' Responses to Effectiveness of AVATED.....	54
Table 4.9 Participants' Responses to Efficiency of AVATED.....	55
Table 4.10 A Summary of Participants Views as captured from the Evaluation Group Discussion.....	58

## LIST OF FIGURES

Figure 2.1 Conceptual framework of the action research study .....	12
Figure 4.1 layout sketch of the AVATED webpage that was agreed on by the stakeholders.....	38
Figure 4.2 The AVATED webpage designed based on the sketch agreed on by the Stakeholders.....	39
Figure 4.3 The AVATED application being tested on a laptop.....	40
Figure 4.4 AVATED application being tested on a Samsung galaxy S6 smart phone.....	41
Figure 4.5 Steps navigation buttons that did not work properly on the smart phone.....	41
Figure 4.6. Participants signing the consent forms during the first implementation Workshop.....	42
Figure 4.7 Number of participants in each Score category of the Pre- Intervention drawing exercise.....	44
Figure 4.8. The researcher installing the AVATED application on participants' PCs.....	47
Figure 4.9. The researcher being guided by the University LMS administrator to upload AVATED files to the LMS system.....	48
Figure 4.10. The researcher conducting one of the training sessions in the drawing room of the CBE department.....	49
Figure 4.11 Comparison of participants' weekly quality of drawings as scored by the lecturers.....	51
Figure 4.12. Researcher guiding the Future Workshop on evaluation of AVATED.....	56
Figure 4.13. Researcher interviewing the Dean Faculty of Engineering in his office.....	60
Figure 4.14. Researcher interviewing the CBE head of department in his office.....	60

**LIST OF ACRONYMS**

AR	Action Research
AVATED	Audio-Visual Animated Technical Drawing
BEng	Bachelor of Engineering
BST	Bachelor of Science Technology
BVoc	Bachelor of Vocational Studies
CAD	Computer Aided Design
CAI	Computer Aided Instruction
CAM	Computer Aided Media
CBE	Civil and Building Engineering Department
CD	Compact Disc
ED	Engineering Drawing
E-Learning	Electronic Learning
FGD	Focus Group Discussion
FW	Future Workshop
ICT	Information and Communication Technology
IT	Information Technology
ITEK	Institute of Teacher Education Kyambogo
LAN	Local Area Network
LCD	Liquid Crystal Display
LMS	Learner Management System
MP3	Media Player 3
MVP	Masters of Vocational Pedagogy

OS	Operating System
PC	Personal Computer
QUT	Queen University of Technology
SWF	Small Web Format
TD	Technical Drawing
TVET	Technical and Vocational Education and Training
TVET	Technical Vocational Education and Training
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPK	Uganda Polytechnic Kyambogo
USB	Universal Serial Bus
VHS	Video Home System
WAN	Wide Area Network

## ABSTRACT

The work processes analysis of the Bachelor of Civil and Building Engineering (BEng) program established that the Engineering Drawing (ED) course content is much to be covered in one semester. This was a major gap in the teaching and learning of the ED course unit. Consequently, the stakeholders' Future Workshop (FW) revealed that audio-visual animated ED tutorials that can enable learning to take place outside the lecture room would solve the identified gap. The purpose of this Action Research study therefore, was to design an Audio-Visual Animated Technical Drawing (AVATED) application, and to evaluate the application's success and challenges when used for improving teaching and learning of ED for better learning outcomes. The conceptual framework was based on e-learning and the integration of Information and Communication Technologies (ICTs) in the teaching and learning process. Fifteen students were selected for the study using stratified sampling technique, and purposive sampling was used to select two administrators, two lecturers, a computer lab technician, and two alumni from the world of work. Data were collected with aid of; focus group discussion, interviews, observations, and stakeholders in a Future Workshop. Results indicated that the AVATED intervention was able to improve participants' frequency of practicing ED which in turn improved quality of their drawings. Including more content, developing a separate application for smart phones, supplying the application on CDs, including more control buttons, and blending the use of AVATED with traditional teaching methods were suggested by the participants during evaluation as a way forward for the application. Findings of the study showed that 95% of participants scored above 70% in Engineering Drawing exercises after the intervention compared to 10% before the intervention.

*Key words: Engineering Drawing, ICTs, E-Learning, and Animated Tutorials*

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Chapter summary

In this chapter, I present the background of the study, information gathered from the situation analysis, statement of motivation and the statement of the problem. The chapter will also unfold the purpose of the study, justification of the study, significance of the study and end with scope of the study.

#### 1.2 Background of the study

Technical Drawing (TD) has been my teaching subject for seventeen years. I have spent this time teaching TD in various secondary schools around the country and the recent nine years as a part-time lecturer of Engineering Drawing (ED) at Kyambogo University. I currently work as a part-time lecturer in the department of Civil and Building Engineering (CBE) where I am teaching Engineering Drawing to students who offer Bachelor of Civil and Building Engineering (BEng), Bachelor of Vocational Studies (BVoc), and Higher Diploma in Civil and Building Engineering (HDC). My tasks as a part-time lecturer in the CBE department include: lecturing, supervising students' projects and practical work, conducting tutorials, timely setting, moderating and marking of tests, course-work assignments' and examinations' scripts. In addition, I invigilate exams, and attend all departmental and Faculty Board meetings.

The CBE department of Kyambogo University was founded in 2002 as a merger of the former School of Building and Civil Engineering of the Uganda Polytechnic Kyambogo (UPK) and the Department of Technological Studies of the Institute of Teacher Education Kyambogo (ITEK). The department offers a four years Bachelor of Engineering (BEng) degree in Civil and Building Engineering and a three years Bachelor of Vocational studies

(BVoc) degree in Technological Studies with Education. The department also offers diploma programmes that include; Ordinary Diploma in Civil and Building Engineering, Ordinary Diploma in Water Engineering, Diploma in Education Secondary (Technological studies) and Higher Diploma in Civil and Building Engineering.

The main goal of the BEng program is to impart, promote and advance Science and Technology for development, and transformation of society. To achieve this goal, the department strives to impart its BEng graduates with rich technical skills both in theory and practice in addition to other skills needed by engineers such as teamwork, social and professional ethics, and environmental awareness and protection. By the end of the program, graduates of the program should have acquired six competencies. The first competence is explaining the theoretical and practical aspects of Analysis, Design and Construction Planning. The second is designing, tendering for and execution of construction projects by working for and with other partners or by self-employment. Then managing construction projects; Maintaining buildings and other civil engineering infrastructure is the third competence. The fourth is carrying out research and innovation in Science, Engineering and other related fields including the use of ICTs in Civil and Building Engineering and the sixth competence is imparting the acquired knowledge and skills to other interested persons.

To achieve competencies in planning and designing of construction projects such as buildings and roads, the students are taught Engineering Drawing (TCBE1103) in the first year of the program. The mode of delivery of Engineering Drawing (TCBE1103) skills and Knowledge is by lectures, tutorials, assignments, tests and practical work. Engineering Drawing (ED) which is also known as Technical drawing (TD) especially at secondary school level is a means of graphical communication that consists of some technical rules or drawing conventions and visual skills (Olkun, 2003). TD is further defined as a means of clearly and concisely communicating all the information necessary to transform an idea or a

concept into reality (Giesecke, et al., 2008). ED is an essential part of Engineering Design and crucial in the graphical communication skills of engineering graduates. Ability to produce, read and correctly interpret engineering documentation (including drawings) is critical for the successful work of professional engineers.

### **1.3 Situation Analysis**

The information gathered by the researcher from the ED course unit lecturers during the Directed Vocational Study (DVS), showed that a topic is always introduced by illustrating it on the chalkboard as the students observe and then tasks are given for the students to work on as the lecturer supervises their progress. The lecturer then moves around the lecture room to guide and help those who need help and wraps up the lecture with a take home assignment to help the students perfect the concepts taught. One of the lecturers pointed out that it's mostly students who never did Technical Drawing at secondary school level that struggle most because everything in geometry is new to them. The students confirmed what the lecturer shared with me and added that during the lecture, the lecturer's explanation helps them to understand everything being taught but after sometime they forget the steps especially those who are taking drawing for the first time.

During the situation analysis, the researcher observed with concern, that a certain group of BEng students experience a lot of difficulty in understanding the ED course unit. This group is comprised mostly of students who have no prior knowledge of Technical Drawing. These students either came from secondary schools that didn't offer Technical Drawing, or they did not offer the subject by choice. According to the Bachelor of Engineering in Civil and Building Engineering (BEng) program book (2009), the entry requirements for the BEng program is at least two principal passes in physics and mathematics obtained at the same sitting of the Advanced Level Examinations or its equivalent (CBE, 2009). The essential subjects are Physics and Mathematics; the relevant

subjects are Chemistry, Economics, Technical Drawing and Fine Art; and the desirable subjects are General Paper and any other Technical Subject. However, from my personal experience as a teacher of Technical Drawing, the subject is offered in very few secondary schools around the country. As such a good number of students are admitted to the BEng program without prior study of mechanical, geometrical and building drawing which makes the teaching of Engineering Drawing a top priority if the department is to produce competent engineers.

A total of four hours a week are allocated to ED on the timetable for each of the day and evening programs and the course unit is offered only in the first semester of year one. Due to the limited time available on the timetable for face to face lectures and tutorials, the entire ED content for the BEng program at the CBE department is compressed into the first semester of the first year of study. This inevitably means that the student has to learn, practice, master and be in position to apply the learned concepts in just one semester. Currently, the lecturer remains the only source of knowledge and in addition, even the available ED text books are not illustrated well enough for a beginner to follow without the instructors' assistance.

At this point of the situation analysis, the pertinent concern that stood out was that the issue of content delivery versus limited time allocated, constituted a major gap when it comes to the teaching and learning process of ED in the BEng program. This called for convening all stakeholders in a Focus Group Discussion (FGD) to brainstorm on the issue and forge a way forward.

#### **1.4 Future Workshop**

In December 2016, the FGD with stakeholders was held using the future workshop (FW) tool to discuss the area of concern identified during the situation analysis. The stakeholders of the CBE department that were selected for the FGD included; the Dean

Faculty of Engineering, Head of Department of Civil and Building Engineering, Lecturers of Engineering and Technical Drawing, Computer laboratory staff and technicians, and current students of the BEng program. Other stakeholders invited for the workshop were former students of the department who are now in the world of work as practicing engineers.

These FGD interviews sought to establish the reasons and solutions for the poor learning outcomes displayed by the BEng students in ED, even after they have studied it in the first semester of their first year in the Engineering course. One of the participants attributed the poor ED learning outcomes displayed by the BEng students to the too much content taught in a very short period. “The students lack initiative to practice learnt concepts” said one of the lecturers who attended the FW. Limited reference sources and the available engineering drawing books not being illustrated well for a student to understand without the help of the lecturer were among the other gaps identified.

During the fantasy phase of the stakeholder’s FW, a number of solutions to the identified gaps were suggested. The solutions that constituted the workshop’s ‘idea store’ were as follows:

- i. Project assignments that enable students put to practice the application of the concepts learnt in the lecture room,
- ii. Use of practical aids and animated models during lectures to reinforce visualization and understanding of concepts,
- iii. Lecturers should give more assignments that can enable students to continue practicing even outside the lecture room, and;
- iv. Develop audio visual animated tutorials that can be accessed outside the lecture room so that students can learn, visualize and practice ED everywhere they are at a given time.

Owing to the limited time available for the study, when the participants evaluated the above 'idea store' using pairwise ranking, idea number four was selected as the intervention that can be implemented in the given time of the study. The participants noted that the use of appropriate teaching software applications reduces the amount of time spent on writing and drawing on the blackboard, gives the time to lecturers to add new information and initiatively teach.

As a student pursuing a Masters in Vocational Pedagogy (MVP), the researcher was required to undertake an Action Research (AR) as part of my studies. This AR involved the researcher conducting a study that not only has direct relevance to my practice of teaching ED at the work place (trade), but also enhances the development of positive learning outcomes for my clients (students) in the department of CBE at Kyambogo University. Action research, therefore, enabled me to be a facilitator of positive changes in the teaching and learning processes experienced by students who offer ED in the BEng program in the CBE department. The ultimate goal of this action research was to collaborate with the stakeholders in trying to design, implement and evaluate an Audio-Visual Animated Technical Drawing (AVATED) application as a tool to better the learning outcomes of the students who study ED in the BEng program.

### **1.5 Statement of the problem**

Through the work processes analysis, the researcher established that the BEng program allocates the ED course unit only four contact hours per week for the lecturer to meet and teach the students. This in turn leaves the lecturers with the option of largely rushing through the course content theoretically with limited demonstration sessions and hands on opportunities for the students. Consequently, the students finish the ED course unit with limited ED skills and yet these are critical for their subsequent engineering studies and operations in the world of work. In addition, FGD interviews that the researcher held with

relevant stake holders through the FW tool revealed that the absence of audio-visual animated tutorials and digital models is one of the major gaps in the teaching and learning processes of the BEng students. This deprives students of a chance to visualize the concepts being taught, and the opportunity to learn and practice drawing outside the lecture room at any time of their own convenience. According to the stakeholders in the CBE department, the use of audio-visual animated tutorials and digital models for learning by the BEng students outside the program's lesson contact hours would go a long way to enhance students' acquisition of ED skills and knowledge. This study was therefore intended to: explore the use of existing Computer Aided Design (CAD) and animation software in the CBE department to design an Audio-Visual Animated Technical Drawing (AVATED) application; implement the use of the AVATED application in the teaching and learning of ED, and Evaluate the impact of using the AVATED application for teaching on students' acquisition of drawing competencies in ED among the students of the BEng program at the CBE department of Kyambogo University.

### **1.6 Purpose**

The purpose of this study was to design an AVATED application that can be used as an ED teaching-learning tool for the BEng students, and to evaluate the application's impact and its challenges when used for improving teaching and learning of ED for better learning outcomes.

### **1.7 Specific Objectives**

- i. Examining the teaching and learning of Engineering Drawing in the CBE department.
- ii. To design an Audio-Visual Animated Technical Drawing (AVATED) application that can be used as an Electronic Learning (E-Learning) tool by CBE students in the BEng program.

- iii. To implement the AVATED application as a teaching-learning tool for learning ED by CBE students in the BEng program
- iv. To evaluate the impact of using the AVATED application for teaching and learning on students' ED learning outcomes.

### **1.8 Justification of the study**

The use of audio-visual tutorials in teaching and learning is not a new phenomenon around the world and its positive impact on the student's visualization and learning outcomes is a known fact. However, most of these studies have been focused mostly on developing self-teaching movie clips and not sequential content for a course unit. The design, implementation and evaluation of AVATED as an e-learning tool for ED, was to enable students of the CBE department to learn more content in less time, study at their own pace and from any location. The combination of text, sound, color, and moving images of the e-learning application was to also motivate the students by shifting the pedagogy from a lecturer – centered classroom based environment to a more learner-centered and everywhere learning environment.

### **1.9 Significance of the study**

The findings of this study are to first and foremost, improve the teaching and learning outcomes of the BEng program in the CBE department. The students were to be able to schedule their own study time and also be able to practice the learnt concepts anywhere and at any time. The AVATED application has been a good teaching tool for the lecturers who will be able to effectively cover more content in a short time. In addition, the findings of this study were of good use in improving students' ED learning outcomes in other departments in the Faculties of Engineering and Science, public and private universities around the country, Vocational Training Institutes and secondary schools that offer technical drawing.

## **1.10 Scope of the study**

The scope of the study included geographical, content and time scopes.

### **1.10.1 Geographical Scope**

The study was conducted at the Civil and Building Engineering department of Kyambogo University. Kyambogo University is located in Kampala district in central Uganda.

### **1.10.2 Content Scope**

The study sought to design an AVATED e-Learning application, Implement, and also evaluate its success and challenges when used as a teaching and learning tool for improving students' ED learning outcomes.

### **1.10.3 Time Scope**

The study took thirteen months because action research is cyclic in nature and as such some aspects of the study were recurrent. Also, the fact that ED is only taught to the BEng program in the first semester of year one, and also considering the limited time of the study, arrangements were made by the stakeholders at the department to organize BEng and BVoc students to volunteer for the implementation of the intervention in the period between March and June 2017.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter provides an overview of previous research on the use of Audio-Visual Animated tutorials (also known as e-learning or multi-media applications) as a tool that uses available ICTs (such as computers and the internet) to enhance the teaching and learning experience. This is in order to scope out the key data collection requirements for the action research study to be conducted, and to form part of the emergent research design process (Dencombe, 1998). The approach adopted is in line with current practice in grounded research work. It is now regarded as acceptable for researchers to familiarize themselves with existing research prior to collecting their own data (Easterby-Smith, Thorpe, & Lowe, 2002).

An appreciation of previous work on Audio-Visual Animated tutorials as an e-learning tool and how they are adapted to available ICTs to enhance teaching and learning will serve three primary purposes. First, through providing direction in the construction of data collection tools, it will guard against the risk of overload at the primary data collection stages of the project. Second, working the action research study findings from extant literature will help maintain throughout the study a sense of the topic's perspective. Finally, this activity will raise the opportunities for articulating a critical analysis of the actual "meaning" of the data collected when the data analysis stages of the research are reached.

The chapter begins by outlining the strategy that was used to search for the data and then sets the conceptual framework of animated tutorials (e-learning) applications in the teaching and learning process. Literature on the previous studies about animated tutorials and the use of ICTs in the teaching and learning process is then discussed under the design, implementation and evaluation themes of the action research study.

## 2.2 Literature Search Strategy

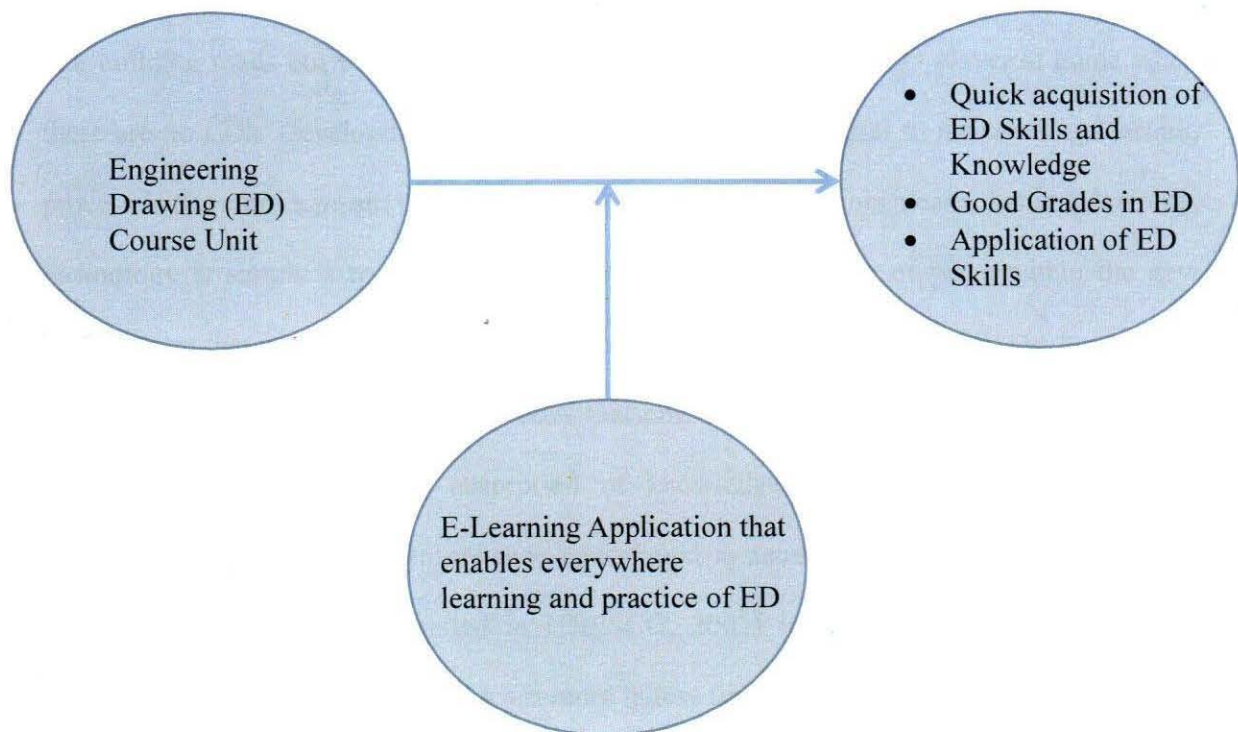
The researcher accessed all literature relevant to animated tutorials and use of ICTs in education, using libraries and search engines. Specifically, the researcher searched Google Scholar in multiple databases to identify the most recent literature on design, implementation and evaluation of animated tutorials and use of ICTs in the teaching and learning process. The researcher used different searches starting with descriptors that appear only in the study title, and later various keywords that had earlier been encountered during the situation analysis and FGDs. During the search, the researcher discovered that the topic of Audio-Visual Animated Technical Drawing (AVATED) was too broad and as such narrowed it to its direct synonyms such as animated tutorials, e-learning, ICTs in education, and multi-media learning applications. As such, the terms used during the literature search included *animated tutorials, ICTs, ICTs in Technical education, e-learning, multi-media learning applications, and e-learning applications.*

The seminal studies threshold for this action research study's literature review is 15 years. However, in some cases studies older than my initial threshold were very useful to the study as they helped conceptualize the historical perspective and relationships that exist between animated tutorials, e-learning, ICTs in education, and multi-media learning applications.

## 2.3 Conceptual framework concerning animated tutorials (e-learning) and ICTs in learning

The conceptual framework of this Action Research was based on e-learning and the integration of ICTs in the teaching and learning process. Figure 2.1 shows the study conceptual framework in which the independent variable is Engineering Drawing and the dependent variables (desired outcomes) are; Quick acquisition of ED Skills, good grades in ED, and application of ED Skills. An animated e- learning application that enables the

learning and practice of ED to take place not only in the lecture rooms but everywhere a student may be, would positively impact on the desired outcomes and as such constitutes the intervening or confounding variable of this action research study.



*Figure 2.1:* Conceptual framework of the Action Research study

The findings of a research by Haddad & Draxler, (2002) conducted in the UK and Africa (Ghana, Rwanda, South Africa, Tanzania) concluded that, when the pedagogy shifted from a teacher - centered classroom environment to a more learner - centered environment, the effectiveness of ICT was enhanced. ICT in the context of this study refers to the computer and internet connections used to handle and communicate information for learning purpose (Mikre, 2011). Tinio (cited in Mikre, 2011) goes on to define e-learning as a learning program that makes use of an information network- such as the internet, an intranet (LAN) or extranet (WAN) whether wholly or in part, for course delivery, interaction and/or facilitation. Web-based learning is a subset of e-learning and refers to learning using an internet browser such as the Moodle, blackboard or internet explorer.

There is a temptation these days to equate technology with computers and the internet, leaving contentware (which is evidently the most crucial component), as one of the most forgotten areas (Wawasan Open University, 2017). Introducing televisions, radios, computers, and connectivity into schools without sufficient curriculum-related contentware is like building roads but without making cars available or buying a CD player at home when there are no CDs. Development of content software that is integral to the teaching/learning process is therefore a must (Wawasan open university, 2017). This means that in e-learning, technology is simply a tool that educators may use in a number of ways within the new environment that can impact student learning and outcomes (Olson, et al., 2011).

Tinio (cited in Mikre, 2011) states that one of the potentials of ICT is its ability to facilitate the acquisition and absorption of knowledge, offering developing countries unprecedented opportunities to enhance educational systems. A meta-analysis of over 500 studies conducted by Kulik (cited in UNESCO, 2003) indicated that students receiving computer-based instruction tend to learn more in less time. Similarly, Harrison, et al., (2001) explain that technology use creates a learner-centered environment by:

- Motivating learners by combining text, sound, color, and moving images that enhance content for easier learning
- Facilitating acquisition of basic skills through drill and practice
- Enhancing teacher training by improving access to and the quality of teacher training.

Hampton and Bartram (cited in UNESCO, 2003) pointed out that the major advantage of web-based training is that students can study anytime at their own pace and anywhere as long as there is a computer connected to the Internet. In addition, Olson, et al., (2011) pointed out that computer based strategies help students develop higher-order thinking and problem-solving skills. Participation in real-life applications allows students to draw analogies, infer relationships, predict outcomes and analyze data (Olson, et al., 2011). Also, Kamakar (cited

in Najafabadi, Poorsadegh, & Mirdamadi, 2013) observes that e-learning brings several attractive opportunities for organizations: (1) it saves time, cost, and effort; (2) satisfies educational needs from remote areas; (3) provides self-learning opportunities; (4) it gives a positive impact on the learning process; and (5) provides a mechanism for collaborative learning (p. 105).

Is the role ICTs can play in education has been noticed by society? Mikre (2011) points out that “because Information and Communication Technologies (ICTs) provide both students and teachers with more opportunities in adapting learning and teaching to individual needs, society is, forcing schools to aptly respond to this technical innovation” (Mikre, 2011). However, the general consensus is that an ICT on its own cannot be regarded as an enabler of knowledge-sharing activity: Huysman & De Wit (as cited in Hall, 2004) notes that “If people do not like to share knowledge, ICT tools will not change their minds. And if the opposite is also true, if people want to share knowledge, they will use whatever is at hand to support it”. They further point out that “communities do not exist thanks to ICT, but ICT might offer good support to communities; especially where people or groups who are distributed over a wide geographical area are concerned” (p. 19). This calls for a blend between traditional and technology driven learning settings.

Voogt (cited in Mikre, 2011) differentiated between traditional learning setting and constructivist approaches. The former considers learning as the transmission of knowledge to students, which is the sole responsibility of the teacher. On the other hand, the constructivist approach considers learning as authentic and learner centered. ICT, the computer for example is a great help in the constructivist approach, where one can design simulated and individualized learning environments to students. The use of such multisensory media provides for optimal combination of media and interaction, it offers increased opportunities

for increased interaction with students, and ensures equity in educational opportunity (A. Baron cited in Yusuf & Falade, 2005, p. 23).

For a long time the education of Engineering Drawing (ED) kept the old style; the teaching thought, teaching contents and teaching methods did not change. As computer hardware and software, multimedia technology, and CAD and CAM have been developed and perfected, the education of Engineering Drawing (ED) faces a great challenge (Zuo et al., 2003). In fact Urdarevik (2013) points out that teaching any topic in engineering graphics from a textbook is traditional, and in many cases, boring and difficult for the students to understand. Kosse & Senadeera (2011) noted that one of the challenges that was identified over the years of teaching the ED course unit in the school of Engineering Systems (SES) at Queens University of Technology (QUT) in Australia, was that due to varying initial drawing skills, it was very difficult to tailor exercises because students' progress at a different rate. They add that "Students are coming to study engineering degrees with drawing skills varying from zero to advanced, which makes it difficult to tailor training" (Kosse & Senadeera, 2011).

The modernization of education is therefore an important research task and Computer Aided Instruction (CAI) and web-based education software are the main means to realize this education modernization (Zuo, et al, 2003). According to Strong and Smith cited in Urdarevik (2013) "*Visualization skills have been found to correlate highly with successes in engineering, and mathematics in general*". It's therefore agreeable across the spectrum that powerful simulation environments, multimedia capability and high-end visualization support enables a learner to relate to the subject much more deeply and hence understand well (Najafabadi, Poorsadegh & Mirdamadi, 2013).

On the issue of technology choices, Nunes & Gaible (2002) point to the use of video, simulation, and animation as the instructional multimedia material that regularly achieves

success. They argue that Videos motivate students by showing real-life situations, in ways that are often superior to a teacher narrating them or a text describing them, and that the most remarkable aspect of simulations is interactivity, or the opportunity for the learner to change values or conditions and see what happens. They add that animations often may be the best tools for creating a sequence of visualizations with increasing degrees of sophistication, enabling student understanding to go far beyond crude and simple models (Nunes & Gaible, 2002).

### **2.3.1 Design of e-learning applications**

If technology-enhanced education programs are taped classrooms, digital texts, and PowerPoint transparencies, then we are missing out on the tremendous potential of technologies that can animate, simulate, capture reality, add movement to static concepts, and extend our touch to the whole universe (Wawasan Open University, 2017). The UNESCO analytical survey on the use of ICTs in Technical and Vocational Education and Training (TVET) pointed out that many course development tools are now available, which allows instructors with no computer programming skills to develop high-quality web-based training programs. The three most commonly used platforms are: Blackboard (<http://www.blackboard.com>), Desire2Learn (<http://www.desire2learn.com>), and WebCT (<http://www.webct.com>). All the three solutions are server-based and allow access through a web browser to provide e-learning solutions through the Web. However, the same survey noted that the disadvantages of these web-based platforms include: user institution having no control over licensing cost; difficulties when the supplier goes out of business; platform providing more unnecessary features; platform not being available in the preferred language; and the platform may require high-end systems (UNESCO, 2003). This means that for an institution to have control over the e-learning applications, they must design it themselves or have it specifically designed for them.

Many studies have identified the challenges affecting designing of an ICT-based training system. For instance, Bersin, Holder and King (cited in Najafabadi, Poorsadegh , & Mirdamadi, 2013) pointed to content development, infrastructure and deployment challenges while White (also cited in Najafabadi, Poorsadegh , & Mirdamadi, 2013) mentioned time constraints . Stevens (cited in UNESCO, 2003) notes that one of the obstacles for online learning is that the development of quality applications requires a team of moderately to highly skilled individuals in computer applications and instructional design. The team may need to include a computer programmer, graphic artist, content specialist, and instructional designer (UNESCO, 2003). Also, Kemske (cited in UNESCO 2003) points to past surveys which have determined that over 200 development hours are required to produce one hour of online learning and that for highly interactive lessons, the number of hours can jump to 800, even 1000 hours.

Ensuring quality and usability of the system is a top priority during the design phase of an e-learning application. Jaryenpaa & Staples (cited in Hall, 2004) argue that in the case of online systems, the interface presented to potential contributors is important. They continue that “Sharing should be higher when the technology attributes and conditions decrease the psychological costs of sharing (e.g. user friendly systems)”. Systems that are difficult to use may impede the growth or critical mass of the system (Huysman & de Wit, 2002). In concert with quality and usability, Hampton and Bartram (cited in UNESCO, 2003) pointed out that people read 25% slower from the screen, and Delio (also cited in UNESCO, 2003) indicated that retention of what is read on the screen is 30% less than from printed materials (p. 35). This means that without adequate infrastructure, the quality of graphics, audio, and video may be sub-par. If the application is not designed properly and the quality is degraded, the applications may hinder learning instead of enhancing it. The learning materials may be reduced to simply a text on a screen (UNESCO, 2003).

Engineering departments around the world have already made progress in as far as designing their own e-learning applications for use in the teaching and learning process. A case in point is Zuo et al., (2003) who notes that the Department of Engineering and Computer Graphics, Guangdong University of Technology, Guangzhou, have already completed a series of multimedia CAI software on Descriptive Geometry and Engineering Drawing and used them in all classes and after classes. Students can review with the Engineering Graphics CD or on the Internet. They add that, the computers have taken over a lot of the teachers work so that teachers pay more effort on innovative research. Zuo et al., (2003) further contend that, without CAI software, the reform of Engineering Drawing would not have been carried out at all. As such they spent years developing multimedia CAI software and permanently updating it according to the teaching progress.

From an instructional architecture perspective, technology enhanced materials may be designed in one of the following three ways: first, as enrichment materials that may be used in addition to existing materials at the discretion of the teacher or learner, second, as structured multimedia programs that cover a particular course, and third, as multimedia modules that are constructed in a flexible way so as to serve as building blocks of different curricula and teaching practice (Wawasan open university, 2017).

On development of e-learning materials, Nunes & Gaible (2002) pointed out that professionals should be involved in production of good storyboards, lighting and shooting the video, and editing and postproduction. Beta-format equipment should be used, rather than VHS, to ensure high quality. For developing simulations, they argue that Java and Shockwave are extremely popular with developers so much so that recent browsers do not even require plug-ins to run code developed in these formats. They add that animations are created by digitizing and sequencing hand-drawn images, or directly through the use of 3-D and other software (Nunes & Gaible, 2002).

To develop the multimedia software for the Department of Engineering and Computer Graphics, Guangdong University of Technology, Guangzhou, Zou et al., (2003) used many developing tools, such as 'TOOL-BOOK', 'AutoCAD', '3Dsmax', 'Photoshop', and 'VB'. For the web-based software, they used 'FrontPage' and 'Dreamweaver' to establish the main page. They used 'Flash' to draw 2D animations and used VRML to establish real time 3D animations.

### **2.3.2 Implementation of e-learning applications in the teaching and learning process**

On the questions of who shares knowledge? Where is knowledge shared? What sort of Knowledge is shared? And, how is knowledge shared? Huysman and De Wit (2002) break down the answers into three critical aspects of knowledge-sharing: managing knowledge-sharing, learning from knowledge-sharing, and ICT support for knowledge-sharing.

Technology can be used in education in two different ways: one as an add-on to make the current model of education more efficient, more equitable and cheaper, and two, by integrating technology into the entire education system to realize structural rethinking and reengineering (Wawasan open university, 2017). To prepare for the education of the future, the blending of technology, pedagogy, and content is paramount and in considering the relationship between them, it is important to explore how teaching and learning can change as the result of using a particular technology (Olson, et al., 2011). Therefore, '*blending*' becomes the key word in implementation of e-learning applications.

Blended Learning refers to learning models that combines the face-to-face classroom practice with e-learning solutions. For example, a teacher may facilitate student learning in class contact and use the e-learning application to facilitate out of class learning (Mikre, 2011). Olson et al., (2011) point out that technology is a powerful and effective tool, however if teachers use it only as a delivery vehicle, the outcomes will be less than its potential. The challenge, they add, is to make full use of technology so that it doesn't become simply a

substitute teacher. Indeed, instructional content can be embedded in the technology and then delivered to the student with the assumption that if you deliver content the students will learn. They conclude that by blending the use of technology with teaching by the teacher, students have been shown to have much higher learning outcomes (Olson, et al., 2011).

For a successful implementation, there is need to have the right media and infrastructure in place. Yusuf & Falade (2005) pointed out that media must be used to improve the quality and quantity of the learning process. Olson, et al., (2011) pointed out that, in a multi-media classroom, educational content is delivered to students in a one-to-many approach. Classrooms would be equipped with a projector, screen (or large LCD), speakers and a classroom computer. The teacher could display various types of content that is housed either on the classroom computer or on the teacher's laptop or other device (Olson, et al., 2011). Also a computer lab is among the most recognizable form of e-learning technologies. Olson et al (2011) continue that a computer lab usually consists of many single personal computer stations. Separate stations permit individual students to move at their own pace through material. Teachers can also lead students or student teams through guided exercises, with each following on their own station (Olson, et al., 2011).

The Department of Engineering and Computer Graphics, Guangdong University of Technology, Guangzhou, China, are among the leading implementers of e-learning applications in the teaching and learning of the ED course unit. Zuo et al., (2003) pointed out that the department abolished all the old teaching methods, including the blackboard and chalk, wall-picture, optics projector and epidiascope etc. All Engineering Drawing classrooms are equipped with multimedia computers, large screens and video projectors. This is because the computer multimedia CAI software and Internet CAI are the main teaching techniques in the school. They add that the schedule of study is controlled by students themselves. Those students, who understand well, can complete the fundamental

requirements early. Thus the teacher assigns them to a higher mission, for example, 3D modeling, small design or joining the teacher's scientific research work (Zuo et al, 2003).

The barriers to implementation of e-learning applications in the teaching and learning processes include accessibility, infrastructure, rigidity to change, and lack of awareness. The reality of the digital divide- the gap between those who have access to, and control technology and those who do not, makes a huge difference in the use of ICTs. This means, that the introduction and integration of ICTs at different levels and various types of education is the most challenging undertaking (Mikre, 2011). Datuk and Ali (cited in Najafabadi, Poorsadegh , & Mirdamadi, 2013) implied that the lack of awareness amongst the population, low adoption rate in most institutions, bandwidth issues and connectivity, computer literacy and the digital divide, lack of quality e-content, difficulty in engaging learners online, and language barriers are the main challenges hindering the migration from traditional learning mode to the e-learning mode (p. 106).

Yusuf & Falade (2005) pointed to electricity, libraries with ICT facilities, and telecommunication as the infrastructural facilities that should be provided in towns and other rural areas to facilitate the use of modern technology products. Olson et al (2011) pointed to the teacher's inability to adapt to technology. They argue that the challenge for many if not most teachers, particularly in developing countries, is changing their practice of teaching in ways that accommodate the use of technology. They point to research which indicates that professional development for teachers, including initial training and ongoing support, is a key factor in supporting successful change in educational practices, including development of e-learning (Olson, et al., 2011).

Thus, Olson et al (2011) conclude that although technology is here to stay and is being rapidly infused into all aspects of education globally, the presence of technology must be coupled with a wider transformation effort to improve student outcomes. They add that the

integration of technology into an educational system is a complex process with implications for policy, curriculum, infrastructure, support and training (students, teachers, tech support staff, administrators, and others).

### **2.3.3 Evaluation of e-learning applications as a teaching and learning tool**

An analysis of several international ICT integration plans shows that the long run adoption of ICT into education systems has been successful when done as an integral and holistic component of education (IETE cited in Olson, et al., 2011). The findings of Kulik (cited in Mikre, 2011) across 75 studies in the United States, showed that: Students who used computer tutorials in mathematics, natural science, and social science score significantly higher on tests in these subjects. Students who used simulation software in science also scored higher (p. 3).

Kozma (cited in Olson, et al, 2011) pointed to research which suggests that simply putting computers into schools is not enough to impact student learning. That said, Kozma continues that, specific applications of ICT can positively impact student knowledge, skills and attitudes, as well as teaching practices, school innovation, and community services (p. 2). Although it is expected that the most direct impact of e-learning would be on the learning achievement of students, the results of large, cross-national studies show that the effects of e-learning applications on learning are complex and closely related to how the technology is used as an educational tool(Olson, et al., 2011).

Two key elements must be taken into account when considering the effectiveness of learning technologies, namely instructional effectiveness; and instructional efficiency (UNESCO, 2003). In many studies, effectiveness has been viewed only in terms of learning gains on post-tests. However, Nathenson and Henderson as cited in UNESCO (2003) argued that although improved student performance is an important element, it should not be the only indicator of instructional material effectiveness (p. 114). In fact, Chinien also cited in

UNESCO (2003) suggests that instructional material effectiveness should be viewed within a framework, which encapsulates three major elements: achievement, study time, and the students' attitude toward the material.

Olson et al (2011) pointed out that the greatest challenge of performing any economic impact, especially with technology interventions, is dealing with the time lag between interventions and outcomes. They continue that, in the e-learning environment, it is important not to fall into the trap of expecting immediate returns from the intervention. This time lag means that an effective assessment program either needs to focus on more immediate metrics—e.g., an intent to pursue a college degree and become an engineer—or to recognize that any assessment must include a long term panel to follow students through the extended transformative process between intervention and economic outcomes (Olson, et al., 2011).

#### **2.4 Literature Summary**

The concepts discussed in this chapter support the rationale for pursuing the development of e-learning applications that can use available ICTs to enhance the teaching and learning process. The literature analysis has reviewed research on the need for ICT in teaching and learning, design and implementation of e-learning applications in teaching and learning, and evaluation of such applications as a teaching and learning tool. Unfortunately, the researcher did not find any research that was on design, implementation, and evaluation of an e-learning application of ED that is based on the course outline approved by the National Council for Higher Education (NCHE).

The successful conduct of this study will contribute to the integration of e-learning in the teaching of Engineering Drawing in the CBE Department of Kyambogo University. The study will also provide recommendations from the analyzed data on design, implementation and evaluation of the application that will inform not only the CBE Department, but also the entire faculty of Engineering and other VET institutions offering the ED course unit.

## CHAPTER THREE

### METHODOLOGY

#### 3.1 Introduction

In this chapter, the researcher gives a detailed description of the research design including the qualitative method of inquiry selected for the study, the population, sample size and sampling technique. The chapter also describes the methods of data collection, instruments of data collection, procedure of data collection, data analysis, and implementation of action production objective.

#### 3.2 Research Design

This study used a collaborative and adaptive research design because it lends itself to use in work or community situations since it is an action research design. The choice for an action research design was because it seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities (Reason & Bradbury, 2001).

The researcher initially adopted an exploratory design so as to gain an understanding of the problem and develop plans for some form of intervention strategy. Then together with the stakeholders, we carried out the intervention (the "action" in Action Research) during which time, pertinent observations were collected in various forms. Owing to the fact that action research is a work in progress (Brydon-Miller, 2003) study, the interventional strategies of this study were carried out in a cyclic manner, and this cyclic process was repeated continually until when a solution was achieved.

#### 3.3 Target Population

The study target population was the year one BEng class from the CBE department. The program had 129 students on the day program and they were taught by a total of 10

lecturers in the first semester of year one. Out of the 129 students 118 were males and 11 were females.

### 3.3.1 Sample population

For this study, the researcher selected participants who were direct stakeholders of ED in the CBE department. These included the department administrators, ED lecturers, computer lab technician, alumni in the world of work and BEng students. Table 3.1 shows the sample population and their respective purpose in the study and implementation of the intervention.

Table 3.1: *Sample Population and their Respective Purpose in the Study*

<b>Participants</b>	<b>Purpose in situation analysis</b>	<b>Purpose in design and implementation</b>
Dean of Faculty of Engineering	Gave general information about the faculty of engineering and share his own experience of ED	Advised on functionality and system design
Head of CBE department	Gave information about the department and shared own experience of ED	Advised on function, system design, and give permission to use CBE premises.
ED Lecturers	Gave information about the teaching and learning processes	Generated content for AVATED
Computer Lab Technician	Gave general information about ICT and E-learning	Availed software and assisted in design and installation
Alumni in the world of work	Gave information on the relevance of content	Advised on relevance of content for AVATED
Students	Gave information on teaching and learning	Provided feedback on design and performance of AVATED

### 3.3.2 Sampling technique

In this study, the researcher used stratified sampling technique to select students to participate in the study and purposive sampling technique to select the dean faculty of Engineering, head of CBE department, ED lecturers, computer lab technician and alumni from the world of work.

A stratified sampling technique was used to select students because their population embraces a number of distinct categories and this sampling technique ensures the representative participation of each category in the study (Teddlie & Yu, 2007). The categories or strata included male and female students, those who offered and those who didn't offer TD at secondary school level. The researcher organized the student population into the separate strata and then sampled each stratum as an independent sub-population, out of which individual participants were selected. Table 3.2 shows the different strata (Gender and TD background) of the target student population of the year one BEng day program.

Table 3.2: *Different Strata of the Target Student Population*

	MALE	FEMALE	TOTAL
Have TD Background	35	3	38
No TD Background	82	9	91
<b>TOTAL</b>	<b>118</b>	<b>11</b>	<b>129</b>

The purposive sampling technique was used to select administrators, lecturers and computer lab technician because each of these categories of persons has important information they can provide that cannot be gotten as well from other choices (Maxwell, 1997). The researcher selected very small sample sizes for these categories because the size of their target populations was equally small.

### 3.3.3 Sample size

Due to the limited resources such as time and money available for this study, the researcher used a smaller but representative collection of the stakeholder's population to implement and evaluate the impact of the intervention on learning outcomes in ED by the CBE students. Table 3.3 shows the sample size for the study. 16% of the total stakeholders of the year one BEng program were selected for the study. Of those selected for the study, 82% were male and 18% female. Also, out of the fifteen students selected for the study, 67% had offered Technical drawing at secondary school level and the remaining 33% had first offered technical drawing at the university.

Table 3.3: *Sample Size for the Study*

Participants	Number of participants (Sample)	Gender		Technical Drawing Experience		Target Population (Size)
		Male	Female	Done TD Before	Never Done TD before	
Dean of Faculty of Engineering	1	1				1
Head of CBE department	1	1				1
Lecturers	2	2				2
Computer Lab Technician	1	1				2
Alumni in world of work	2	1	1			N/A
Students	15	12	3	10	5	130
<b>Total</b>	<b>22</b>	<b>18</b>	<b>4</b>	<b>10</b>	<b>5</b>	<b>136</b>

### **3.4 Methods of data collection**

The methods of data collection for this study involved focus group discussions, individual interviews and observations.

#### **3.4.1 Focus group discussions**

The study employed this method to collect information from stakeholders in the CBE department with the aid of the FW tool that gives guidance on the subject and stages of group discussions held at the different stages of the AR study. Groups offer the ideal setting to make participants “do” something and answer questions in a more active way, taking the discussion more in-depth and in a potentially more enjoyable way (Colucci, 2007). This method enabled the participants to generate ideas through brainstorming and open discussions of issues at hand.

#### **3.4.2 Individual Interviews**

One of the researcher’s main tasks in this study was to understand the views of the interviewees (Kvale, 1996) and also pursuing in-depth information around the topic (McNamara, 1999). This method was used with the dean of faculty of engineering, the head of CBE department, lecturers and computer laboratory staff. In all cases, the interviews enabled triangulation of the information obtained from the different categories of participants in the focus group discussions, thus strengthening the validity and reliability of the data that was collected.

#### **3.4.3 Observations**

This method was used to establish the infrastructure, equipment and technology used in the teaching and learning process of ED at the CBE department. Observation combines participation in the lives of the people being studied with maintenance of a professional distance that allows adequate observation and recording of data (Fetterman, 1998). This method was therefore used to verify documented information about ED such as time tables,

course outline and the program book. Observational data collected helped to evaluate the fidelity of an intervention across settings and identify when 'stasis' has been achieved (Cohen & Crabtree, 2006).

### **3.5 Instruments of data collection**

The instruments that were used in the study are the individual interview guide, focus group discussion guide, observation checklist, and questionnaires.

#### **3.5.1 Individual interview guide**

This study sought to get in-depth information from participants about the teaching and learning of ED. Thus, the study employed interview guides in order to get in-depth information pertaining to individual participant's experiences and viewpoints on the study topic (Turner, 2010). This instrument helped to elicit information about specific topics of the study.

#### **3.5.2 FGD Guide**

The FGDs were structured around a set of carefully predetermined questions laid out in a FGD guide. The guides had a maximum of ten carefully predetermined questions depending on the study stage (Design, Implementation or Evaluation) and were structured in a way that would stimulate a free flowing discussion. This guide sought to get information about the participant's perceptions, opinions, beliefs, and attitudes towards the study interventions.

#### **3.5.3 Observation checklist**

A checklist was designed and developed for the study. This instrument was used for verification of data from interviews and getting additional data that may have been missed. This instrument enabled us gather data concerning the various equipment used in the teaching and learning of ED at the CBE department. This instrument was also used to

compare the students' drawing speed, neatness and accuracy in drawing before the intervention and after the intervention of the study findings.

#### **3.5.4 Questionnaires**

The study employed self-developed questionnaires with survey questions asked to study participants, and designed to extract specific information (see Appendix B, C, D, and F). The questionnaires served four basic purposes: (1) collected the appropriate data, (2) made data comparable and amenable to analysis, (3) minimized bias in formulating and asking questions, and (4) made questions engaging and varied. The questionnaires generally consisted of open and closed-ended questions or items. Closed-ended questions forced a response, scored quickly, and were easy to evaluate, whereas Open-ended questions allowed the participant to provide a more complete or comprehensive response.

To ensure validity of this instrument, the questions were based on the setting and lived experiences of the study area (CBE department) and also fell within the experiences of the participants. Also, this instrument was pretested with a randomly selected group of students from the CBE department in a pilot study. To ensure reliability of the questionnaire, particular questions or items were often restated several times.

#### **3.6 Procedure of data collection**

The researcher secured a letter from the coordinator of MVP that introduced me to the head of the CBE department to allow me undertake the study. During interviews, the researcher recorded the data in a log book and also used the phone's voice recorder to record the proceedings. The phone's video recorder was used to capture information and data during focus group discussions and my phone's camera to capture information during observations and focus group discussions. In this study, the researcher enlisted the services of colleagues in the MVP program to help with recording data and taking pictures during focus group

discussions and future workshops. Data was collected at four phases and these were the situation analysis phase, design phase, implementation phase, and the evaluation phase.

During the situation analysis phase, the researcher collected data by recording information in the log book and taking photos with the phone camera. In the design phase data was collected by documenting the programming and animation procedures in the log book and Microsoft word document. The researcher also took screen shots of the application pages for use as photos. In the implementation phase, data was collected by use of documenting, voice and video recording responses of participant's activities and interactions with the application. Also recorded in the log book, were the procedures of installation and testing the application on participants' computers and smart phones. During the evaluation phase, the researcher collected data by taking minutes of participant's responses during the evaluation FGDs and FW. Questionnaires to capture participant's views and comments on the performance of the application in regards to solving the identified gap were also used.

### **3.7 Data analysis**

In this study, the researcher broke down the information under each study objective into themes and then analyzed the data collected under the respective themes. Since the data was qualitative in nature, the researcher discerned, examined, compared and contrasted, and interpreted meaningful patterns of the data. Meaningfulness of data was determined by the extent to which it addressed the study objectives.

### **3.8 Implementation of Action production objective**

The action production objective of this study included the work plans for the entire design, implementation and evaluation phases of the action research study and the budget estimates for accomplishing all the three phases.

### 3.8.1 Work plans

This Action Research Study took thirteen months from the time of conducting a situation analysis in the CBE department all through to the defence of the report. Table 3.4 shows the Action Research Study Work Plan that started in December 2016 with the situation analysis to identify the gaps that were subjected to a FW in the same month. From January to February 2017, the proposal was written and the Action Implementation and evaluation of the interventions carried out from February to June. The write-up of the Action Implementation and Evaluation was done in the months of July and August and a draft report was ready for the Mini oral presentations that took place in September 2017. After making corrections that were pointed out during the mini oral presentations, the final dissertation was submitted in October 2017 and then defended in December 2017.

Table 3.4: *Action Research Study Work Plan*

Activity	Time Frame													Deliverables
	2016	2017												
	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Situation Analysis														Report
Future workshop														Report
Proposal Writing														Proposal
Action Implementation and evaluation														Design, Implementation, and Evaluation of AVATED
Action Writing														Action Study Report
Mini oral presentation														Presentation and Corrections to report
Submission														Submit study report
Defense														Defend the study report
Graduation														Graduate

Appendix G, H and J show the detailed work plans for the implementation of the action production objective. The design phase started on 13<sup>th</sup> February 2017 and ended on 17<sup>th</sup> March 2017 (see Appendix F). During this phase we had the preliminary works (13<sup>th</sup> – 17<sup>th</sup> February), functionality (20<sup>th</sup> – 24<sup>th</sup> February), Development (27<sup>th</sup> – 10<sup>th</sup> March), and Testing (13<sup>th</sup> – 17<sup>th</sup> March). The implementation phase was 20<sup>th</sup> March and end on 7<sup>th</sup> April 2017 (see Appendix G). In this phase we had installation and training (20<sup>th</sup> – 24<sup>th</sup> March), and used the application (27<sup>th</sup> – 7<sup>th</sup> April). Lastly, the evaluation phase started on 10<sup>th</sup> April and ended on 28<sup>th</sup> April 2017 (see Appendix H).

### 3.8.2 Budget

Table 3.5 shows the budget for the design, implementation, and evaluation of the AVATED application.

Table 3.5: *Estimated Budget for the Design, Implementation, and Evaluation of AVATED*

S/N	ITEM	QUANTITY	UNIT COST	TOTAL COST
<b>EXPENSES</b>				
1	Purchase of computer Software	3	150,000	450,000
2	Hiring IT expert (software training)	1	300,000	300,000
3	Transport refund for stakeholders	20 x 5 workshops	5,000 x 20 x 5	250,000
4	Lunch and break tea for workshops	20 x 5 workshops	10,000 x 20 x 5	500,000
5	Stationary and logistics	assorted	assorted	100,000
<b>TOTAL</b>				<b>1,600,000</b>

## CHAPTER FOUR

### ACTION IMPLEMENTATION RESULTS AND EVALUATION

#### 4.1 Introduction

This chapter presents a detailed description of activities undertaken in the design, implementation and evaluation of the Audio-Visual Animated Technical Drawing (AVATED) application as a teaching and learning tool. These details include the various phases involved in the design of the application and a presentation of the key tasks that were undertaken during the implementation of AVATED. The chapter concludes with the presentation of findings and data collected from the evaluation of AVATED as a teaching and learning tool in the Civil and Building Engineering (CBE) department of Kyambogo University.

The detailed description of activities undertaken during the action implementation and evaluation are organized under three headings derived from the objectives of the study and under each heading the information is organized by themes described in the study work plan (See appendix F, G, and H).

#### 4.2 Design of the AVATED application

The design of AVATED included four stages and these were; the preliminary works phase, the functionality phase, development phase and then the testing phase.

##### 4.2.1 Preliminary works phase

The preliminary works phase of the AVATED application started with the identification of the ED content to be included in the design, then the acquisition of the software needed to design the application, and ended with learning how to use the software.

The content for the AVATED application was derived from the ED course outline in the BEng program book (2009) and together with the course unit stakeholders; it was organized and itemized in order. Not all the content could be included in the short time available for the study but a few key topics identified by the stakeholders were selected.

The design of the AVATED application involved nine types of software, which were used to; draw and animate drawings, record and edit sound, and edit videos. The researcher acquired the necessary software from the CBE computer lab technician and software vendors in Kampala. The software that was used included the Automated Computer Aided Design software (Auto CAD), Adobe flash, Adobe Dream Weaver, Solid works, Windows sound recorder, Nero Record, Nero Video, Freemake Video converter and Microsoft word. Table 4.1 shows the type of software and their respective functions in the design of the AVATED application.

Table 4.1: *Software used to Design the AVATED Application*

	<b>Software</b>	<b>Function</b>
1	Auto CAD	Making all the drawings used in AVATED
2	Adobe Flash	Animation of drawings into motion and adding sound
3	Solid works	Animation and modeling of solids
4	Adobe Dream weaver	Designing the AVATED website
5	Windows Sound Recorder	Recording all the sound used in the application
6	Nero Recorder	Converting sound media into usable small formats
7	Nero Video	Trimming and sequencing animation videos
8	Freemake Video Converter	Converting videos into usable small formats

The researcher had good knowledge of all the drawing, animation, and word processing software but required basic training in the sound, video and web design software. As such, the researcher underwent basic training in the use of sound, video and web software from software technicians at APTECH computer center in Kampala. The researcher also made use of the good internet connection at NOMA to download the numerous self-learning tutorials on the internet such as Linda.com and others on YouTube.

#### **4.2.2 Functionality**

The functionality phase of the AVATED application included two activities and these were: determining the functions and then the system architecture of the AVATED application. During the future workshop with stakeholders, a number of functions for the AVATED application were suggested to form the basis of the applications functionality. These included;

1. Easy to use and navigate
2. Clearly define and explain the topic
3. Show the application of the topic in Engineering
4. Show examples of the topic in real day-to-day life
5. Include audio explanation of the topic
6. Include a video of the topic in three dimensional motion
7. Show step by step visual animation of the examples
8. Have assignments and tasks for students to practice
9. Have provision for submission of work and also feedback from the lecturer
10. Include links to other university sites

The design layout and structure of how the application would look like was also discussed with the stakeholders and a number of suggestions were fronted. The internet was a very good source of ideas and information on the design of a simple but interactive e-learning

application. Throughout the design phase, the layout and structure of the application kept on changing as new and better ideas kept on emerging as we progressed.

#### **4.2.3 Development of AVATED**

The development phase of the AVATED application included drawing of all figures that were to be used in the application, animation and recording audio for the animation, and finally designing the home page layout to host all the files.

All drawings were first drawn to scale and dimensioned in Auto CAD then exported to Adobe Flash for animation. In Adobe Flash, the drawings were split into parts based on the frames of the timeline so as to give them a sequential motion. Also, animated models are developed in Solid Works and exported to Adobe flash for illustration of given examples. Action script for the navigation and control buttons were then written and included in the animation.

Sound was recorded by the windows sound recorder and converted to the MP3 format by Nero Record. The researcher recorded himself in an enclosed room and with a microphone to minimize on noise disturbance and echo. The researcher read out the animation narration and steps from a prepared text so as to ensure that the correct information is recorded with less mistakes and omissions. The recorded sound was then converted to Media Player 3 (MP3) format that is compatible with most audio players and as such adobe flash player 9 that was used to create the animated motions. The MP3 audio file was then imported into the Adobe flash library and later into the motion timeline to give audio to the animation.

To host the animated examples on one platform, that is both easy to use and install on the internet, computers and smart phones, there was a need to create a webpage. A basic webpage was designed using the Adobe Dreamweaver software. The first step in designing the website was to create the local root folder where all the AVATED content for the website

would be stored. The second step was creating a home page that would be the first page that the user of AVATED sees when they open the application. This homepage was saved as index.html so that it would tell web browsers that it's the first page that should be opened when someone visits the AVATED site. The layout of the website homepage was agreed upon and sketched out by the stakeholders during the discussions on the functionality of AVATED and its these sketches that were followed during design. These sketches showed where titles, images, navigation buttons and text would appear on the screen. Figure 4.1 shows a layout sketch of the AVATED webpage that was agreed on by the stakeholders during one of the FGD of the development phase.



Figure 4.1: A layout sketch of the AVATED webpage that was agreed on by the stakeholders

The Kyambogo University logo and a photo of the CBE department were posted at the top of the website homepage to enable the users of AVATED relate and connect easily with the application. Creating links to the Kyambogo University website through the logo and the photo provided an opportunity for users to navigate to the university website from AVATED much more easily. Links were made from the home page to other important information that was saved in the local root folder in the photo definition format (PDF). Figure 4.2 shows the final AVATED webpage that was designed based on the sketch agreed on by the stakeholders.

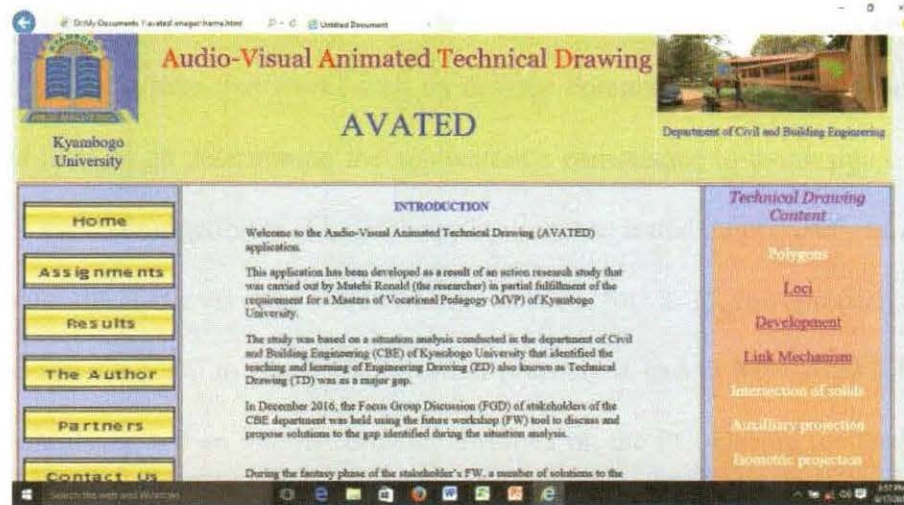


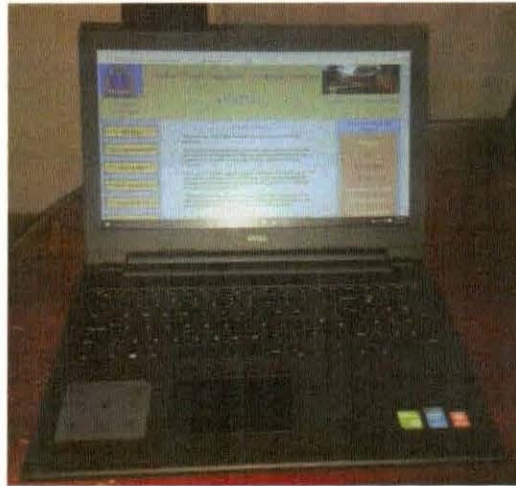
Figure 4.2: AVATED webpage designed based on the sketch agreed on by the stakeholders

#### 4.2.4 Testing

To ensure that AVATED works properly, the application underwent unit testing, integration testing, and then system testing before it was determined to be ready for implementation.

Unit testing involved the testing of the various parts of the application to determine how perfectly they work on personal computers and smart phones. The various parts that were tested included; animations, videos, sound tracks, and webpages. To test the animations, the flash files were tested on a number of windows platforms and different screen sizes to determine how well the animations run and fit on the screen. During the testing of the videos, a number of challenges were encountered especially with compatibility of the MP4 video formats and macromedia flash. After a number of tests, the small web format (SWF) proved to be the best format for the videos and as such was used. The webpage was tested for usability, navigation from one page to another, speed of loading and workability of the various links.

AVATED was then tested to determine how well the various parts of the application integrate into one system that works well on desktop computers, laptops, and smart phones. These tests focused on determining the application's compliance to the design requirements and various media compatibility. First, the application was tested on personal computers (PC) to determine the basic system requirements needed for it to run properly. The tests established that for a PC to run the application properly it had to have Adobe PDF reader, Adobe Flash player and an internet browser installed on the PC. During the tests on PCs, it was also discovered that when opened in the Internet Explorer web browser, the application run properly but when opened with the Mozilla Firefox web browser some components of the application could not run properly. Figure 4.3 shows the AVATED application being tested on a laptop.



*Figure 4.3:* The AVATED application being tested on a laptop

Tests on smart phones were conducted on Samsung, HTC and Techno phones that were all running the Android operating system (OS) that happens to be the most popular OS in use in the country today. The tests established that to run the application properly, the phone had to have Adobe Air, Small Web File (SWF) player, and an internet browser installed on the smart phone. Figure 4.4 shows the AVATED application being tested on a Samsung galaxy S6 smart phone.

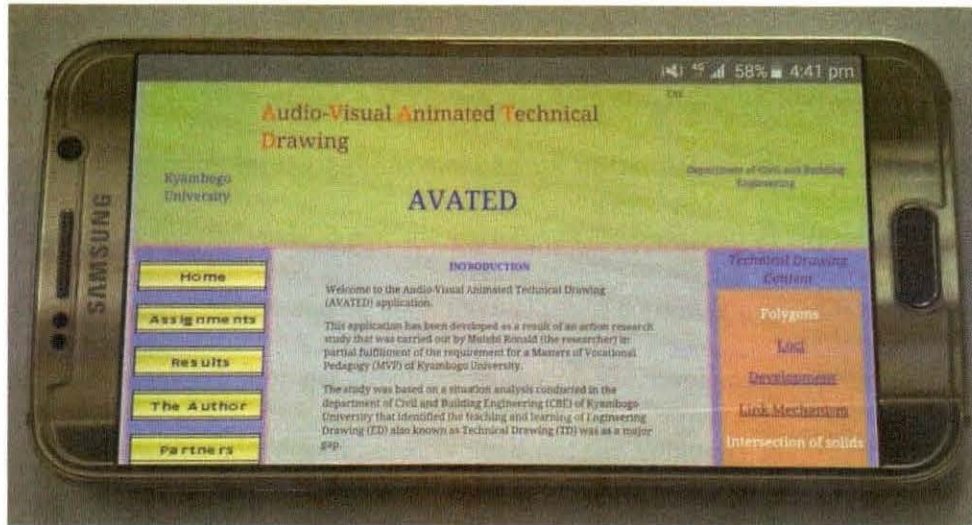


Figure 4.4: AVATED application being tested on a Samsung galaxy S6 smart phone

The smart phone tests established that some features of the application such as the University Logo and the CBE department photo did not appear when the webpage was opened. It was noted that during the smart phone tests the animated flash files played continuous without stopping at the end of each step as programmed. This rendered the steps buttons useless and as such hindered smooth navigation around the animated videos. Figure 4.5 shows the steps navigation buttons that did not work properly when the application was installed on the smart phone.

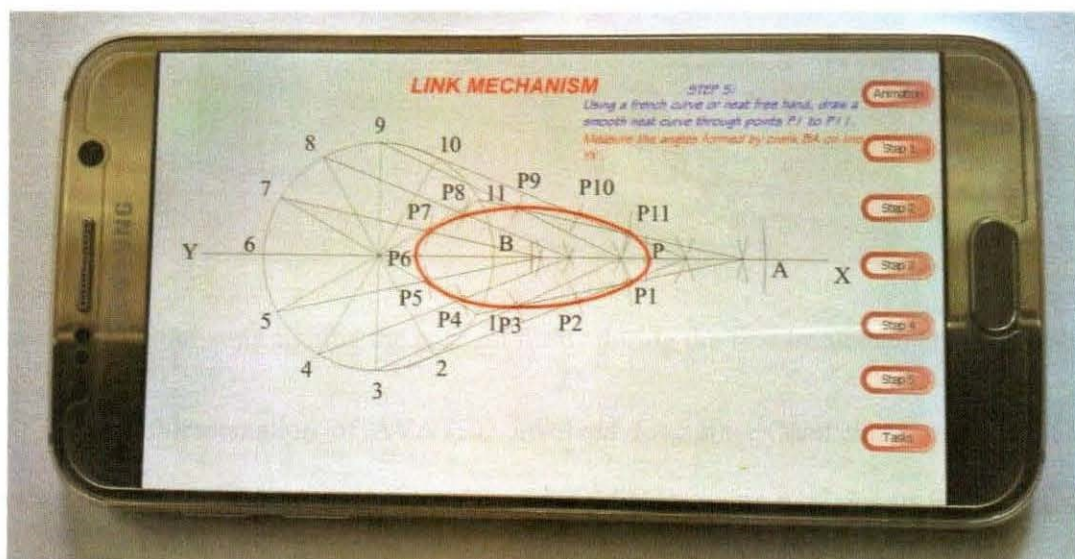


Figure 4.5: Steps navigation buttons that did not work properly on the smart phone

### 4.3 Implementation of the AVATED application in the teaching and learning of ED

The implementation of AVATED as a teaching and learning tool of ED was done by installing the application on the laptops and phones of the fifteen students and two lecturers that were selected for the study. First, the participants were asked to fill a consent form that clearly defined the procedure and as such the tasks and activities that each participant would be asked to undertake and/or get involved in during the implementation of the study. The consent form shown in appendix F, clearly spelt out the voluntary nature of the study, risks and benefits of being in the study, absence of any form of compensation, and confidentiality of participants' responses and personal information. To protect the identity and confidentiality of the participants, the researcher assigned the students pseudo names that included 'Participant 1' up to 'Participant 15'. Figure 4.6 shows participants reading through and signing the consent forms.



*Figure 4.6:* Participants signing the consent forms during the first implementation workshop

The implementation of AVATED involved four stages and these were; collecting drawing background data, installation of the application, training participants in the use of the application, and then the use of the application in the teaching and learning processes.

### 4.3.1 Collecting drawing background data

The researcher and stakeholders collected data on the drawing background of the participants so as to get a baseline upon which the impact of the intervention would be measured. To capture the participants drawing background and ED learning experience at the University, the participants were asked to fill a questionnaire that is shown in appendix B. The questionnaire included questions on ED background, speed of drawing, neatness, use of instruments, and motivation for ED. Also, the participants were given a Pre-AVATED intervention drawing exercise from a topic that the participants had already covered in the course of their ED study at University. The lecturers assessed the participants' Pre-AVATED intervention drawing exercises for neatness, pencil-work and accuracy of drawings and the final score was computed into a percentage. The percentage scores were then ranked as Very Good (70% and above), Good (60% - 69%), Fair (50% - 59%), and Poor (49% and below). Table 4.2 shows the participants scores in the Pre-AVATED intervention drawing exercise.

Table 4.2: *Participants' Scores in the Pre-AVATED Intervention Drawing Exercise*

Quality of Drawing	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant	Participant	Participant	Participant	Participant	Participant
Very Good				■											
Good	■									■	■	■			
Fair			■		■	■	■					■		■	
Poor		■						■	■				■		■

The clustered column chart in Figure 4.7 shows a graphical comparison of the number of participants in every drawing quality category. The chart shows that the majority of the scores of the participants' Pre-Intervention drawings were either just fair or poor in quality.

Of the fifteen students selected, six students started offering TD from O-level, four started from A-level and five students only started Drawing at the University. Out of the five students that started drawing at the university, four expressed having a bad ED learning experience at university and only one mentioned that the experience was interesting. On motivation and interest for ED, the students who started drawing at secondary school level, reported high motivation for drawing whereas those that started drawing at University reported low interest and motivation for ED. The trend was not any different when it came to the use of drawing instruments and speed of drawing. The participants who started drawing from the university reported that they were not comfortable with the use of instruments and as such were slow in drawing whereas those that started drawing from secondary school were very comfortable with the instruments and as such fast in drawing.

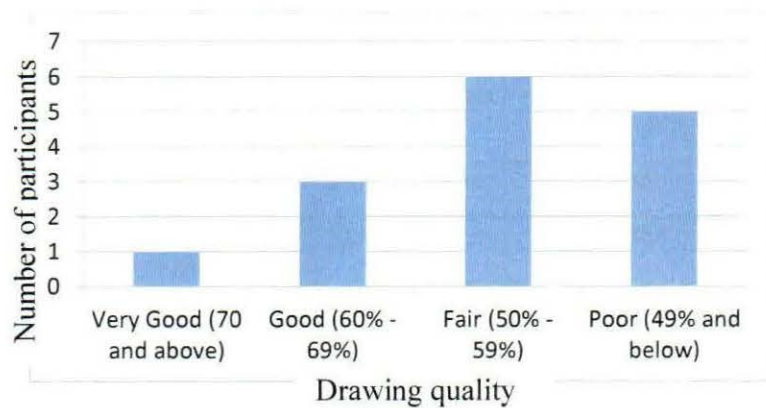


Figure 4.7: Number of participants in each Score category of the Pre- Intervention exercise.

The majority of the students that never offered TD at secondary school pointed out that their ED learning experience at University was not good. Phrases such as; “Not Good”, “Felt left behind”, “Lecturers never considered TD beginners”, “Horrible”, and “Lecturers taught verbally” characterized their responses when asked to comment on their ED learning experiences at University. Table 4.3 shows the participants by pseudo name, gender and also their respective drawing background.

Table 4.3: *Participants' Gender, TD Background Information, and ED Learning Experience at University*

<b>Participant</b>	<b>Gender</b>	<b>TD Background</b>	<b>TD Competence</b>	<b>Drawing Speed</b>	<b>Drawing Neatness</b>	<b>Instruments Use</b>	<b>Motivation for ED</b>	<b>ED Experience At University</b>
1	Male	O-Level	Very Good	Fast	Neat	Very Comfortable	Very High	Drawings not well illustrated
2	Male	University	Fairly Good	Very Slow	Fair	Not Comfortable	Low	Horrible. Lecturers taught verbally
3	Male	O-Level	Good	Fast	Fair	Comfortable	Very High	Fairly Interesting
4	Male	O-Level	Excellent	Fast	Neat	Very Comfortable	High	No Alternative references
5	Male	O-Level	Very Good	Fast	Neat	Very Comfortable	High	Not motivating
6	Male	A-Level	Good	Slow	Fair	Comfortable	Medium	Enjoyable
7	Male	A-Level	Fairly Good	Slow	Fair	Comfortable	Medium	Interesting
8	Male	A-Level	Fairly Good	Fast	Fair	Comfortable	Very High	Interesting
9	Male	University	Fairly Good	Slow	Fair	Not Comfortable	Medium	Never considered TD beginners
10	Male	O-Level	Excellent	Very Fast	Neat	Very Comfortable	Very High	I love the subject
11	Male	O-Level	Very Good	Fast	Neat	Very Comfortable	Very High	Enjoyable
12	Male	University	Excellent	Fast	Very Neat	Comfortable	High	Interesting
13	Female	University	Fairly Good	Slow	Fair	Comfortable	Medium	Felt left behind
14	Female	University	Fairly Good	Slow	Fair	Not Comfortable	Medium	Not Good
15	Female	A-Level	Excellent	Fast	Neat	Comfortable	High	Enjoyed it

### 4.3.2 Installation of AVATED

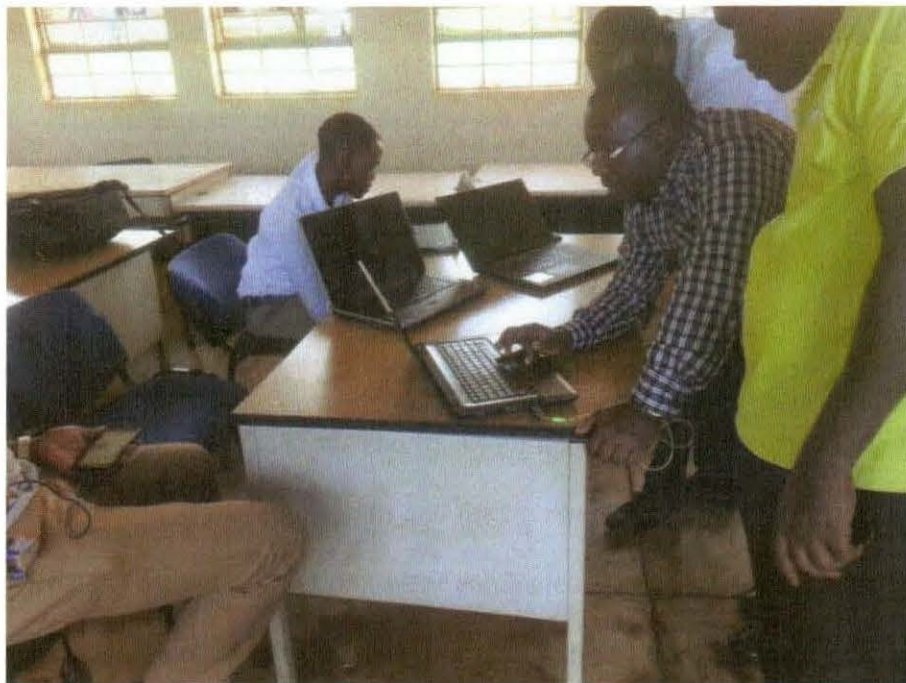
The AVATED application was installed on participants' computers, smart phones as well as the university Learner Management System (LMS). The researcher convened participants for an installation workshop during which, with the help of some participants they installed the application on laptops and smartphones. Out of the fifteen students participating in the study, twelve students had laptops and nine had smart phones that had the capability of running the application. All the two lecturers that were part of the study installed the application on both their laptop and smartphone. Table 4.4 shows the ICT device on which the participants installed AVATED.

Table 4.4: *Device on which the participants installed the AVATED application*

Participant	AVATED Installed on Laptop	AVATED Installed on Smartphone
Participant 1	✓	
Participant 2	✓	✓
Participant 3		✓
Participant 4	✓	
Participant 5	✓	
Participant 6	✓	✓
Participant 7	✓	
Participant 8	✓	✓
Participant 9		✓
Participant 10	✓	
Participant 11	✓	✓
Participant 12	✓	✓
Participant 13		✓
Participant 14	✓	
Participant 15	✓	✓
Lecturer 1	✓	✓
Lecturer 2	✓	✓

The installation of AVATED on personal computers was done by transferring the application files from the source computer (where it was developed) to a flash disk that was in turn used to install the files onto the participants' computers and laptops. This was done with the help of participants who had computer knowledge and this helped in speeding up the installation process. Figure 4.8 shows the researcher and stakeholders installing the AVATED application on participants' PCs.

The installation of the application on smart phones was done by connecting the phone to the researcher's computer with a USB cable and then transferring the application files to the phone.



*Figure 4.8:* The researcher installing the AVATED application on participants' PCs.

The installation of AVATED onto the LMS system was done by uploading the application files to the system with the help of the system administrator. This involved sequencing of the topics in the order of how they will be taught and then scheduling dates when these topics would be available for the students to access them. Figure 4.9 shows the

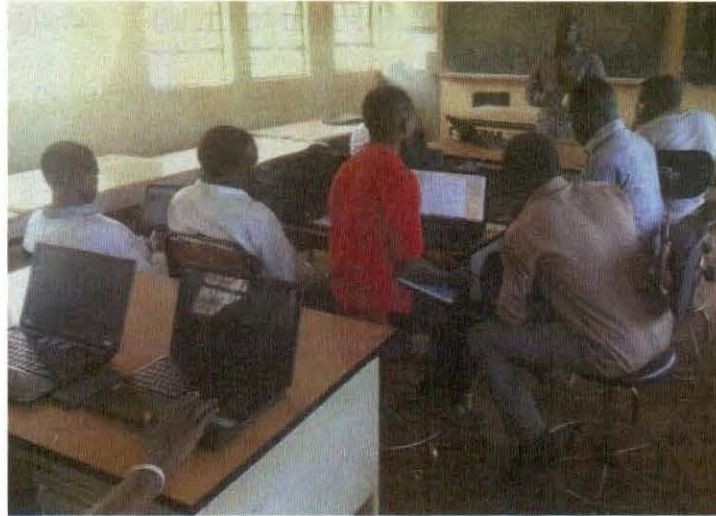
researcher being guided by the University LMS administrator to upload files of the AVATED application to the LMS system.



*Figure 4.9:* The researcher being guided by the University LMS administrator to upload AVATED files to the LMS system.

### **4.3.3 Training of participants**

To be able to use AVATED properly and effectively, the participants underwent training in the use of the application. The training included a one day workshop for training the students in the use of the application and then a number of one on one training sessions for the lecturers. The training sessions were conducted by the researcher and they focused mainly on navigation around the application interface so as to get to the desired information. The training also equipped participants with the know-how of overcoming the performance glitches that had to that point been noticed during development but because of time constraints had not yet been eliminated completely. Figure 4.10 shows the researcher conducting one of the training sessions in the drawing room of the CBE department.



*Figure 4.10:* The researcher conducting one of the training sessions in the drawing room of the CBE department.

#### **4.3.4 Using AVATED as a learning tool**

The three weeks before semester two examinations gave the participants a chance to use the AVATED application as a teaching and learning tool. The university LMS was not used by the participants because the process of admitting the students to the system before they could use it was taking long. The participants and the researcher agreed to use the laptops and smartphones to continue with the intervention because of the limited time that was available before university exams started. With the application on their respective computers and smart phones, the participants used the numerous examples and animations of the application in the learning process of three ED topics (one per each week) that were selected by the researcher.

To monitor continued usage of the application, the student participants were required to attempt the drawing examples illustrated in every topic on AVATED as well as the tasks included at the end of each example. The researcher then met all the participants once every week to discuss progress and also ask the lecturers to assess the quality of the students' drawings so as to ascertain whether they are actually using the application and if so, how it's



The clustered cylinder chart in Figure 4.11 compares the data of the participants' weekly drawing quality as they used the intervention with the Pre-Intervention scores which showed that by the end of the first week of using the AVATED application, three participants produced Poor quality drawings and four had fair quality drawings. By the end of week three, there was no participant with poor quality drawing and only one student had drawings whose quality were ranked by the lecturers as Fair. The results of the drawing work over the three weeks also shows that the percentage of participants producing Very good quality drawings moved from 20% of the participants in the first week of using the AVATED application to 66.6% of the participants by the end of the third week of using the application.

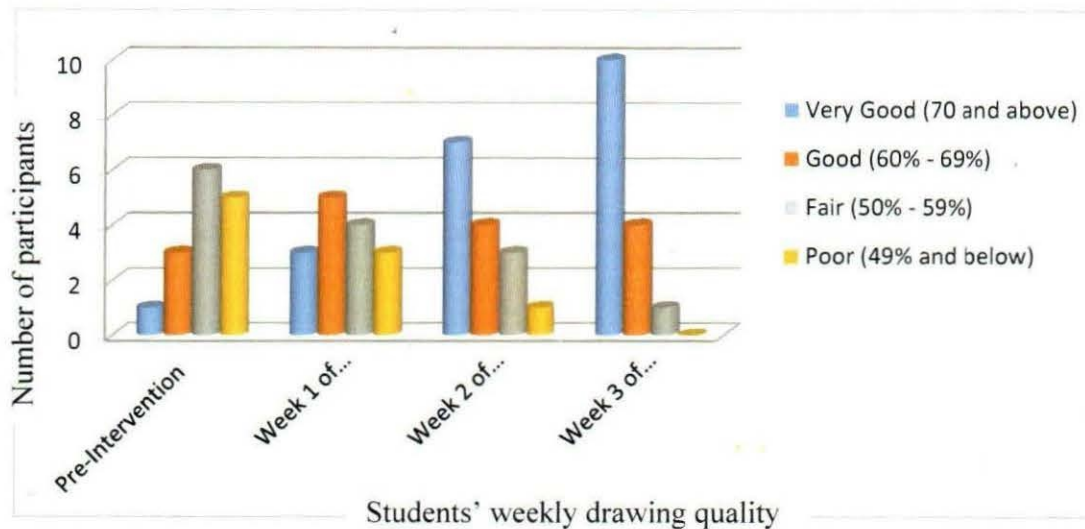


Figure 4.11: Comparison of participants' weekly quality of drawings as scored by the lecturers.

#### 4.4 Evaluation of the AVATED application as a teaching and learning tool

During the evaluation of AVATED as a teaching and learning tool, the researcher collected data from questionnaires, group discussions, and interviews. The collected data was analyzed by constantly comparing and triangulating the information gathered from the various tools and based on generated themes.

#### 4.4.1 Questionnaires

This evaluation method was used to collect data from the student participants of the study using the questionnaire tool shown in Appendix C. The questions of the tool were organized to collect information on four themes and these were; Design, Implementation, Effectiveness, and Efficiency of the AVATED application.

##### 4.4.1.1 Design of AVATED

This section of the evaluation questionnaire sought to explore the participants' responses on the overall design, drawings and animations used in the AVATED application. Table 4.6 shows the participants' responses to various questions on the design of the AVATED application. The participants' responses showed that they all agreed that the applications' design and animations were good. However one participant felt that the figures used in the application were poorly drawn.

Table 4.6: *Participants' Responses to the Design of AVATED*

Responses		Number of Participants (Frequency)
Qn. 1	How do you describe the overall design of AVATED?	
A	Its poorly designed	0
B	Fairly well designed	7
C	Its excellently designed	8
Qn.2	What is your view on how the figures used in AVATED were drawn?	
A	They were drawn very well	9
B	They were drawn fairly well	5
C	They were drawn very badly	1
Qn.3	What is your view on the animations that are used in AVATED	
A	They are very good	6
B	They are fairly good	9
C	They are not good	0

#### 4.4.1.2 Implementation of AVATED

This section of the evaluation questionnaire sought to explore the participants' responses on the installation process, performance, and effectiveness of training in the use of AVATED. Table 4.7 shows the participants' responses to various questions on the implementation of the AVATED application. The responses showed that two participants had difficulty in installing the application and another two participants responded that the application kept on freezing and stopping. However 80% of the participants' responses showed that the application installed and even worked very well on their devices.

Table 4.7: *Participants' Responses to the Implementation of AVATED*

Responses		Number of Participants
Qn.4	On what device did you install AVATED?	
A	Smart phone Only	3
B	Laptop only	6
C	Laptop and smart phone	6
Qn.5	How do you describe the installation process of AVATED on your device?	
A	I had difficulty to install AVATED	3
B	It failed to install	0
C	It was easy to install	12
Qn.6	After installation of AVATED on your device, how did AVATED perform?	
A	It always hanged and stopped working	2
B	Some files failed to work	1
C	It worked very well	12
Qn.7	Did you undergo training on how to use AVATED?	
A	Yes	13
B	No	2
Qn.8	Was the training effective in getting you started in the use of AVATED?	
A	No	0
B	Yes	15

#### 4.4.1.3 Effectiveness of AVATED

This section of the evaluation questionnaire sought to explore the participants' attitude towards AVATED, the usability of the application, and indication of participants' sense of achievement after using AVATED. Table 4.8 shows the participants' responses to various questions on the effectiveness of the AVATED application. The responses showed that there was no participant who found the application hard to use and navigate whereas a majority ranked it as being interactive and engaging. Most of the participants' responded that AVATED had positively impacted on their mastery of ED concepts and so was their preference for it to be used simultaneously with existing traditional methods of teaching.

Table 4.8: *Participants' Responses to Effectiveness of AVATED*

Responses		Number of Participants
Qn.9	How did you find AVATED in terms of usability?	
A	Very easy to use and navigate around	8
B	Fairly easy to use and navigate around	7
C	Hard to use and navigate around	0
Qn.10	On a scale of 1-10 how do you rank AVATED in terms of being interactive and engaging?	
A	1-3	0
B	4-6	6
C	7-10	9
Qn.11	How would you prefer AVATED to be packaged or made available for learning?	
A	CDs	5
B	University Learner Management System	1
C	As an application on the Internet	8
D	Installed in department computer lab	1
Qn.12	Now that you have used the AVATED application, how do you compare it to the traditional chalkboard method that was being used previously?	
A	I prefer the chalkboard method only	0
B	I prefer the use of AVATED only	3
C	I prefer both being used simultaneously	12
Qn.13	How has AVATED impacted your ability to master concepts of ED?	
A	Has not had an impact on me at all	0
B	Has had limited impact on me	1
C	Has had an impact on my ability	9
D	Has had a great impact on my ability	5

#### 4.4.1.4 Efficiency of AVATED

This section of the evaluation questionnaire sought to explore the ability of AVATED to address the ED teaching and learning gaps that were identified during the work process analysis. The section also sought responses on participants' opinions to the ability of the application to solve the identified gaps as proposed in the fantasy phase of the stakeholders' future workshop. Table 4.9 shows the participants' responses to various questions on the efficiency of the AVATED application. The responses showed that all participants agreed that the application solved the issue of too much content to be covered in a limited time.

Table 4.9: *Participants' Responses to Efficiency of AVATED*

Responses		Number of Participants
Qn.14	To what extent does AVATED solve the issue of too much content to be covered in a limited time?	
A	Solves it completely	5
B	Solves it to some extent	10
C	Does not solve the issue at all	0
Qn.15	Has AVATED improved the frequency at which you practice drawing?	
A	No	1
B	Not sure	1
C	Yes	13
Qn.16	On a scale of 1-10, how do you rank AVATED in terms of enabling you to learn engineering drawing at any time of your choice and from any location?	
A	1-3	0
B	4-6	3
C	7-9	7
D	10	5

#### 4.4.1.5 General Comments

Question seventeen of the evaluation questionnaire sought to elicit open-ended comments of the participants' general experience of using AVATED. The majority of the participants' responses ranged from concerns about compatibility issues with some web browsers on laptops and smart phones, to the need for the application to be made accessible

all over the country. Four participants pointed out that the application simplified drawing work but also added that it should be developed further to include all topics in ED. “Learning is fun because it takes place everywhere at any time and with less direction” was the response of one of the participants to the question. Another participant that started offering TD at the university pointed out that “I wish the application was available when we started the ED course unit”. Also, two participants pointed out that the quality of the application’s audio needed to be improved so as to make it more audible and clearer.

#### 4.4.2 Evaluation Group Discussion

To triangulate the information gathered with the questionnaire and also capture voices of participants, the researcher convened the participants for a Future Workshop (FW) to evaluate AVATED as an ED teaching and learning tool. The workshop that was guided by the protocol shown in appendix L, focused on what had worked well and what had not worked well with the four themes of the study that included; Design, Implementation, Efficiency, and Effectiveness of AVATED. During the workshop, participants discussed the ‘why’ side of what went well and what did not work well and then pointed out the way forward for AVATED. Figure 4.11 shows the researcher guiding the FGD on evaluation of the AVATED tool.



*Figure 4.11:* The researcher guiding the Future Workshop on evaluation of AVATED.

The various views of the participants as shown in appendix N (Minutes of the meeting) were sorted and then categorized under the four themes of Design, Implementation, Effectiveness, and Efficiency. Most of the voices coming out of the evaluation group discussion on the four themes of Design, Implementation, Effectiveness, and Efficiency of AVATED were very similar to the information that had been captured in the questionnaires, however vital new information came through when it came to the way forward for the intervention.

On the Design of AVATED, participants suggested that more resources be allocated towards the development and inclusion of more content and a separate application be developed for mobile phones so as to address the glitches experienced when running the application on smart phones. The fast tracking of the University LMS system was proposed as the way forward to ease implementation whereas the inclusion of more control buttons in the application was proposed as a solution to usability issues. Table 4.10 shows a summary of participants' views organized under the four themes that guided the evaluation group discussion.

Table 4.10: A Summary of Participants Views as captured from the Group Discussion

	<b>What worked well?</b>	<b>What did NOT work well?</b>	<b>What is the way forward?</b>
<b>Design</b>	<ul style="list-style-type: none"> <li>• Good design</li> <li>• Good choice of colors for the drawings (Black and Red)</li> <li>• Audio clear, basic, and simple enough to be understood</li> </ul>	<ul style="list-style-type: none"> <li>• Only a few topics included</li> <li>• Some phone screens are too small to see the drawing lines.</li> <li>• Some buttons not working on smart phones</li> <li>• Files too heavy for some phones with small memory</li> </ul>	<ul style="list-style-type: none"> <li>• Allocate more resources to development and inclusion of more content</li> <li>• Develop separate application for mobile phones</li> </ul>
<b>Implementation</b>	<ul style="list-style-type: none"> <li>• Easy to learn and use</li> <li>• Worked very well on Laptops</li> <li>• Enabled team learning as participants shared laptops</li> </ul>	<ul style="list-style-type: none"> <li>• Some students couldn't afford Laptops</li> <li>• When files got corrupted installation meant going back to the researcher</li> </ul>	<ul style="list-style-type: none"> <li>• The University LMS system should be fast tracked</li> <li>• Should be packaged and supplied on CDs.</li> </ul>
<b>Effectiveness</b>	<ul style="list-style-type: none"> <li>• Increased interest in ED</li> <li>• Seeing and listening to the step by step process as one draws made learning fun</li> <li>• Interactive and easy to navigate around</li> </ul>	<ul style="list-style-type: none"> <li>• Need for self-drive to motivate your own self to learn and cover content</li> <li>• Absence of fast forward and rewind buttons is inconveniencing</li> </ul>	<ul style="list-style-type: none"> <li>• Need for lecturers to give assignments that compel learners to use application</li> <li>• To include more control buttons</li> </ul>
<b>Efficiency</b>	<ul style="list-style-type: none"> <li>• Cuts costs of weekly handouts and printing</li> <li>• Can learn at own pace and cover content faster</li> <li>• Can Learn from anywhere at anytime</li> <li>• Can always revisit a topic that has been forgotten or not well understood</li> <li>• Easy to remember what is watched that what is read</li> </ul>	<ul style="list-style-type: none"> <li>• Moving with Laptop everywhere is risky</li> <li>• Not attending lectures because one feels he's ahead in coverage</li> <li>• Some addicted to hard copies of handouts</li> </ul>	<ul style="list-style-type: none"> <li>• Delivery on Internet would enable learning from any available device</li> <li>• Use AVATED to cover content in conjunction with traditional methods</li> </ul>

#### 4.4.3 Interviews

This evaluation method was used to collect data from the dean of the faculty of Engineering, head of CBE department, the two lecturers, and the CBE Lab technician who participated in the study at Kyambogo University. The interviews that were guided by the interview guide tool shown in appendix K focused mainly on Design, Installation, Effectiveness, and Efficiency of AVATED.

On design, all the interviewees agreed that the application's design was good and enabled easy ergonomics in terms of use and performance. One of the participants pointed out the need to engage professional Information Technology (IT) to improve the overall design without changing the basic concept which they agreed was a plus in as far as integrating the use of ICTs in the teaching and learning process. Two key issues were re-echoed by each of the interviewee when it came to installation of the application. The first was the need to include a setup file in the application that would enable it to self-install without the need for manually having to transfer files from one computer to another during installation. The second issue was that more work had to be done on the application to enable it install and run smoothly on all types of computers, smart phones and operating systems.

Each of the lecturers interviewed embraced the applications ability to cover more content in a very limited time because of its audio-visual animations and availability for the learner to access at any time and any place. However, one of the interviewees cautioned on the continued need for face to face teaching and learning. "AVATED should not replace the lecturer but only be used to reinforce what has been learnt during lectures" said one of the lecturers during the interview. It was clear from the interviews that the need to use AVATED alongside the traditional chalk board method was loud and consistent. The Dean faculty of Engineering who also happened to be the principal supervisor of the intervention was appreciative of AVATED's ability to use available ICT's to facilitate everywhere learning.

“Am impressed with what has been done so far” were his words when asked to comment on the intervention. Figure 4.12 shows the researcher interviewing the Dean Faculty of Engineering.



*Figure 4.12:* The researcher interviewing the Dean Faculty of Engineering in his office.

On the way forward for AVATED, the head of the CBE department, pointed out that the intervention should also be extended to other drawing course units in the department such as Civil Engineering and Architectural drawings. “Make another mechanism where the civil drawing component can be included in the application to help students before they start CAD drawing” said the Head of the CBE department when asked about the future of the application. Figure 4.13 shows the researcher interviewing the head of CBE department at Kyambogo University.



*Figure 4.13:* The researcher interviewing the CBE head of department in his office.

## CHAPTER FIVE

### DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

#### 5.1 Introduction

This study was conducted to explore and understand the gaps that exist in the teaching and learning of ED in the CBE department in the faculty of Engineering of Kyambogo University. The central phenomenon of the study was to explore the use of existing Computer Aided Design (CAD) and animation software to design an Audio-Visual Animated Technical Drawing (AVATED) application; implement the use of the AVATED application in the teaching and learning of ED, and Evaluate the impact of using the AVATED application for teaching on students' acquisition of drawing competencies in ED among the students of the CBE department.

The chapter presents the interpretation of the action research study findings in relation to the study objectives and generated themes, recommendations for action and future research, and conclusions.

#### 5.2 Interpretation of the Findings

This section contains discussion, analysis, and interpretation of findings in relation to the conceptual framework of the study and findings from previous research on the use of e-learning applications in the teaching and learning process but with particular reference to ED.

##### 5.2.1 Interpretation of themes related to Design of AVATED

Objective 1 of this action research study related to the use of existing Computer Aided Design (CAD) and animation software to design an Audio-Visual Animated Technical Drawing (AVATED) application. The following three themes were identified: preliminary works, functionality, development and then testing.

**Preliminary works:** Identifying the content and software to be used in the design of the AVATED application constituted the first phase of the design process. The time available to the researcher and the participants to design the intervention was not enough to develop and include the entire ED content in the AVATED application. In agreement, Bersin, Holder and King (cited in Najafabadi, Poorsadegh, & Mirdamadi, 2013) pointed to content development, whereas White (cited in Najafabadi, Poorsadegh, & Mirdamadi, 2013) mentioned time constraints as the major challenges affecting design of an ICT-based training system.

The availability of a majority of the software needed to design the intervention in the CBE computer lab, eliminated the need to spend money on purchasing it and as such made the design process cheaper and easier. Also the researcher's prior knowledge in computing was of great benefit in the preparation for designing the intervention. This is alluded to by the Academy of Mine (2017) who pointed out that, one of the biggest competitive advantages in designing e-Learning platforms is having skills and resources to create high quality, in-depth and interactive content.

**Functionality:** Towse (2009) noted that the most important aspect of e-Learning development (or any training intervention for that matter) is defining the right learning objective. He adds that, an ineffective learning objective will result in an unsuccessful training module, despite all the subsequent hard work, time, and effort. A developer's key strength is "translating" technical choices and issues into understandable terms and timelines (Towse, 2009). Although Towse was focused mostly on online e-Learning modules, his observations are also valid for e-learning content delivery applications such as AVATED.

The functions and system architecture of the AVATED application were deemed so important. As such the researcher worked with the stakeholders when determining these two aspects so that as intended users, they can own the intervention. The Academy of Mine

(2017) noted that when designing your e-Learning platform it's easy to get overwhelmed or excited about all of the unique features you could add to your online course. However, at the end of the day you need to ask yourself if those educational tools really help your students' progress towards their educational goals. There is no point in over-complicating your e-Learning platform if it's not necessary (Academy of Mine, 2017).

Towse (2009) reported that users will have all the knowledge and information regarding the subject matter, but it is the developer's job to distill those ideas into online working theory. He adds that, there are a variety of challenges associated with e-Learning, from the "Death by PowerPoint" scenarios, to an overload of on-screen animation and effects that ultimately overwhelm and dilute the core messages. The key to producing effective and successful e-Learning materials is creating focused core messages. The fact that the delivery vehicle is electronic shouldn't take away from the training fundamentals of teaching and educating the participant (Towse, 2009).

**Development:** The development of e-Learning content benefits from a well-defined and streamlined process. Beginning the process before the actual content development starts will ensure that the learning objectives are achieved, that the e-Learning is usable across numerous platforms, and, most of all, that the content is accepted and completed by the desired audience (Towse, 2009). When it comes to eLearning, content is king and means everything when it comes to creating a great eLearning experience (Pappas, 2014). Pappas adds that when the content of your eLearning falls flat, or it just confuses the audience, it can be a stressful affair. With all the software sourced, content selected, and the researcher trained in the use of animation and web page software, the development process proceeded smoothly.

The need to develop the application in the limited time available for the action research intervention, the researcher needed a helping hand on some of the basic activities of

the development process. On the enormous workload involved in developing e-learning content, Stockley(2014) advised that If it makes sense, find partners internally or externally for developing content, or even in the more technical set-up. The only cost effective and readily available option was to source help from the very group that is the beneficiary of the application – the stakeholders.

The easy to use structure of most of the sourced software and the inclusion of how-to use tutorials in their help menu is what quickened the development process. This enabled some of the stakeholders with basic computer knowledge to get involved in the development process especially when it came to drawing of figures with AutoCAD and typing the steps for the animation. This is in line with what Towse (2009) reported that “in previous years, the domain of e-Learning development was purely for the selected few with intricate knowledge of specific tools and technologies but with the rise of Rapid Development Tools that are now widely available, creation of e-Learning material can be a streamlined and effective process”. Also the UNESCO analytical survey on the use of ICTs in Technical and Vocational Education and Training (TVET) pointed out that many course development tools are now available, which allows instructors with no computer programming skills to develop high-quality web-based training programs (UNESCO, 2003).

**Testing:** The testing process is the third major step in the technology project development and as with the development process, the complexity of the testing process will depend on the complexity of the technology being implemented (ACE, 2017). The testing phase of the AVATED application established compatibility issues especially when it came to embedding MP4 video formats into macromedia flash files. As Tallam (2014) reported, embedding videos within a Flash file is the easiest way to deliver videos through eLearning courses. As such numerous tests had to be carried out on various options to the problem until the right solution to embedding the videos was got. The solution to the problem lay with

Tallam (2014) observation that if you use different frame rates, the video playback may become inconsistent. As such, the frame rate of the video had to be set to the same rate as the .swf file.

The marked difference in performance of the application on the Explorer and Mozilla Firefox web browsers, as well as difficulty to run AVATED on older versions of windows was also a major concern during testing of the application. Rathbone (2014) reported that many companies design their software to run on a specific version of Windows. When a new Windows version, like Windows 8, appears a few years later, some older programs feel threatened by their new environment and refuse to work. In agreement, Posey (2013) adds that some applications are hard-coded to look for a specific version of Windows. However, Rathbone (2014) advised that if an older program refuses to run under a newer windows version, you still have hope because of Windows' secret *Compatibility mode*. This mode, he adds, tricks programs into thinking that they're running under their favorite older version of Windows, letting them run in comfort (Rathbone, 2014). This is what created the need for expert technical assistance in fine tuning the application. The expert assistance that was sought not only solved AVATED's compatibility issues with older versions of windows, but also pre-empted any such issues arising with future windows releases.

The AVATED tests also established that for the application to work properly on the smart phones, more work still had to be done on the application both in terms of the development software (switching to the use of mobile application development tools) and hosting website (switching to the use of mobile web browsers). This was in-line with the observation that "not all apps work on all mobile devices" (Federal Trade Commission, 2017). Bhatia (2013) adds that challenges in mobile application development stem from the complex nature of the mobile ecosystem. This means that two separate applications need to be developed if the intervention is to be used on both the personal computers and smart

phones. To eliminate the glitches, each application has to be specifically designed and developed for the respective device on which it's intended to run. However, Bhatia warns that by catering for a variety of these devices, mobile app developers may run into issues with developing and maintaining multiple versions of the same app leading to the increased costs. (Bhatia, 2013).

### **5.2.2 Interpretation of themes related to Implementation of AVATED**

Objective 2 of this action research study related to the implementation of the AVATED application as a teaching and learning tool in the CBE department. The following three themes were identified: Collecting Drawing background data, Installation of AVATED, Training of participants, and Using AVATED as a learning tool.

**Collecting Drawing background data:** The findings from the drawing background data collected showed that student's with no prior experience in TD admitted for the BEng program were experiencing difficulty learning ED. Statements such as "Horrible, Lecturers taught verbally, Lecturers never considered TD beginners, Felt left behind, and Not Good" characterized their responses when asked about their ED learning experience at University. However, there were also those who had done TD at secondary school that responded with statements such as "Drawings not well illustrated, Fairly Interesting, No Alternative source of knowledge, not motivating" when asked the same question about their ED learning experience at University.

These findings galvanized the need for a teaching method that is tailored to allow for repetitiveness and at the pace of the user so as to cater for individual differences in TD backgrounds. This is supported by Zuo et al., (2003) who reported that with e-learning in the Department of Engineering and Computer Graphics, Guangdong University of Technology, the schedule of study is controlled by students themselves. Those students, who understand

well, can complete the fundamental requirements early. The New Zealand Curriculum Guides (2013) advised that because students have unique packages of prior learning and experience, they can respond in very different ways to the same new learning. But unless they can connect it to and integrate it with what they already know, they will struggle to remember it, let alone understand and apply it. When teachers deliberately build on what their students know and have experienced, they maximise the use of learning time, anticipate students' learning needs, and avoid unnecessary duplication of content (New Zealand Curriculum Guides, 2013).

The participants drawing background data collected during the implementation of the intervention also showed a direct relationship between the level at which one started drawing and; the level of comfort in the use of instruments, drawing speed, motivation for ED, and one's ED learning experience at University. In the context of the study, this relationship means that an intervention that targets one of the above variables would automatically go a long way in addressing all the others and as such make the students' ED learning experience at the university good. Introducing a teaching and learning method such as AVATED that makes the learning experience interesting, would surely impact positively on all the other variables. In agreement, Stockley (2014) reports that e-learning is a wonderful opportunity to stretch the organization, by introducing new methods and approaches that take advantage of technology.

The findings of the Pre-intervention exercise showed that the majority of the participants drawing quality scores were below 60%. These scores were important to the study because they created a baseline upon which Post-intervention scores would be measured to determine improvement in the quality of drawing. With the knowledge of their prior drawing learning already captured, the scores of the pre-Intervention drawing exercises enabled the researcher to know the current drawing abilities of the participants. The New

Zealand Curriculum Guides (2013) are in agreement. On the strategies to recognise students' experiences and prior knowledge, the New Zealand Curriculum Guides (2013) advised to begin with a "know the learner" activity, gathering information from students' learning done in previous years, and assessing existing knowledge.

**Installation of AVATED:** The fact that some participants had no laptops and others had no smartphones with the capability of playing Small Web Format (SWF) media was testament to how the cost of acquiring ICT equipment is still a major challenge facing implementation of e-learning methods. Ying Wu cited by Gowen .A. (2009) noted that, "Without a computer there's a kind of a wall, a barrier to the world."

The failure to use the University LMS system as had earlier been planned was due to the delayed process of admitting the participants to the system by the system administrators. This coupled with the fact that some participants had no laptops or smart phones constituted a major infrastructural challenge to the implementation process. This is supported by Mikre (2011) who pointed out that among the barriers to implementation of e-learning applications in the teaching and learning processes is lack of accessibility and infrastructure. The infrastructural challenges were solved by encouraging the participants to share laptops and smart phones throughout the three weeks of implementing the intervention.

It was also evident from the findings that the application was installed by transferring the application folder from the researcher's computer to the participants' devices. The researcher and stakeholders lacked the technical knowledge required to write the necessary setup codes for the application and as such opted for the easy path of having the application on the participants' devices. This was a very long process compared to the use of a setup installation that would have the application easily installed by the participant at any time and any place.

**Training of participants:** The results of the training sessions in the use of AVATED showed that the participants understood the use of the application in a short time and kept a positive attitude throughout the training. This is attributed to three factors: the participants' basic computing knowledge, the simple design of the application, and the fact that they all participated in the development process of the application. These three factors ensured that the application is easy to use just as Huysman and De Wit., (2002) observation that "systems that are difficult to use may impede the growth or critical mass". In addition, Mahmud and Ismail (2010) reported that formal ICT training and ICT experience influence the teachers' knowledge, skills and attitude.

**Using AVATED as a learning tool:** Ferriman (2013) reports that, the right e-learning implementation builds on an established base. He adds that, if existing learning methods are basic, then the initial e-learning implementation should be basic as well. "You don't need to use all the features of an e-Learning intervention straight away, but slowly integrate them over time" (Ferriman, 2013). This is the exact blue print that was followed in the three weeks of the participants using the AVATED intervention. The participants used the intervention to learn one topic every week and always started from the well-illustrated examples and after understanding the steps of constructing the example in question, they proceeded to attempt the tasks included in the topic. This step by step progression made learning enjoyable because it built from simple to complex basics of drawing.

Consistent use of ICT based learning requires a very high degree of self-motivation since the process is more learner centered. To have all participants continuously using the AVATED application and constantly requesting for more content to be added was an indication of how the application is engaging and interactive. This is in concert with Ferriman's (2013) observation that "engaging learners actively for online learning is one of the main factors that determines the success or failure of the e-Learning process and hence is

key to its implementation and sustainability”. He adds that in any e-learning project, some learners may find it difficult to move from traditional to new e-learning modes (Ferriman, 2013).

The observed improvement in quality of participant’s drawings was a result of the continuous practicing of drawing that was enabled by the fact that the participants could access drawing content every time they wanted to and wherever they were. This finding is in line with the observation by Foxtan (2011) that if you want to get better at drawing you need to practice regularly. Foxtan adds that, if you practice effectively, you can progress much faster than you would have thought possible with much less effort and that you’ll also feel energized and positive about the improvements you see.

### **5.2.3 Interpretation of themes related to Evaluation of AVATED**

Objective 3 of this action research study related to the evaluation of the AVATED application as a teaching and learning tool in the CBE department. In this section the researcher analyses and interprets the responses of the participants in regard to the following four themes: Design, Implementation, Effectiveness, and efficiency of AVATED as a learning tool.

**Responses on Design:** The fact that all participants responses, as captured by the questionnaire, on the design of the application and animations used were either very good or fairly good means that on the whole the application design got an approval. However, the closeness of the number of participants responding with very-good and those with fairly-good means that more work needs to be done to make the design even better. The voices coming through the evaluation FW also confirmed the design approval that had been captured by the questionnaires. Participants’ sustained calls for more content to be included in the application meant that the application had scored highly in as far as creating interest in ED learning.

The observation by one of the participants that he had difficulty seeing the drawing lines on the small phone screen was a timely pointer to the right direction in as far as having the application run on smart phone devices. This observation is in line with what Bhatia (2013) reported on running desktop applications on mobile devices. He noted that some enterprise app developers treat mobile devices as just another screen and extend enterprise applications to mobile devices without realizing that user interactions and behaviors are vastly different. He continues that this generalization makes for an unintuitive and cumbersome experience for users resulting in low adoption and usage of the application (Bhatia, 2013).

The strong responses concerning the glitches that were experienced while running the application on smart phones pointed to a technical flaw that could not have been foreseen by the researcher in the design phase. The absence of an Information Technology (IT) expert on the design team meant that certain technical matters such as the need to develop separate applications for the personal computers and then the phone were bound to happen. This is in line with Stevens (cited in UNESCO 2003) observations that one of the obstacles for online learning is that the development of quality applications requires a team of moderately to highly skilled individuals in computer applications and instructional design. He adds that the team may need to include a computer programmer, graphic artist, content specialist, and instructional designer (UNESCO, 2003).

**Responses on Implementation:** The responses of participants in regards to the implementation process of AVATED showed that they were all in agreement that it was easy to learn and use, worked well especially on Laptops and enabled team learning. All the participants that took part in the training of how to use the application also responded that it was effective in getting them started. However, the fact that the application was loaded by transferring files from the researcher's computer to that of the participants emerged as a

The observation by one of the participants that he had difficulty seeing the drawing lines on the small phone screen was a timely pointer to the right direction in as far as having the application run on smart phone devices. This observation is in line with what Bhatia (2013) reported on running desktop applications on mobile devices. He noted that some enterprise app developers treat mobile devices as just another screen and extend enterprise applications to mobile devices without realizing that user interactions and behaviors are vastly different. He continues that this generalization makes for an unintuitive and cumbersome experience for users resulting in low adoption and usage of the application (Bhatia, 2013).

The strong responses concerning the glitches that were experienced while running the application on smart phones pointed to a technical flaw that could not have been foreseen by the researcher in the design phase. The absence of an Information Technology (IT) expert on the design team meant that certain technical matters such as the need to develop separate applications for the personal computers and then the phone were bound to happen. This is in line with Stevens (cited in UNESCO 2003) observations that one of the obstacles for online learning is that the development of quality applications requires a team of moderately to highly skilled individuals in computer applications and instructional design. He adds that the team may need to include a computer programmer, graphic artist, content specialist, and instructional designer (UNESCO, 2003).

**Responses on Implementation:** The responses of participants in regards to the implementation process of AVATED showed that they were all in agreement that it was easy to learn and use, worked well especially on Laptops and enabled team learning. All the participants that took part in the training of how to use the application also responded that it was effective in getting them started. However, the fact that the application was loaded by transferring files from the researcher's computer to that of the participants emerged as a

pertinent concern to the participants. As such, the need to have the application packaged as an easy to install software that is supplied on CDs dominated responses to the concern. These responses mean that the participants were so interested with the whole idea of being in charge of their learning that they even wish to have the ability to repair or reinstall the application on their own should it ever get corrupted or crash.

**Responses on Effectiveness:** In many studies, effectiveness has been viewed only in terms of learning gains on post-tests. However, Nathenson and Henderson as cited in UNESCO (2003) argued that although improved student performance is an important element, it should not be the only indicator of instructional material effectiveness. Chinien also cited in UNESCO (2003) suggests that instructional material effectiveness should be viewed within a framework, which encapsulates three major elements, achievement, study time, and the students' attitude toward the material. In this regard, the participants' good attitude towards AVATED by responding that it improved their interest in ED, and also the majority's response that it had had an impact on their ability to master ED concepts, means the application is effective.

The participants' responses showed that they ranked it highly in terms of being interactive and engaging. "Seeing and listening to the step by step process as one draws made learning fun" recounted one of the participants during the evaluation FW. These responses hinged on the fact that the combination of animated graphics and sound inevitably captured the attention of the participants. This is supported by Basu (2009) who noted that "thanks to Flash, the web is a far more interactive place today because it still holds sway when one thinks of rich animations and advanced interactive games". Whereas Basu's observation was based on web content and computer games, his views about the power of flash animations remains valid even with e-learning applications.

Responses on navigating around the AVATED application were divided. On the one hand, during the evaluation FW, participants complained about how the lack of fast forward and rewind buttons made navigation around the application inconveniencing; on the other hand when asked on the questionnaire how they found AVATED in terms of usability, they all responded with either “very easy” or “fairly easy to use and navigate around”. Despite the difference in opinions from the two sets of evaluation responses, it was clear from the voices at the evaluation FW that the inclusion of fast forward and rewind buttons was very necessary.

It was clear from the responses that the majority of participants preferred the AVATED intervention to be used simultaneously with the traditional chalk board method. This finding can mean two different things depending on how it’s interpreted. First, it shows that although the intervention had a higher approval rating from the participants, they still feel that there are elements of the traditional method such as the physical presence of the lecturer in class that they may still need. This is in line with the blended learning that is recommended by Mikre (2011). Mikre advocated for learning models that combine the face-to-face classroom practice with e-learning solutions. He adds that a teacher may facilitate student learning in class contact and use the e-learning application to facilitate out of class learning (Mikre, 2011). Secondly, the findings can also mean that despite the majority approval, the participants still can’t trust the intervention to take over from the traditional methods entirely or at least not in this short time. The latter is supported by Stockley (2014) who reported that, the introduction of new methods and technologies can create hesitation at both the employee and management levels.

**Responses on Efficiency:** Balanskat, Blamire & Kefala (2006) observed that when considering the impact of ICT in education there tends to be a focus on whether and to what extent, ICT can raise pupil attainment. Yet, they continue, it is often difficult to establish

hard evidence of improved pupil attainment as a result of using ICT because isolating the impact of ICT from all other factors that can affect achievement can be problematic (Balanskat, Blamire, & Kefala, 2006). In agreement, Olson et al., (2011) also reported that although it is expected that the most direct impact of e-learning would be on the learning achievement of students, the results of large, cross-national studies show that the effects of e-learning applications on learning are complex and closely related to how the technology is used as an educational tool, and other factors. Olson et al.,(2011) continue, that specific applications of ICT can positively impact student knowledge, skills and attitudes, as well as teaching practices, school innovation, and community services (Olson, et al., 2011).

During the stakeholders FW on the identified gap in the teaching and learning of ED, it was suggested that the solution to the gap was the development of audio visual animated tutorials that can be accessed outside the lecture room so students can learn, visualize and practice ED everywhere they are at a given time. As such the key performance indicators for the efficiency of the application in terms of solving the issue of too much content covered in a limited time were; to have audio and visual (animations) capabilities, enable frequent practice of ED, and have the ability to be used everywhere.

The voices coming through the evaluation FW were mostly about how AVATED's ability to support everywhere learning at ones convenience had enabled the participants' to learn at their pace and that it would enable them to use the time outside the lecture room to learn more. The statement that "learning ED is fun now because it takes place everywhere at any time and with less direction" by one of the participants, was evidence of how well the application addressed the cardinal gap of too much content covered in a limited time by enabling everywhere learning. This is in agreement with Stockley (2014) who reported that an e-learning intervention should be chosen because it is the most efficient and effective way to meet the identified learning need.

The participants responses during the evaluation FW, also unearthed new pertinent information that had not come through thus far during the study. Participants, especially the lecturers, pointed out the issue of students not attending lectures because one feels he's ahead in coverage of the content and as such attending lectures would be a waste of their time. This concern of lecturers about lecture attendance of students who feel they have covered ahead was addressed by Zuo et al., (2003) when they reported about the case of the Department of Engineering and Computer Graphics, Guangdong University of Technology, Guangzhou, China, who are among the leading implementers of e-learning applications in the teaching and learning of the ED course unit. They reported that those students, who understand well, can complete the fundamental requirements early. Thus the teacher assigns them to a higher mission, for example, 3D modeling, small design or joining the teacher's scientific research work etc. (Zuo et al., 2003).

Also coming through for the first time was the participants' comments on how the AVATED application had helped cut costs of weekly photocopying of handouts and printing assignments. Although not in the original intended functions of the application, this revelation was of great significance to the study especially in terms of cutting down on paper use and as such being an environmentally friendly intervention since less paper means less trees cut to make them.

### 5.3 CONCLUSIONS

Noam cited in UNESCO (2002) pointed out that, “In the past, people came to the information, and the information was at the university. In the future, the information will come to the people, wherever they are”. By taking the learning of ED from just being confined in the lecture rooms, out to the students’ hostels, on taxis, in the village and any place where the student may be at a given moment, the AVATED application has surely taken the students’ acquisition of drawing competencies in ED a step ahead.

The positive responses of the participants in regards to; design, attitude, usability, sense of achievement and ease of AVATED use means that the application has been able to address the issue of too much content versus limited time that was identified as a gap in the teaching and learning of ED. The intervention has offered new and better opportunities for differentiated learning of ED, students work more independently, and as such ED lecturers will now have more free time to assist individual students according to need.

**The ED Lecturers:** To ensure a smooth integration of the AVATED application into the teaching and learning processes of the ED course unit, the following recommendations are proposed for action by the course unit lecturers;

- The lecturers should use AVATED to cover content in conjunction with traditional methods. It's recommended that they keep attending to the students during the designated times for the course unit.
- The lecturers should give assignments that compel learners to continue practicing drawing as they use application.

**University LMS Administrator:** To ensure a smooth integration of the AVATED application into the teaching and learning processes of the ED course unit, the following recommendations are proposed for action by the LMS administrator;

- The admission of all CBE students offering ED to the University LMS system should be fast tracked to enable them access the application from any device that has internet. This would eliminate the need to carry their laptops around.
- High speed internet should be installed everywhere around the university to enable students' access and download AVATED content on the online university LMS network.

#### **5.4.2 Recommendations for Future Research**

Action Research is an ongoing activity and as such there still exist several gaps in this area of teaching and learning of ED that calls for further research. I therefore propose four questions for future research:

- What is the long term impact of AVATED on the learners' ability to apply learnt concepts at the workplace?

- To what extent does the current ED assessment criterion reflect a learner's competence in regards to parameters of drawing such as neatness, speed of drawing, interpretation, accuracy, and use of instruments?
- How relevant is the current ED content to the learners' future studies and the workplace?
- How can the AVATED application keep pace with the ever changing advancements in technology?

The timeframe for conducting this action research study could not permit me to assess the long term impact of this intervention on the learners especially when it comes to applying the learnt concepts at the workplace. This information is very crucial in determining the overall effectiveness and efficiency of the intervention and as such highlight the weaknesses of the application that may need to be redesigned in the future.

Whereas the main focus was on delivery of ED content, during the course of this research study, I discovered several gaps especially in the area of assessment that were critical to the successful teaching and learning of ED but as such fell outside the scope of the study. The successful teaching and learning of ED in the CBE department can not only be addressed with an excellent delivery application such as AVATED but a three dimensional approach that also includes revising the ED curriculum and designing a pragmatic assessment criterion for ED. The curriculum needs to be designed based of the requirements of the world of work and the assessment structure should encompass all parameters of drawing such as neatness, speed of drawing, interpretation, accuracy, used of instruments among others.

In addition, the ever changing technologies make it imperative that this intervention is constantly upgraded and refined to suit the hardware and software requirements of the ICT technology of the moment in time. The ICTs of tomorrow will be even more superior and have unlimited capabilities and as such the AVATED concept will need to be evolved.

## REFERENCES

- Academy of Mine. (2017). *Developing Your e-Learning Platform*. Retrieved September 20th, 2017, from Academy of Mine: <https://www.academyofmine.com/developing-your-e-learning-platform/>
- ACE. (2017). *Elections and Technology*. Retrieved september 27th, 2017, from The Electoral Knowledge Network: <http://aceproject.org/ace-en/topics/et/etb/etb02/etb02b/etb02b03>
- Balanskat, A., Blamire, R., & Kefala, S. (2006). *The ICT Impact Report - A review of studies of ICT impact on schools in Europe*. European Schoolnet.
- Bhatia, N. (2013). *Avoid these 6 Mobile App Development Challenges*. Retrieved september 25th, 2017, from Propelics: <https://www.propelics.com/avoid-6-mobile-app-development-challenges/>
- Brydon-Miller, M. (2003). Why action research. *Action Research Volume 1(1)*, 9-28.
- Department of Civil and Building Engineering. (2009). *Bachelor of Engineering in civil and Building Engineering*. Kyambogo University: Kampala.
- Cohen, D., & Crabtree, B. (2006). *Qualitative Research Guidelines Project*. Retrieved from Robert woods Johnson Foundation: <http://www.qualres.org/HomeObse-3594.html>
- Colucci, E. (2007). "Focus Groups Can Be Fun": The Use of "Focus Groups Can Be Fun": The Use of Focus Group Discussions. In *Qualitative Health Research* (pp. 1422-1433). Melbourne: Sage Publications.
- Dencombe, M. (1998). *The Good Research Guide: For small-scale social research projects*. London: Open University Press.
- Easterby-Smith, M., Thorpe, R., & Lowe, A. (2002). *Management Research: An introduction*. London: Sage.

- Federal Trade Commission (2017). *Understanding Mobile Apps*. Retrieved september 20th, 2017, from Federal Trade Commission: <https://www.consumer.ftc.gov/articles/0018-understanding-mobile-apps>
- Ferriman, J. (2013). *7 Key Steps to Successful ELearning Implementations*. Retrieved August 20th, 2017, from LearnDash: <https://www.learndash.com/7-key-steps-to-successful-elearning-implementations/>
- Field, A. (2005). *Discovering statistics using SPSS*. London: Sage Publications Ltd.
- Giesecke, F. ..., Spencer, H. E., Hill, I. L., Dygdon, J. T., Novak, J. E., & Lockhart, S. D. (2008). *Technical Drawing*. New Jersey: Prentice Hall Press.
- Gowen, A. (2009, December 6th). *Without ready access to computers, students struggle*. Retrieved September 27th, 2017, from Washington Post: <http://www.washingtonpost.com/wp-dyn/content/article/2009/12/05/AR2009120501746.html>
- Haddad, W. D., & Draxler, A. (2002). *Technologies for Education: potentials, parameters, and prospects*. Paris: UNESCO .
- Huysman, M., & de Wit, D. (2002). *Knowledge Sharing in Practice*. Dordrecht: Kluwer Academic, cop.
- Kosse, V., & Senadeera, W. (2011). *Innovative approaches to teaching engineering drawing at tertiary institutions*. Brisbane: Manchester University Press.
- Kvale, S. (1996). *Interviews: An introduction to qualitative research interviewing*. London: Sage Publications.
- Maxwell, J. (1997). Designing a qualitative study. In L. Bickman, & D. Rog(Eds), *Handbook of applied social research methods* (pp. (pp.69-100)). Thousand Oaks, CA: Sage.

- McNamara, C. (1999). *General Guidelines for conducting interviews*. Minesota.
- Mikre, F. (2011). The Roles of Information Communication Technologies in Education. *Ethiopia Journal of Education and Science Vol. 6, NO. 2*.
- Najafabadi, M. O., Poorsadegh , M., & Mirdamadi, S. M. (2013). Challenges of Application ICTs in Technical and Vocational Training from Students' and Instructors' Perception in Maragheh. *International Journal of Advanced Science and Technology Vol. 53*, 105-112.
- New Zealand Curriculum Guides. (2013, August 12th). *Making connections to prior learning and experience*. Retrieved September 26th, 2017, from New Zealand Curriculum Guides - Senior Secondary: <http://seniorsecondary.tki.org.nz/Health-and-physical-education/Pedagogy/Prior-learning-and-experience>
- Nunes, C. A., & Gaible, E. (2002). Development of multimedia materials. In W. D. Haddad, & A. Draxler, *Technologies for education* (pp. 94-117). Paris: UNESCO.
- Olkun, S. (2003). Making Connections: Improving Spatial Abilities . *International Journal of Mathematics Teaching and Learning*, 1.
- Olson, J., Codde, J., deMaagd, K., Tarkelson , E., Sinclair, J., Yook , S., (2011). *An Analysis of e-Learning Impacts & Best Practices in Developing Countries With Reference to Secondary School Education in Tanzania*. East Lansing: Michigan State University.
- Pappas, C. (2014). *The Ultimate eLearning Course Design Checklist* . Retrieved september 28th, 2017, from e-learning Industry: <https://elearningindustry.com/the-ultimate-elearning-course-design-checklist>

- Rathbone, A. (2014). *How to Run Older Programs under Windows 8*. Retrieved september 25th , 2017, from Dummies: <http://www.dummies.com/computers/operating-systems/windows-8/how-to-run-older-programs-under-windows-8/>
- Reason, P., & Bradbury, H. (2001). *Handbook of action research: participative inquiry and practice*. London: Sage Publications.
- Rhodes, R., & Cook, L. (1978). *Basic Engineering Drawing*. London: Pitman Publishing Limited.
- Schutt, R. K. (2011). *Investigating the Social World*. Washington DC: Sage.
- Teddies, C., & Yu, F. (2007). Mixed Methods Sampling: A Typology with Examples. *Journal of Mixed Methods Research*, 77-100.
- Towse, M. (2009). *Best Practices: Creating Successful Online Modules*. Retrieved September 2nd, 2017, from Learning Solutions: <https://www.learningsolutionsmag.com/articles/56/best-practices-creating-successful-online-modules>
- Turner, D. (2010). Qualitative interview design: A practical guide for novice investigators. *The Qualitative Report* 15(3).
- UNESCO. (2003). *The use of ICTs in Technical and Vocational Education and Training*. Moscow: UNESCO Institute for Information Technologies in Education.
- Urdarevik, S. (2013). Using models to teach and learn. *ASQ Advancing the STEM Agenda Conference* (p. 9). Michigan: Grand Valley State University.
- Wawasan open university. (2017). *ICT in Education: Technology for Education-the parameters*. Retrieved from Wawasan open university web site: 2017 [woulibrary.wou.edu.my/weko/eed502/technology\\_for\\_education\\_the\\_parameters.ht](http://woulibrary.wou.edu.my/weko/eed502/technology_for_education_the_parameters.ht)

- Yusuf, M. O., & Falade, A. A. (2005). Media in Distance Learning: The Nigerian National Teachers Institute Distance Education Program. *Turkish Online Journal of Distance Education*, 23-31.
- Zuo, Z., Feng, K., & Chen, B. (2003). The Modern Education Mode for Engineering Drawing. *Journal for Geometry and Graphics Volume 7 (2003), No. 1,, 121-128.*

**Appendix B: Student's questionnaire 1****Pre-Drawing data (To be filled by participant selected for implementation of AVATED)**

Please tick the most appropriate answer to the question asked

1. What is your background in Technical Drawing (TD)?
  - A. Started doing TD in O-level (S1-S4)
  - B. Started doing TD in A-level (S5 –S6)
  - C. Started doing TD at the university (Semester 1 of year 1)
  
2. How do you rank yourself in terms of competencies in TD?
  - A. Excellent
  - B. Very Good
  - C. Good
  - D. Fairly Good
  
3. How do you rank yourself in terms of drawing speed?
  - A. Very fast
  - B. Fast
  - C. Slow
  - D. Very Slow
  
4. How do you rank the neatness of your drawing work?
  - A. Very Neat
  - B. Neat
  - C. Fair
  - D. Untidy
  
5. How comfortable are you with using drawing instruments?

- A. Very comfortable
- B. Comfortable
- C. Not comfortable

6. How do you rate your interest and motivation for TD?

- A. Very High
- B. High
- C. Medium
- D. Low

7. Besides the teacher and/or lecturer, what TD references and resources have you consulted or used during your study of TD so far?

-----  
-----  
-----

8. Did you find TD lectures interesting and enjoyable? Please briefly explain your answer.

-----  
-----  
-----

9. In your own opinion, do you think you will be able to recall and as such apply the TD content you have learnt so far to solve future problems in engineering? Please briefly explain your answer.

-----  
-----  
-----

10. In your own words, describe your TD learning experience so far?

-----  
-----  
-----

**Appendix C: AVATED Evaluation Questionnaire**

Please tick the most appropriate answer to the question asked

**Design of AVATED**

1. How do you describe the overall design of AVATED?
  - A. Its poorly designed
  - B. Fairly well designed
  - C. It excellently designed
2. What is your view on how the figures used in AVATED were drawn?
  - A. They were drawn very well
  - B. They were drawn fairly well
  - C. They were drawn very badly
3. What is your view on the animations that are used in AVATED?
  - A. They are very good
  - B. They are fairly good
  - C. They are not good

**Implementation of AVATED**

4. On what device did you install AVATED?
  - A. Smart phone
  - B. Laptop
  - C. Laptop and smart phone
5. How do you describe the installation process of AVATED on your device?
  - A. I had difficulty to install AVATED
  - B. It failed to install completely
  - C. It was so easy to install
6. After installation of AVATED on your device, how did AVATED perform?
  - A. It always hanged and stopped working
  - B. Some files failed to work
  - C. It worked very well
7. Did you undergo training on how to use AVATED?

- A. Yes
  - B. No
8. Was the training effective in getting you started in the use of AVATED?
- A. No
  - B. Yes

**Effectiveness of AVATED (Attitude, Achievement and Usability)**

9. How did you find AVATED in terms of usability (ease of use and navigation around the application)
- A. Very easy to use and navigate around
  - B. Fairly easy to use and navigate around
  - C. Hard to use and navigate around
10. On a scale of 1-10 how do you rank AVATED In terms of being interactive and engaging
- A. 1-3
  - B. 4-6
  - C. 7-10
11. How would you prefer AVATED to be packaged or made available for learning?
- A. CDs
  - B. University Learner Management System
  - C. As an application on the Internet
  - D. Installed on department computers in the computer lab
12. Now that you have used the AVATED application, how do you compare it to the traditional chalk board method that was being used previously?
- A. I prefer the previous chalk board method only
  - B. I prefer the use AVATED only
  - C. I prefer both being used simultaneously
13. How has AVATED impacted your ability to master concepts of engineering drawing
- A. Has not had an impact on me at all
  - B. Has had limited impact on me
  - C. Has had an impact on my ability to master concepts

D. Has had a great impact on my ability to master concepts in engineering drawing

**Efficiency of AVATED (ability to address identified gaps)**

14. To what extent does AVATED solve the issue of too much content to be covered in a limited time?

- A. Solves it completely
- B. Solves it to some extent
- C. Does not solve the issue completely

15. Has AVATED improved the frequency at which you practice drawing?

- A. No
- B. Not sure
- C. Yes

16. On a scale of 1-10, how do you rank AVATED in terms of enabling you to learn engineering drawing at any time of your choice and from any location?

- A. 1-3
- B. 4-6
- C. 7-9
- D. 10

17. Describe in detail, your experience of using AVATED and any comments that you may wish to add on its performance, effectiveness and efficiency.

.....  
.....  
.....  
.....  
.....

**Appendix F: Consent Form for Study Participants**

Date: \_\_\_\_\_

Greetings:

I am a Masters of Vocational Pedagogy (MVP) student at Kyambogo University.

I am pleased to invite you to participate in a research study on the 'Design and Evaluation of an Audio-Visual Animated Technical Drawing Application as a Learning Tool'.

You were specifically invited to participate in this study because I believe that as a stakeholder, you have, one way or another, a part to play in making the teaching and learning of Engineering Drawing (ED) in the department of Civil and Building Engineering of Kyambogo University.

**Background Information of the Study**

The purpose of this study is to design an AVATED application that can be used as an ED teaching and learning tool for the Bachelor of Engineering (BEng) students, and to evaluate the software's success and challenges when used for improving teaching and learning of ED for better learning outcomes. More specifically, by this study, we shall seek to:

1. Design an Audio-Visual Animated Technical Drawing (AVATED) application that can be used as an Electronic Learning (E-Learning) tool.
2. Implement the AVATED application as a teaching-learning tool in the BEng program
3. Evaluate the impact of the AVATED application on the teaching and learning outcomes of ED.

**Procedure**

If you agree to be in this study, you will be asked to:

- Participate in a workshop organized for installation and training of how to use the AVATED application that will be held at NOMA 2 computer lab at Kyambogo University,
- Participate in four sessions of 1 hour long drawing exercises at a place mutually agreed upon,
- Fill in a data collection questionnaire at the end of each drawing session.
- Participate in a Focused Group discussion (FGD) to evaluate the AVATED application as a teaching and learning tool for ED.
- Give permission to have your responses Video-Taped and transcribed;
- Give permission for photos taken during the workshops and FGDs in which you appear, to be used in the report of the study,
- Take part in a follow-up interview if necessary;
- Meet with me, the researcher, to review your responses to confirm that they were correctly interpreted

### **Voluntary Nature of the Study**

Your participation in this study is voluntary. I will respect your decision of whether or not you agree to participate in this study. You may decline to answer any question(s) as you wish or terminate your involvement in the study at any time if you so decide.

### **Risks and Benefits of Being in the Study**

There are minimal risks through participation in this study. Your responses to questions during the interview will be kept confidential. Should there be an inadvertent breach of confidentiality, you will be informed immediately. But I assure you that such very unlikely inadvertent breach will not expose you to any risk. Findings and recommendation from this study may positively impact on the teaching of ED in the department of CBE of Kyambogo University and other Vocational institutions that offer the ED course unit.

**Compensation**

There is no compensation provided for participation in this study. There will also be no financial cost to you should you agree to participate.

**Confidentiality**

All responses during the study will be kept confidential. I will not use your name, personal information, or your responses for any other purpose outside of the study. Data will be kept strictly under the MVP program and Kyambogo University regulations.

**Contacts and Questions**

You may ask any questions you have now. Or if you have questions later, you may contact me via phone at 0772373643 or e-mail at [mutronnie77@gmail.com](mailto:mutronnie77@gmail.com). If you want to talk privately about your rights as a participant, you can call Charity Byarugaba. She is the MVP program administrator who can discuss this with you. Her phone number is 0774945565 or email address [charity24pounds@gmail.com](mailto:charity24pounds@gmail.com).

**Statement of Consent**

I have read the above information and I feel I understand the study well enough to make a decision about my involvement. By signing below, I understand that I am agreeing to the terms of the study described above.

Name and phone number of Participant \_\_\_\_\_

Date of consent \_\_\_\_\_

Participant's Signature \_\_\_\_\_

Researcher's Signature \_\_\_\_\_

**Appendix G: DESIGN WORK PLAN**

	Major Objectives	Key Tasks	Lead Person	Time Frame						Deliverables
				February			March			
				13 <sup>th</sup> -17 <sup>th</sup>	20 <sup>th</sup> -24 <sup>th</sup>	27 <sup>th</sup> -28 <sup>th</sup>	1 <sup>st</sup> -3 <sup>rd</sup>	6 <sup>th</sup> -10 <sup>th</sup>	13 <sup>th</sup> -17 <sup>th</sup>	
1	Preliminary Works	Identify Content	Lecturers							AVATED Content
		Acquire Software	HOD CBE							Use drawing, animation, and website design software
		Learn Software	Researcher							
2	Functionality	Determine Functions	All							Come up with the basic structure of the application
		System Architecture	All							
3	Development	Draw Figures	Researcher							Play back animations and a hosting home page
		Animate and Audio	Researcher							
		Home page Layout	Researcher							
4	Testing	Unit Testing	All							AVATED application works as planned and designed
		Integration Testing	LMS Admin							
		System Testing	LMS							

**Appendix H: IMPLEMENTATION WORK PLAN**

	Major Objectives	Key Tasks	Lead Person	Time Frame			Deliverables
				March		April	
				20 <sup>th</sup> -24 <sup>th</sup>	27 <sup>th</sup> -31 <sup>st</sup>	3 <sup>rd</sup> -7 <sup>th</sup>	
1	Installation	Computer lab computers	Researcher and LMS	[REDACTED]			Installing the AVATED application on computes, Laptops and Smart phones
		Personal laptops	Researcher and LMS				
		Smart phones	Researcher and LMS				
2	Training how to use	Training Lecturers	Researcher	[REDACTED]			Lecturers and students learn how to use the AVATED application
		Training Students	Researcher				
3	Using the application	Lecturers	Researcher		[REDACTED]		Lecturers and students use the AVATED application as a teaching and learning tool
		Students	Researcher				

**Appendix J: EVALUATION WORK PLAN**

	Major Objectives	Key Tasks	Lead Person	Time Frame			Deliverables
				April			
				10 <sup>th</sup> -14 <sup>th</sup>	17 <sup>th</sup> – 21 <sup>st</sup>	24 <sup>th</sup> -28 <sup>th</sup>	
1	Evaluation	Evaluation of application system and Performance on different media	Researcher and Stakeholders				Determine how well the application runs on the desktop computers, Laptops, Smart phones and the university LMS network.
		Evaluation of application ergonomics (Ease of use)	Researcher and Stakeholders				Determine how comfortable the lecturers and students are with using the application as a teaching and learning tool.
		Evaluation of the applications ability to address the identified gaps	Researcher and Stakeholders				Determine whether the application is the perfect solution to the gaps identified by the stakeholders during the work process analysis and future workshop.

**Appendix K: AVATED EVALUATION INTERVIEW GUIDE**

- RQ1.** How do you describe the overall design of AVATED?
- RQ2.** What are your comments on the installation and performance of AVATED on your device?
- RQ3.** How do you compare AVATED with the chalk board method that was previously used in terms of being interactive and engaging in terms of teaching and learning?
- RQ4.** To what extent does AVATED solve the issue of too much content to be covered in a limited time?
- RQ5.** In your opinion, to what extent will AVATED improve the frequency at which you students practice drawing and also enable everywhere learning at ones convenience?

## **Appendix L: PROTOCOL FOR AVATED EVALUATION WORKSHOP**

**Research Topic:** Design and Evaluation of an Audio-Visual Animated Technical Drawing Application as a Teaching and Learning Tool

### **Introductory Protocol**

Thank you for agreeing to gather together so we all share our experiences of using AVATED as a teaching and learning tool. Together we shall evaluate the design, implementation, efficiency, and effectiveness of AVATED as you committed to do in the consent form that you signed when selected to participate in the study. I wish to also remind you that you are at liberty to withdraw from the study at any point if you so desire.

Let us begin with self-introduction (Name and TD background)

### **Discussion Points**

1. What is working well with the;
  - a. Design of AVATED
  - b. Implementation of AVATED
  - c. Efficiency of AVATED
  - d. Effectiveness of AVATED
2. What is NOT working well with the;
  - a. Design of AVATED
  - b. Implementation of AVATED
  - c. Efficiency of AVATED
  - d. Effectiveness of AVATED
1. What is the way forward for AVATED

## APPENDIX M

### **Minutes of the CBE Engineering Drawing Course Unit Stakeholder's Future Workshop held at Noma 1 House on 2<sup>nd</sup> December 2016**

#### **Attendance**

In attendance were 15 students, two lecturers, dean of faculty of Engineering, the Civil and Building department computer lab technician, and two members from the world of work.

#### **Agenda**

1. Opening Prayer
2. Communication from the Researcher (Preparatory Phase)
3. Critical Phase
4. Categorizing the identified gaps
5. Pairwise Ranking
6. Fantasy Phase
7. Reality Phase
8. Closing Prayer

#### **Minute 1: Opening Prayer**

A short prayer was led by the chairperson

#### **Minute 2: Communication from the Researcher (Preparatory Phase)**

The researcher welcomed members to the workshop. He introduced the background and purpose of the future workshop, the area of concern, and took participants through the values and rules of the workshop.

The researcher introduced the area of concern as ‘ENGINEERING DRAWING TRAINING IN THE DEPARTMENT OF CIVIL AND BUILDING ENGINEERING’ and then the purpose of the future workshop which was ‘To subject the area of concern to a more in-depth inquiry so as to establish gaps and then determine an appropriate intervention for improvement’.

### Minute 3: Critical Phase

The critical phase of the workshop was kick started by the researcher asking the participants to visualize what their expectations of engineering drawing were at the beginning and what their real experiences of the course unit have been.

EXPECTATIONS	EXPERIENCES	GAPS
To find different sources of knowledge	Only source of knowledge is the lecturer	Limited sources of knowledge, and Available engineering drawing books are not illustrated well for a student to understand without help of the lecturer
To find some practical aids and models to help in visualization of concepts	Delivery is only by lecturers demonstrations and sketches on the chalk board	No practical teaching aids and animated models to reinforce learning
To do more practical work and application of learnt concepts	Students don't engage in practical application of knowledge learnt	Too much time spent on interpretation of drawings in theory and not how to apply the concepts to actual practical work
To use Computer Aided Design (CAD) software	Only an introduction to computer aided designs (CAD Soft wares) is given leaving the rest of the training as a personal initiative	No in-depth CAD training that matches what is needed at the world of work, and Computers not enough for students hands-on training.
Use ICTs as a learning platform	Teaching and learning takes place only in the lecture room	No audio visual tutorial packages for use in teaching and learning, and
To be taught what is only	Same content for all programs	Same Engineering Drawing content for all programs in the

relevant to one's trade	regardless of trade	department.
Course unit to be spread throughout duration of program to enable comprehension of content	content squeezed into just one semester and this means covering too much in such a small time	Too much content taught in a very short period (one semester), and Lecturers do not demonstrate with instruments because of time.
Engineering drawing as a communication tool was to be given the attention it deserves in terms of practice of learnt concepts	Study and draw only for the exams	No orientation for the course, and No student initiative to practice learnt concepts
To visit world of work and keep pace with modern practices	No field trip for the course unit	Students don't relate course unit to world of work

#### **Minute 4: Categorizing the identified gaps**

The workshop suggested four headings in which to categorize the generated gaps and these were as follows:

##### 1. ICT integration into learning

- No in-depth CAD training that matches what is needed at the world of work
- Computers not enough for students hands-on training.
- No audio visual tutorial packages for use in teaching and learning

##### 2. Teaching and learning methods

- Too much time spent on interpretation of drawings in theory and not how to apply the concepts to actual practical work
- Too much content taught in a very short period (one semester)
- No student initiative to practice learnt concepts
- Students don't relate course unit to world of work

##### 3. Department administration

- Same Engineering Drawing content for all programs in the department.
- No orientation for the course

#### 4. Instructional materials

- Limited sources of knowledge
- Available engineering drawing books are not illustrated well for a student to understand without help of the lecturer

### Minute 5: Pairwise Ranking

The stakeholders then used Pairwise Ranking to determine which of the headings and subsequent gaps were more pressing and as such needed immediate attention so as to improve the area of concern.

	1	2	3	4	Total tally	Ranking
1					1	3
2	1				2	1
3	3	2			2	1
4	4	2	3		1	3

Table 3: Pairwise Ranking of gaps

Heading 2 and 3 tied in the ranking and the stakeholders voted again to determine which of the two was a more pressing issue as far as Engineering Drawing at the department was concerned. In the second vote, heading 3 got 2 votes and heading 2 got 6 votes. The stakeholders agreed that teaching and learning methods gaps were the most pressing issues at the department and as such needed urgent intervention.

### Minute 6: Fantasy Phase

The facilitator guided the participants to produce ideas and solutions by critiquing the identified gaps from a bad to good situation without barriers in the mind. This generated many good solutions for the 'idea store' and these are outlined below under the respective gap they address.

1. Too much time spent on interpretation of drawings in theory and not how to apply the concepts to actual practical work
  - Project assignments that enable students put to practice the application of the concepts learnt in the lecture room,
  - Use of practical aids and animated models during lectures to reinforce visualization and understanding of concepts,
  - Include field practical work to enable the students relate what is learnt in the lecture room with what is in the world of work.
2. Too much content in limited time
  - Allocate more time to engineering drawing and split the content into different units spread over the duration of the program,
  - Develop audio visual animated tutorials applications to use in teaching so learning can also take place outside the lecture room,
  - Tailor make content to a particular program (teach only what is relevant for the trade) so as to reduce on content.
3. Students lack self-initiative to practice drawing
  - Lecturers should give more assignments that can enable students to continue practicing even outside the lecture room,
  - Attach allowances for marking assignments so as to motivate lecturers to give and mark more assignments,

- Reward students for extra practice with coursework marks so as to encourage them to continue practicing,
  - Develop audio visual animated tutorials that can be accessed outside the lecture room so students can learn and practice everywhere they are at a given time,
  - Lecturers to avail themselves for student's consultations on practice tasks that may have given them difficulty,
  - Encourage students to buy learning materials such as drawing equipment so they can continue to practice in their own free time without having to rely on borrowed equipment,
  - Computer lab technician should participate in the teaching process especially in CAD training. This will enable students to practice CAD outside the lecture room at ones convenience.
4. Students don't relate course unit to world of work
- Students should get an Engineering Drawing orientation at the beginning of the course unit. This should emphasis that Engineering Drawing is the backbone of all engineering works,
  - Field tours at the beginning of the course unit to emphasize relevance, application and triangulation of concepts learnt,
  - Use of project based learning to enable students relate what is being learnt with actual application throughout the course of study.

#### **Minute 7: Reality Phase**

The researcher guided the stakeholders through an evaluation of the 'idea store' to choose the best suited ideas or solutions that can be put to more concrete terms.

The idea of Audio-Visual Animated Technical Drawing tutorials was chosen as the most realistic idea that can be implemented in the available time.

Stakeholders agreed that the intervention should have the following functions

11. Easy to use and navigate
12. Clearly define and explain the topic
13. Show the application of the topic in Engineering
14. Show examples of the topic in real day-to-day life
15. Include audio explanation of the topic
16. Include a video of the topic in three dimensional motion
17. Show step by step visual animation of the examples
18. Have assignments and tasks for students to practice
19. Have provision for submission of work and also feedback from the lecturer
20. Include links to other university sites

#### **Minute 8: Closing Prayer**

The meeting was closed with a prayer from one of the members.

**APPENDIX N****Minutes of the AVATED Evaluation Group Discussion Workshop that took place at the CBE department on the 2<sup>nd</sup> June 2017****Attendance**

In attendance were 15 student participants and two lecturers of Engineering Drawing

**Agenda**

1. Opening Prayer
2. Communication from the researcher
3. What is working well with the;
4. What is NOT working well with the;
5. What is the way forward for AVATED
6. Closing Prayer

**Minute 1: Opening Prayer**

The workshop was opened by a prayer led by one of the participants.

**Minute 2: Communication from the researcher**

The researcher guided the participants to select the minute's secretary for the day.

The researcher then thanked the participants agreeing to share their experiences of using AVATED as a learning tool as they committed to do in the consent form that they signed and also reminded them of their right to withdraw from the study at any point should they so desire.

**Minute 3: What is working well?**

The participants discussed and raised a number of areas that they felt were points about the intervention and these included the following.

### Design

- A number of participants said that AVATED had a good design
- The red and black colors used for the drawings are good.
- Audio clear, basic, and simple enough to be understood

### Implementation

- AVATED is Easy to learn and use
- The application Worked very well on Laptops
- AVATED enables team learning as participants shared laptops

### Effectiveness of AVATED

- The application increased our interest in ED
- Seeing and listening to the step by step process as one draws made learning fun
- AVATED is interactive and easy to navigate around

### Efficiency of AVATED

- Participants agreed that AVATED cuts costs of weekly handouts and printing
- The application has enabled us to learn at own pace and cover content faster
- Has enabled us to learn from anywhere at anytime
- Can always revisit a topic that has been forgotten or not well understood
- It's easy to remember what is watched that what is read

### **Minute 4: What is NOT working well?**

Then the participants discussed and raised a number of areas that they felt were issues that were not working well with intervention and these included the following.

### Design

- Participants raised the concern of only a few topics being included in the application
- The issue of phone screens being too small to see the drawing lines was also raised.
- Some buttons not working on smart phones

- It was also mentioned in the discussions that the application files too heavy for some phones with small memory

#### Implementation

- The issue of cost of laptops was raised
- Participants pointed out that when files get corrupted installation meant going back to the researcher and this was inconveniencing

#### Effectiveness of AVATED

- Need for self-drive to motivate your own self to learn and cover content was raised as a major concern
- Absence of fast forward and rewind buttons was found to be inconveniencing participants

#### Efficiency of AVATED

- Participants observed that moving with Laptops everywhere is risky and increases the chances of them being stolen
- The issue of not attending lectures because one feels he's ahead in coverage was also raised
- Some participants said they were addicted to hard copies of handouts

#### **Minute 5: Way forward for AVATED**

The participants discussed and raised a number of solutions the challenges of AVATED and these included the following.

- The Civil and Building Engineering department should allocate more resources to development and inclusion of more content in AVATED
- A separate application for mobile phones should be developed
- The University LMS system should be fast tracked
- AVATED should be packaged and supplied on CDs

- There is a need for lecturers to give assignments that compel learners to use application
- More control buttons should be included in the application
- Delivery of AVATED on the internet would enable learning from any available device
- Use AVATED to cover content in conjunction with traditional methods

**Minute 6: Closing Prayer**

The meeting was closed by a prayer from one of the participants.