EVALUATION OF THE TEACHING AND LEARNING OF 3-D COMPUTER-AIDED DESIGN IN THE DEPARTMENT OF INTEGRATED RURAL ART AND INDUSTRY, KNUST

By

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Philosophy in Art Education and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

I dedicate this thesis to my Late father Rev. Bernard Sarfo, my mum Rose Sarfo who gave me the push when life got tougher and then finally to the people in my life who believed in me.

ABSTRACT

The Department of Integrated Rural Art and Industry (IRAI) has been ultimately considered as a distinctive Department, in the Kwame Nkrumah University of Science and Technology, which is purposefully focuses on designing and production of artefacts. The programme equips students with the needed skills to identify and promote the indigenous art and craft of the traditional Ghanaian heritage. In this regard, the Department adopted a Computer- Aided Design (CAD) module in their product design discipline to equip learners with the relevant practical skills to aid them in the execution of their works of art with state of the art technologies. It is obvious that the teaching methods, availability and technical expertise of CAD and digital literacy of students tend to significantly contribute to the artistic development of students and influence the designing and execution of artefacts. However, 10 years on after its introduction in the IRAI curriculum, an official evaluation has not been done to ascertain the effectiveness and impact on its teaching and learning.

Owing to the aforementioned issues, this study sought to identify and describe the nature of 3-D CAD subject contents in the IRAI curriculum and to find out the contents and the existing instructional methods adopted in the teaching of 3-D CAD. Ultimately, the study evaluated the effectiveness of the application of 3-D CAD in Product designing by students. The study adopted the qualitative research method using the Kirkpatrick's 4 Levels of Instructional Evaluation in order to gain insight into the teaching and learning of 3-D CAD. 207 fourth year and third year undergraduate students and 2 lectures were sampled for this study.

Findings revealed that traditional methods of designing and solving problems had made way for new technologies making students to become more conscious of new aspects of visual expressions by exploring different software to express their creativity. The usefulness and relevance of 3D CAD on students' area of specialization is high, nevertheless, however, the issue of congestion of the syllabi and the inadequate time allocated for the course burdens instructors coupled with insufficient teaching and learning resources. In enhancing students' designing skills, the module of 3-D CAD ought to be introduced early simultaneously with other foundational courses in the IRAI curriculum.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter provides explanations on the background of the study, statement of the problem, objectives of the research, research questions and delimitations of the study. Significance of the study, abbreviation and terms found in the study have also been discussed.

1.1 Background to the Study

Current and emerging technologies are transforming the way people learn and live. In the same vein, the phenomenon of educational technologies has come to revolutionize the traditional processes of teaching and learning. Butzin (2000) asserts that, there have been massive improvements in academic performance universally due to the use of computer and internet technologies. For instance, one can draw, paint, and make prototypes of works and a lot more in record time with the advent of computers. Computers have led to the development of new technologies for which art has not been left out. With the introduction of information technology in recent times, the expert practice of product design and its education have been part of the front-runners of consuming the computer technology proficiency. Owing to the improvement of technology, designers are gradually employing Computer- Aided Design (CAD) as tools in the course of the designing process (Allsop 2009).

Moreover, Wands (2011,p.34) postulates that "Given the digital literacy of the current generation of university students, three-dimensional (3-D) software can significantly

contribute to their artistic development". This artistic development can be in sculpture, metal products design among other disciplines.

As part of its vision, KNUST is to effectively train top workforce for the various areas of study for Ghana's economic system and equip graduates with the knowledge and expertise to support the industrial and socio-economic development of Ghana to fit into the ever-growing technological world.

Department of Integrated Rural Art and Industry has been ultimately considered as a unique area, which is strategically focused on a twofold undertaking namely, designing and production. In this regard, the Department of IRAI as part of their programme has integrated Computer- Aided Design module in their discipline to help advance students' knowledge in technology. The ability to express one's creative thoughts effectively continues to be the focus of the IRAI programme. To this effect, some computer applications and hardware have been adopted by the Department of IRAI in teaching and learning to equip learners with the relevant practical skills to aid them in the execution of their works of art. The availability and technical expertise of CAD and other hardware tend to influence the designing and execution of artefacts. Therefore, the Department of IRAI has adopted 3-D Computer- Aided Design as part of the product design course that is ran in the Department.

3-D CAD tools have been at the disposal of the designer or artist for about half a century and has played an essential role in academia and industry in recent times, particularly in the area of product designing. Similarly, 3-D CAD is employed in the fields of engineering, architecture and mechanical for producing all kinds of designed products as a replacement of the tiresome manual method of designing and production of artefacts. Primarily, hand drawing and manual product designing was meant to be substituted with the advent of CAD tools. Higher institutions later adopted CAD into

their curriculum as a result of the improvement of its hardware and software (Daud, Taib, and Shariffudin 2012). 3-D software now remain the main tools used for three-dimensional designing and the production processes by means of Computer-Aided Design applications (Martinez 2012). In other words, 3-D Computer-Aided Design plays an important role in the production of three-dimensional (3-D) works of art, beginning with creating and developing concepts from the preliminary stages through to the final stages.

Design involves problem-solving and creativity, which can be achieved with 3-D Computer-Aided Design. The connection between design and production is the planning and execution of a conceived idea. A design may be a mere plan that does not include a production, although a working knowledge of such processes is usually expected of designers (Ward 2010 as cited in Apau 2013). 3-D Computer-Aided Design is the creation, presentation and analysis of a design to develop computer-generated images of works of art that give people understanding. Examples of current software used are Rhinoceros 3D, 3-Ds Max, Cinema 4D among others. Presently, 3-D modelling is seen in automobile, ceramics, sculpture, jewelry, packaging, furniture designs and architectural applications among others (Martinez 2012).

The use of 3-D Computer-Aided Design tools by artists help them to unleash their imagination without any restriction of skills in the designing and production process (Mahmoud and Elbelkasy 2013). Some art and design programmes in most higher education institutions across the world have incorporated CAD courses in their curriculum, and in line with global trends the Department of IRAI, have been running the Advanced Product Design course, where learning and teaching of 3-D CAD is done. Several design courses using ICT tools have emerged to enhance the designing and

production of artworks. However, these tools since introduced have not seen the significant revolution anticipated of them.

Melody and Modupe (2003) as cited in Asinyo (2009, p. 191), insists that evaluation is conducted to "examine and report on the strengths and weaknesses of programmes, policies, personnel, processes, outcomes, and organizations to improve their effectiveness". Evaluation offers significant information for additional development and expansion of any programme. Even though learners in institutions make use of different types of technologies to perform numerous tasks such as idea development, making prototypes among others, no proper evaluation regarding how it is faring in its usage has been carried out.

In light of the issues raised, the study sought to provide meaningful data and gain understanding on the level to which 3-D Computer-Aided Design integration is meeting its objectives of providing a holistic ICT-based training and a modern educational experience for students. It also sought to investigate the benefits, downsides of CAD and the impacts on students' works in the Department of IRAI. Again, this study offered insightful perspective on the current 3-D CAD training at the Department of IRAI focusing on the shortfalls limiting a full utilization and realization of CAD in the product design course.

1.2 Statement of the Problem

Technologically based design education is a vehicle to promote creative thinking and creativity of learners in Visual Art Education, especially at the higher education level. In this regard, Visual Arts Education programmes at the tertiary level have integrated ICT across all subject areas to help students use ICT to solve simple to complex

problems. In fact, Computer- Aided Design in the product design course is a compulsory subject in the Department of IRAI. When learners acquire the desired skills and knowledge in Computer- Aided Design in the product design course, it is expectant of them to exhibit such competences in solving real life problems in their area of study. For instance, students are expected to use Computer- Aided Design software to execute their projects works in the area of idea developments and for digitally rendering final artefacts. Erdener (2006) posits that, the traditional methods of designing and solving problems are making ways for new technologies thereby giving students the impetus to cognitively use modern technology to solve problems in their subject areas.

Furthermore, the introduction of CAD in the IRAI curriculum is done purposely to equip students to explore, develop and communicate ideas through creativity and the use of computerized methods of productions. Unfortunately, after 10 years of its introduction no evaluation has been done to ascertain its effectiveness and impact in its teaching and learning in the Department of IRAI. It stands to reason that, integrating ICTs into the teaching and learning of visual art would assist students in the areas of idea development, simulation of artefacts and other manufacturing concepts (Asinyo 2009).

It is therefore no denying the fact that, the teaching and learning of 3-D Computer-Aided Design plays an important role in this regard, however the teaching, learning, attitudes of students, benefits and the shortcomings of 3-D Computer-Aided Design in the Department of IRAI have not been officially evaluated. In effect, the introduction and usage of 3-D Computer- Aided Design in art is on the rise, but its application in the art studio is yet to be considered. The question however remains, is it increasing the creativity of its users? Owing to the background given, this study is aimed at identifying the benefits and shortcomings of the teaching and learning of 3-D CAD as well as

evaluating its impact on students' artistic works. Asinyo (2009), asserted that, there is the need for every implemented framework to be revised every three successive years for efficient teaching and learning of ICT and failure to conduct evaluations occasionally could result in its weakness.

1.3 Objectives of the Study

1. To identify and describe the nature of 3-D CAD subject contents in the IRAI curriculum.
2. To examine the contents and the existing instructional methods adopted in teaching 3-D CAD in product design in the Department of IRAI.
3. To evaluate the effectiveness of the application of 3-D CAD in Product designing by students in the Department of IRAI.

1.4 Research Questions

1. What is the nature of the 3-D CAD subject contents in the IRAI curriculum?
2. What are the subject contents and existing instructional methods adopted in teaching 3-D CAD in product design in the Department of IRAI?
3. How effective is the application of 3-D CAD in Product designing by students in the Department of IRAI?

1.5 Delimitation

The scope of this research will be limited to the teaching and learning of 3-D CAD in product designing in the Department of IRAI, KNUST. The content will only focus on evaluating the 3-D Computer- Aided Design subject taught in product designing in the Department of IRAI curriculum.

1.6 Definition of Terms and key concepts.

Computer-Aided Design*:* Computer- Aided Design (CAD) refers to the process of using computers and specialist software to create virtual three-dimensional models and two-dimensional drawings of products.

Three-dimensional (3-D): Three-dimensional is any object that is solid instead of flat, as it can be measured in three different directions, typically the width, length and height. It also refers to a software that creates both three-dimensional and two-dimensional images.

Two dimensional (2-D): They are objects that have length and breadth but lack depth and its mostly flat and not solid.

Product Designing: It is a critical observation at what is required, investigating and coming out with concepts and design that form new products or enhance on current ones. It seeks to produce resourceful, user-friendly and aesthetic articles.

1.7 Abbreviations/Acronyms

CAD - Computer- Aided Design

2-D - Two-dimensional

3-D - Three-dimensional

IRAI – Integrated Rural Art and Industry

KNUST - Kwame Nkrumah University of Science and Technology

1.8 Importance of the Study

- The research is conducted to help realize and understand the current state of the 3-D Computer-Aided Design as taught and applied in the Department of IRAI.
- It will unearth the strengths, weaknesses and future direction of the teaching and learning of Computer- Aided Design in the Department of IRAI.
- This will also serve as a reference material for future studies in the area of Computer- Aided Design.
- This research serves as an insightful guide for art educators, reviewers, curriculum planners and art students as it will add to the literature on how 3-D CAD is integrated in the teaching and practice of product designing.
- The results of the evaluation will aid in expanding and strengthening areas of CAD training in the Department and the transference of technology and knowledge from the Department to the Ghanaian indigenous craft industry and vice versa.
- Students and artists will be encouraged to employ and apply a wide range of Computer- Aided Design software to widen their knowledge in visualizing production methods in the art industry.
- Finally his study will enlighten the University authorities and lecturers on the importance and efficient approaches in teaching product designing using 3-D Computer-Aided Design and its impact on students' products whiles encouraging other institutions and students to employ 3-D Computer-Aided Design in producing works of art.

1.9 Arrangement of the Rest of the Chapters

The Chapter Two of this study offers empirical and theoretical reviews on Computer-Aided Design, product designing and its impact on teaching, designing and production of artefacts. In Chapter Three, the methodology employed, population, sampling techniques and tools for data collection as the treatment of data are dealt with. In Chapter Four, an in-depth analysis and interpretation of the collected data is reviewed. Chapter Five involves summary of the main findings, conclusions and recommendations of the research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

This chapter reviews some of the significant fundamentals of Computer-Aided Design of from its beginning stages, its integration into product design, and the impact it has had on products designs. It also deals with some significant theories in teaching, learning and evaluation. In this review are the following sub-topics:

- Overview of the Department
- Computer- Aided Designing
- 3-D Computer- Aided Designing
- Education and Technology in the Era of Globalization
- Product designing in art
- Impact of 3-D CAD on Design Education
- Concept of Teaching
- Theories of Learning
- Training in CAD
- Basic Concept of Assessment
- Kirkpatrick's 4 levels of instructional evaluation

2.1 Overview of the Department of Integrated Rural Art and Industry

The Department of the Integrated Rural Art and Industry is one of the six Departments under the Faculty of Art in the College of Art and Built Environment, KNUST. The sole aim of the Department is to train students to assist in all art related industries in the country. Students are equipped with the requisite knowledge in understanding and

appreciating the several raw materials in Ghana and how to process them into finished products. Technology involved in art and design are also learnt in order to gain experience on new materials, processes, products through the exploitation of students' creativity, problem solving and intellectuality required in the art and design industry. Graduates from the Department are endowed with curiosity, scientific knowledge, creativity, inventiveness and capabilities in their field.

The Department of IRAI has the following as their aims and objectives

- The programme basically aims at equipping students with the requisite kills to identify and promote the indigenous art and craft within traditional Ghanaian heritage.
- Training people to acquire professional skills in designing, production and marketing of indigenous artefacts (combining both practical functions with contemporary aesthetics).
- Students of the Department are equipped with professional entrepreneurship skills.
- Through the training from the programme, graduates are adequately equipped to solve the several related technological problems in the country.

In the 2006 vice chancellor's report, the Department was recognized for its vison as being a niche in the visual arts in the area of integrating the various areas of the indigenous and contemporary craft. The Department provides a structure of courses that offers people with practical, academic skills and knowledge that individuals require for an advance education and profession. The Department's responsibility is conveying innovative dimensions into both the indigenous and contemporary art and craft industry through producing very skilled graduate designers yearly. Hence the Department employs new developments in terms of technology, skills, materials and tools in the art

and crafts industry. History of the Department (2007) names Mr, Lionel Kov as the idea behind the creation of the Department. One of the reasons for the creation of the Department was the realization of the nonexistence of locally made art and crafts products in the University and its environs anytime foreign tourists come in search of such artefacts. Unlike the locally made Ghanaian artefacts the artefacts produced from the Department bears requisite aesthetics values. The programme that started as a diploma programmes in 1976 was upgraded to a four year degree programme in 1998 after a successful running of the diploma programme. The establishment of the programme was to enhance the local art and crafts industries in the area of finishing, designing, innovation and technological transference, materials, tools, and methods. Since the use of 3-D CAD in product designing is a major component of the structure of the Department, the study is a step in the right direction in evaluating the teaching and learning of the 3-D CAD module in the product design course of the Department of IRAI.

2.2 Computer-Aided Design (CAD)

Though enough research has been conducted on the use of Computer-Aided Design in engineering design, there has not been enough research on the use of Computer- Aided Design in design education and three-dimensional art (Field 2004). Computers and their attendant software are the principal components of the present day design. These tools make up a system referred to as Computer-Aided Design. Designers use CAD to develop designs and drawings that can be displayed as three-dimensional models and used in analysis and testing. Though CAD has surpassed the use of traditional methods of designing with an increase in speed, power, accuracy and flexibility, designing with computers is not totally without its attendant problems and trade-off (Shumaker et al.

2017). CAD is been applied globally in all design related projects hence its inclusion in the art and design curriculum which is applied in design projects from the beginning stage to the finishing stage. One of the utmost indispensable skills required of graduates and experts are design reliability and competencies in both 2-D and 3-D concepts (Pluralsight 2014). This makes CAD predictably the utmost need of the 21st century designer since it is one of the proficiencies required of a contemporary product designer or artist in the professional field of design.

According to Ennis-Cole (2002), Computer-Aided Design is the use of computers to design 3-D models of physical objects. Computer-Aided Design in this context is a computer application employed by a computer system to produce, enhance or modify a design and also to provide precision in drawing (Englander 2009).

As argued by Leach (2002), CAD is a tool that can be employed for the activities of designing and drafting. He goes on further to explain that it is used to create rough idea sketches while it is more appropriate in making detailed drawings. CAD is employed in creating 2-D and 3-D computer-generated prototypes of products, where their final appearance can be visualized and examined. Unlike the traditional means of designing using the basic drawing mechanism where sketches are first produced accompanied by detailed drawings before the actual designed product is modelled. In CAD, product designs are visualized on the computer screen and subjected to viewing before the real product is produced. Computer- Aided Design comes in the formats of either three-dimensional (3-D) or two dimensional (2-D) which is employed to create figures in solids, surfaces and curves in a three-dimensional (3-D) or two dimensional (2-D) space.

In the current technological era, various CAD tools are available which requires the user to employ diverse methods to create computer generated art and product designs

(Zhao et al., 2011). Specific software of CAD are available for several kinds of design: electronics, engineering, architectural, interior decorating, and other artefacts.

Numerous types of software in CAD have over the years been advanced for the use by designers working in automotive, electronic, and architecture often employing the CAD software to make drawings instead of the conventional hand drawing. This is simply because drawings done using CAD can be altered and improved till the preferred results are attained. A designer using CAD is afforded input tools to make more efficient the processes of designing; manufacturing, documentation and the drafting processes. Until the inception of CAD, physical prototypes of products were built for prior testing, but with the prototyping in CAD, future problems are foreseen by designers and this prevents the wastage of time and money (Patel 2015).

The first CAD system was introduced in the 1980s which was then available on a personal computer instead of a mainframe computer. Using the CAD system was not only restricted in engineering applications but by the 1990s it had extended to other industries (Ennis-Cole 2002). The art industry adopted and incorporated the use of CAD in designing after it had been in existence with other industries. However, not until the year 2005 the usage of CAD received complete acknowledgement and was then adopted into the product design curriculum in the Department of IRAI. Unver (2006) believes that CAD is now not only a minor module in design education and product designing but a vital tool in the processes of design.

2.2.2 Concepts of 3-D CAD

Over the years, the art and design processes have exploited the advent of CAD and its innovation. Designers have been using 3-D CAD to their advantage to improve their

designs and enhance communication since the evolution of 2-D to 3-D CAD in the current digital era. In forthcoming with concepts of a design, Patera (2009) claims that mental images of the designer in order to be expressed must be rendered into a visual form which should be revised and developed for the comprehension of the general public. Design as a term in product designing is well-defined by Hill (1998 p.225) as the "inception of an idea or the realization of a need, to the completion of a prototype and reflection on it in order to verify functions as intended". It is also defined by Hill and Anning (2001) as thinking of a thing one needs or developing on a thing that already exists. Consequently it is agreed that designing helps in bringing creative ideas into reality as being propounded by the researchers above. Nonetheless the design process is seen as a sequence of stages and activities that targets at attaining a specific set goal (Blossom and Thompson 2005). In this regard, the design process are devised activities that is targeted at altering current state of affairs to ideal ones. Paper is the first medium by which designers usually adopt to sketch their concepts helping them bring their imagery into a visual reality. However, there have been the influx of specific hardware and software to facilitate digital sketching and modelling. Higher institutions later integrated it into their curriculum CAD as a result of the improvement of its hardware and software (Duad *et al.* 2012).

The acquisition of CAD knowledge is based on procedural knowledge and declarative knowledge, but the classroom based CAD training focuses of declarative knowledge disregarding procedural knowledge. Whereas the ultimate knowledge required in CAD training or skills is both the declarative knowledge and the procedural knowledge. According to Bhavanani et al. (2000), CAD's declarative knowledge is having an understanding on how a particular CAD software operates. Whereas Chester (2007) maintains that declarative knowledge is the awareness on the command tools that are

offered in 3-D CAD. In all, declarative knowledge in CAD is about understanding the processes of the individual tools in a CAD software and how to manipulate them in realizing a preferred outcome.

2.2.3 3-D Computer-Aided Design (3-D CAD)

3-D Computer-Aided Design plays an important role in the production of three-dimensional works of art, beginning with creating and developing concept to the final stages. Unver (2006) believes that there have been intense influences of new technology on the profession of three-dimensional design in recent times. 3-D CAD software are now the main tools for three-dimensional design and production processes by means of Computer- Aided Design applications (Martinez 2012). 3-D CAD software as posited by Janssen (2013) is a type of computer software that allows the development, design and production of 3-D graphics. The software enables its users to design and visualize an object of graphical element in a three-dimensional space. 3-D CAD involves mathematics, geometry and design hence 3-D designers produce files that characterize geometric shapes to form 3-D objects. The implementation of 3-D CAD in product design curriculum equips students to discover the properties of three-dimensionality in the product design process and consequently ameliorate their understanding of their designs (Unver 2006).

The connection between design and production is the planning and execution of a conceived idea which 3-D CAD comes with immense input in this regard. Design involves problem-solving and creativity which is the function of 3-D Computer- Aided Design. A design may be a mere plan that does not include a production, although a working knowledge of such processes is usually expected of designers (Ward 2010 as cited in Apau 2013). In this regard 3-D CAD offers the user an array of options and

features in the early conceptual stages of a product designing and therefore ones gets to know the implication of his choice of design with rapidity. 3-D CAD involves mathematics, geometry and design hence 3-D designers produce files that characterize geometric shapes to form 3-D objects. Using 3-D Computer-Aided Design as tools by an artist help unleash their imagination without any restriction of skills in the designing and production process (Mahmoud and Elbelkasy 2013). Presently 3-D CAD is seen in automobile, ceramics, sculptures, jewelry, packaging, furniture designs and architectural applications among others (Martinez 2012).

2.2.4 Main Characteristics of 3-D CAD Software

CAD skill is currently one of the highly demanded expertise required of a designer. As a result, CAD over the years has advanced into an exceedingly compelling means of designing (Wu 2009). This implies that generally, there has been a strong impact of new technologies in the area of three-dimensional design and designing in recent times. There are excess CAD packages accessible to product designers which include Unigraphics, solidworks, Rhinoceros 3-D, Sculptris, Zbrush, Cinema 4D these are but a few example of some common 3-D CAD software. Aside the aforementioned methods of designing with CAD, there are also three-dimensional (3-D) scanning, haptic modelling which can import and transform sketches into 3-D designs (Cambell et al. 2003 and Qin et al. 2001).

3-D CAD modeling unlike traditional modelling using traditional materials like clay is an additive method which permits learners to practice the prospects in creating artefacts in any dimension. Since 3-D CAD comprises geometry and mathematics, its usage is virtually based on mathematical systems and skills that designers use to produce files

that characterize geometric shapes to form 3-D models. Based on this mathematical system, during the 3-D CAD design process, numbers are often entered to achieve a precision of the models. Although designers and artists are naïve on the mathematics of computer applications, industrial designers and engineers mostly are the ones who relate to these new technological inventions. But recent advancement in CAD has improved the user interface in order for designers to maneuver their way around the software, and with other features designers are able to tackle aesthetics as a requisite in art and design.

In using 3-D CAD, technical drawing precedes the other processes in the design process, using the fundamentals like polygon, arc, line, scaling in making changes in a design. Learners tend to master the program's commands when they become familiar with the application. They become abreast with the structure of the 3-D CAD software after using the basic commands and menus to create designs. 3-D CAD software exists to create solid modelling through making basic geometric shapes as prism, cone, sphere, cube revolving around an axis provided among the tools. 3-D CAD often employs different software where they play various roles in modelling such as surface modelling and visualization. The adjourning software known as rendering software allows designs to look like realistic objects after completing the modelling process in 3-D CAD.

According to Rodriguez (1992), a model in design is a precise depiction of a real device, process or system. There exists several kinds of models of CAD, which includes solid, wireframe and surface representation (McMahon and Browne 1998). A wireframe model employs an assemblage of curves in representing a three-dimensional (3-D) form. Surface models are usually used in constructing difficult curved surfaces and its often attached to a wireframe whiles solid models employs geometric vertices, edges, and faces in creating three-dimensional objects. The wireframe and surface modelling

feature in 3-D CAD allows for the creation of a skeleton- like internal framework of the product being designed.

2.3 Education and Technology in the Era of Globalization.

ICT is currently considered greatly among developing countries and developed countries hence Agbetuyi and Oluwatayo (2012) explains that the socio-economic development of each country is dependent on the impetus of ICT. The part ICT plays in research, learning and education is indispensable and developing countries are required to form polices in realizing its appropriate utilization.

In Ghana, it is widely recognized that the tertiary sector of our education system is the main consumer of advance ICTs compared to other levels of its education sector. Individual tertiary institutions in Ghana have their distinct policies on ICT. The existence and implementation of these policies facilitate learners' access to internet connection and computers and its accessories. Nonetheless, not every tertiary establishment in Ghana maximizes the deployment and usage of these ICTs.

The ministry of education of Ghana rolled out policies in the year 2008 with the main objective of integrating ICTs into the educational structure. The ultimate aim of government's policy was to provide the education sector with empowering prospects for citizens to acquire the essential expertise irrespective of their educational level. The inclusive aim of the policy was:

To enable graduates from Ghanaian educational institutions to boldly and innovatively use ICT tools and resources to develop essential skills and knowledge needed to be active participants in the global knowledge economy by 2015 (MOE 2008, p.18).

The Faculty of Art of KNUST also has internal related policies on ICT in advancing the course of education in the institution and the country as a whole. It is maintained in these policies that utilizing ICTs would enhance our educational value and translate into boosting transformation and innovation. However little has been documented on how these policies are being played out in the running of affairs with regards to teaching and learning in the faculty of art KNUST. The faculty of art on the premise of the following objectives strive for excellence in the training of staff and students in ICTs:

- To offer sufficient logistics and facilities for training in ICT.
- To urge staff and students in the usage of ICTs for teaching, learning and doing research.

World Bank (2000), emphasize the need for much technological training for students to equip them for their job prospects. A research by Skills Fast UK (2006), in the area of CAD skills assessment recognized that there is knowledge and specialized abilities gap among designers as a result of deficiency in trainings and technological advancements. Tikam (2013) reckons that technology touches on all facets of education ranging from learning to teaching and assessment. The use of CAD has been within the confines of bigger IT companies until recently becoming accessible to tertiary institutions to step-up their access of CAD. In the wake of fierce competition and swift technological development, it is essential for designers in developing world to be at par with the up-to-date developments of technology employed in the art and design field. The usage of technology is militating the exploration of ideas for both teachers and students in use of various digital technologies. In the UK, the art and design is making momentous input to the plan of higher education and its socio-economy sphere, as a result changes are being made to their curricula in the area of art and design (Patera 2009).

It is internationally recognized that experts in the area of CAD are insufficient even in the wake and rapid rate of technological changes. This is attributed to the fact that changes in the growth of technology is faster than the educational system (Brown 2009). This assertions accounts for the limited contributions of CAD and its technological advancements to the design industry and academia in Ghana and Africa in general. Particularly in the face of technological advancement and globalization, there is a demand for well-versed people to meet these growing needs (Winthrop and McGivney 2016). Therefore there is a need for professionals in the field of design to constantly acquire up-to-date ideas and expertise in the area of designing to help enhance its rapid development.

2.4 Product Designing in Art

The field of product design has been one of the fundamental pillars of the art and design field. Product design is the generation, concept development, test and manufacturing that result in a product (Raph 2009). Design can also be considered an organized arrangement of one or more elements and principles for a particular purpose (Odame and Obiri-Yeboa 2011). The authors above believe that awareness of the elements and principles of design is the initial stage in the creation of a successful work of art.

Unver (2006) asserts that the main aim of training students in product design is to equip graduates to practice as professionals in the area of developing products conceptually. Designers create product designs using a systematic approach by evaluating and conceptualizing ideas to make them into tangible products. There are similarities between the fields of product design engineering, art and architecture as both employ the same basic strategies in arriving at final products in their respective discipline. However, traditional art schools regard product design as a specialty in three-

dimensional designs whereby household items that are used daily in our lives are made. Nonetheless product designing seeks to produce resourceful, user-friendly and aesthetic articles. For this reason, Unver (2006) opines that product designing requires critical observation at what is required, investigating and coming out with concepts and designs that form new product or enhance on current ones. The indispensability of the product design course is realized in its ability to inspire leaners to challenge conventional ways and reflect on innovative ways of product designing. The philosophy of the product design programme is directed by inquiring on the position and impact of product design in our century. This enquiry is geared towards creating a viable future by developing creative methods of product designing.

The stages of designing as identified by the Wisconsin Department of Public Instruction (2013) are as follows.

- **Identify and Define the Problem**: indicating the requirement for the idea or product and describing concisely the nature of the idea or product.
- **Brainstorm, Research and Generate Ideas:** Conduct research in order to gain ideas for solving problem and thinking through ideas generated.
- **Determine Criteria for Solution:** Set forth criterion or standard in measuring the proposed idea or product.
- **Explore Possible Solution:** Trying out several potential solutions.
- **Select Appropriate Solution:** Choosing the right and suitable idea to give solutions to the defined problem.
- **Create and Implement Solution:** Create the idea in solving problem.

Test Solutions and Evaluate, Reflect, Redefine and Rework: testing the idea or product whether it is suitable. Brainstorm through and identify the strength and

weakness and resolve if there are any errors. It is worth noting in practice that the process of design is likely to prove to be non-linear, circular or repetitive. In the design process, each step leads to the other.

Moreover the procedure of product designing demands meticulous steps and a well prearranged production, the product design phases comprise the following steps:

1) Design brief
2) Product design specification
3) Concept design (concept generation and concept evaluation)
4) Prototyping
5) Testing
6) Manufacturing
7) Finishes
8) Mass production

The design stage where CAD is employed also comprise the following steps:

(i) Problem identification
(ii) Preliminary ideas
(iii) Refining of the process
(iv) Analysis of process
(v) Decision process
(vi) Implementation.

In summary, product designing goes through taking a design brief, creating preliminary sketches, making in depth drawings, rendering and making samples for testing. Whiles CAD advanced to simplify designer's creative products, Martin-Erron (2016) believes that this does not accomplish the requirement of creativity. There are many aspects of

the process of design that might be affected by the introduction of computers. This has generally been seen as a progress towards a better way of designing, many exponents of CAD including this author have often argued that it should improve process and product in all endeavors of design. Remarkably, little empirical evaluation of such claims have actually been carried out.

Principal of the process of product designing is the drawing process. Drawings are mostly used to communicate the outcomes of a product design to viewers or clients, nevertheless it acts as a vital tool and plays a significant role in the process of designing. Although computers may not be used directly in generating images in the visual arts, the designer may choose to employ the computer as a supplementary to his or her conventional techniques. The creativity and cognition series have discovered that many designers admit that they have at their disposal creative opportunities as a result of the availability and provision of new possibilities of computers and CAD. Lawson (2002) asserts that the provision of new possibilities on existing CAD software is not enough but, the designer or user should be able to creatively use it in designing. Creative thinking needs to be researched, deliberated and challenged in the educational environment to allow the improvement of both students and designs briefs (Unver 2006). The study of product design facilitates students' developments in the creative art environment. The amalgamation of the technology of CAD and creative thinking can develop learners' interpretation of a final design of a product, organization and its functioning. Students of product design are to acquire skills and knowledge that will empower them as designers to handle diverse tasks in designs.

2.4.1 CAD versus Conventional Method of Product Designing

The known conventional discipline-specific skills are being substituted through the progressive pervasion of new technologies and new media (Patera 2009). With regards to the existence of CAD in the design field, whereas some are convinced that the traditional method thus hand drawing is not essential in producing a design with the availability of CAD, others maintain that both hand drawing and CAD are needed. A research by Brandon and McLain-Kark (2001) maintained that CAD and hand drawing are both indispensable in the design process. In their study of two groups from an interior design class, the same design project was to be executed individually using either the hand drawing method or the CAD method. After assessing the final design of the two different techniques using a seven point design criteria it was established that there is no variance among the two methods (Brandon and McLain-Kark 2001). On these grounds we can argue that the two methods of design are indispensable in the process of design however considering the numerous advantages that are associated with CAD, the use of CAD in designing remains imperative to the modern product designer. The 3-D CAD process begins with the creation of 2-D CAD drawing using the available software and then emphasizing the significant themes which is then taken through numerous phases before reaching the last stage in a three-dimensional form.

2.5 Impacts of 3-D Computer- Aided Design on Design Education

Designing in art has been with humanity from time immemorial and there is an ever-growing industry embracing art and design in its disciplines ever than before. Art and design can be found in the built environment, engineering, information and architecture (Patera 2009). The field of art and design as stated by QAA (2008) has embraced and integrated the creative prospects these emerging technologies have brought which has

necessitated the birth of other disciplines and innovations. On the basis of the evidence presently available, it seems fair to suggest that several innovations have been seen in the field of product designing as new technologies have adequately equipped designers of the 21st century evolution. One should better comprehend the commitment CAD makes to the designing procedure and be cautious that its execution does truly realize changes in the mind and abilities of the users. Regarding conventional methods and CAD, the conventional skills of drawing which have been indispensable in the advancement of forms have not been entirely displaced however CAD technology is changing the landscape of design education.

Common knowledge and existing research appears to authenticate the opinion that the advancement of technology is widening the scope of product designing and design education nonetheless, Reffat (2007) on the contrary believes the usage of CAD in designing robs the conventional process of designing. Additionally Lawson (2002) opines that the assertion by producers of CAD software that the designing process is enhanced with CAD is untrue. Although Lawson (2002) does not say so directly, he apparently assumes that the CAD software does not provide essentially what it postulates to give. Benton (2007) predicts into the future that the field of architecture and other design fields would have computers steadily substituting traditional ways of designing hence the necessity to adjust the curriculum of product design and other CAD related courses to allow the incorporation of CAD. These conclusion, which Benton discusses on the integration of CAD in the field of art curriculum adds weight to the argument that traditional methods of designing will be displaced by existing and incoming technologies.

2.5.1 The Role of 3-D Computer-Aided Design in Product Designing

The improvement found in technologies in the digital world and design are redefining the code of the concept of design education in the arts. The place of 3-D CAD in product designing is the usage of computer programs in creating 2-D/3-D graphic depictions of physical objects. In the area of the integration of ICT and art, a notion is held by the majority that the use of existing technologies in creating certain artworks make them loose a touch of their conventional essence. On the other hand, Bagley (n.d) contends that creating works of art digitally usually enhances its prospects and does not make a work of art to lose its emotional attachment. Creating artistic design ideas become easily achievable using 3-D CAD and further evidence supports this in the conclusions of Zoran (2013) who contends that 3-D technologies have the tendency of rendering artefacts to be distinctive.

Some researchers are of the view that using a digital or a manual process does not make a final product design different from the other since both processes are the application of one's unique skills for practical results. Bagley (n.d) believes a product design be it digital or the manual process is the manipulations of tools with the human action and skills at the end. He adds that using the skills involved in digital process in creating artistic product unlike the traditional practices provide many prospects. With regards to the major role of 3-D CAD in product design, much is dependent on the efficient usage of the techniques and skills of a user with both CAD and traditional methods expertise (Meneely 2007**).** Meanwhile working using the 3-D CAD enhances users' visualization of their designs notwithstanding, conventional sketching using pencil and paper provides easy means of swiftly putting down artistic ideas (Bottomly and Goodwin 2004).

The use of CAD by a designer is not limited to only two dimensional (2-D) representations as recently 3-D CAD representations of physical objects have emerged to be an invaluable form of expressing artistic ideas in product designing. Baker believed that the use of drawing only plays supplementary roles as it has been reduced to only a means to an end (Baker 1993 as cited in Erdener 2006). 3-D CAD models play an immense role in storing creative ideas, development and presentation of designs, with the use of computers allowing the designer to easily alter and make variations of a design.

A research done by Şenyapili and Basa (2006) established that more than 80% of students perceived designing with the traditional methods as difficult than using the computer software which requires less time, physical effort to learn and use. In contrast Şenyapili and Basa (2006) maintain that hand drawing is regarded more effective than the use of computers as it is able to determine ones capability of expressing himself artistically. Brandon and McLain-Kark (2001) argue that creative students are able to come up with solution oriented designs regardless of the use of either CAD or the traditional methods.

A study by Cil and Pakdil (2007) on instructors in architectural design studios established that a large number of instructors interviewed assumed that creativity is hampered by the use of computers. Basically students tend to become over reliant on computers as certain basic brainstorming are left for computers to do which would have increased their creativity if it was not executed by the computer. Whereas some researchers provide ample evidence that computers inhibits creativity, Jonson (2005) research on design ideation convinces me that creativity is enhanced with the use of CAD as his research showed that when users employ CAD efficiently creativity is enhanced**.** The skills one acquire in the use of these 3-D CAD software plays a major

role on the outcome of design projects. However professionals in the CAD industry consider that it is imperative for learners to go through the traditional methods of designing for some rudimentary designing skills before moving on to CAD**.**

2.5.2 Potential Benefits of Using 3-D CAD in Product Design

3-D CAD comes with immeasurable benefits for its users whether in production companies or for students, they offer unparalleled insights when creating designs. Outstanding inventions replacing the traditional ways of designing and manufacturing appears to transform the entire trend of product designing and manufacturing of products (Erdener 2006). Again Lu (2009) confirms that in the present-day design industry, CAD is now the widely recognized drafting tool employed in this industry. It is evident that many design studios across the globe are beginning to employ the system of CAD in their design process. One reason is that CAD offers the methods for developing design concepts in a three Dimension space that tends to all outline issues of design that would have generally been overlooked in two Dimensional (2-D) illustrations on the sheet. The use of 3-D CAD by a designer aids him in optimizing; creating and modifying a design thereby enhancing the quality of design with an increase in the designer's efficiency as well as improving communication **(**Wuritka *et al*. 2014). This assertion implies that the quality of product designs are greatly enhanced as designers' skills are also partly improved. Again digital model from CAD affords the opportunity for the designer to deliberate, visualize and enable assumptions to be made in the process of designing (Dong and Gibson 1998 as cited in Obafemi and Oluwaseun 2015).

The advancement of 3-D CAD as an innovative medium and its impact is characterized by empirical studies by a lot of researchers. According to a research by Salman (2011),

Bachelor of architecture students displayed thorough representation of 3-D CAD by modifying the process of design intensely. In this study, the researcher gave close consideration to the effects of conceptual thinking of students in the conceptual stage using CAD in the design procedure. The results of this study make available substantial indication that the thinking process is immensely impacted by the support of CAD. It can be concluded that the external support from CAD helps in the idea development of a design which would not have been possible on paper or through the traditional process of designing. Moreover through analysis using the 3-D CAD system, possible difficulties can be eradicated in the virtual model on the computer screen before actual production takes place (Erdener 2006). As a matter of fact, CAD enables animation of the various individual components of a virtual prototype and future imminent errors could be eliminated beforehand. The potent tools of CAD enhance visualization and creativity, which is able to alleviate most difficulties encountered in product designing and production with a more efficient analysis.

Current research appears to validate the fact that there have been a major impact of the use of 3-D CAD software in the area of designing over the years. Siersema (2015) postulates that the impact of 3-D CAD is seen in the thinking process through the visualizations and the interactions that is evident in the use of this software. The use of 3-D CAD affects the users mind as it is able to display ones ideation instantly and enable the visualization of how the end product of a design would look like through the computer screen. This goes a long way to aid learners who struggle with having a mental picture of how their design ideas might look like. Therefore, Siersema (2015) views rest on the assumption that visual thinking is promoted using 3-D CAD, which in turn have a positive effect on the creative process.

In the field of product designing, 3-D CAD has numerous primary advantages over working in two dimensional (2-D) and the traditional process of designing. As a matter of fact there is an ongoing evolution of the product design field to 3-D CAD, for this reason academic institutions are reacting positively to the need for designers to be equipped with 3-D CAD skills. In the communication of artistic ideas 3-D CAD is preferable than 2-D drawings as visualization is enhanced through the features of zooming, measuring and rotating (Dassault Systèmes 2010). 3-D CAD has been realized as an enhancing tool in the processes of designing and that which also facilitates communication of ideas between the designer and clients or viewers.

Through the CAD software the output and quality of a design is improved, communication is also enhanced through documentation where the manufacturing process uses the database created (Khemani and Stonecypher 2008). Users of 3-D CAD find possible solutions to immediate problems by using their creative designing skills and the available computer programs to produce a realistic model of an anticipated idea on a low cost of production (Blackadder 2015).

2.5.3 Challenges of Using 3-D CAD in Product Designing

Recently, there has been an advocateby literature on the adverse effects of CAD's usage on the education and practice of the design field especially architecture **(**Olukoya Obafemi and Oluwaseun 2015**).** Its effects were recognized on the psychological efficiency of present-day undergraduates and professional practicing with CAD in their individual area of specialization. The consensus view seems to be that there are several challenges that are seen in the use of Computer-Aided Design in educational institutions, key is the deficiency of 3-D CAD skills of instructors and posture towards an integration into their pedagogy (Basa and Şenyapili 2004). In the midst of immense gains of CAD in designing, some design educators feel reluctant to incorporate CAD

in their syllabus. Prevalent to this is the notion held by some educators in the design field that creativity is hindered with over reliance on computers (Jonson 2005). According to Ibrahim (2007), tertiary institutions with CAD in their curriculum are not at par with current advancement of CAD in the design industries. This discrepancy is alluded to many factors, which include some design educators overlooking the essence of the new technologies contribution to design education. On the other hand, basics of design thus drawing by hands is being relegated to the background as some stakeholders do not see its essence with the advent of CAD. This is affirmed by Hanna and Barber (2001) that design concepts are strengthened and improved through hand sketching during the initial phases of designing. As a result, CAD may possibly hamper creativity if the learner is always obsessed with the CAD software instead of their ideas of design (Lawson 2002). Allsop (2009) argues that working with CAD would be time consuming for beginners compared to sketching during the early phase of the design process thus conceptual phase.

A study by Basa and Şenyapili (2005) points out the core obstacle of educators reluctance to embrace the integration of CAD in their teaching is as a result of their low adeptness of computer usage. This low adeptness is owned to lack of the use of computers during the training of these educators during their era of training. This creates uneasiness when they attempt to improve their teaching with the introduction of CAD. Yazicioglu (2011) points out that some educators have preference for specific courses that tend to sway learners to still use the traditional methods of pencil and paper skills instead of computer programs in the process of design and the presentation of projects. Pektaş and Erkip (2006) affirm that many institutions are experiencing oppositions between CAD and the traditional design tools. In catching up with the

current trends in design, instructors must develop and adjust to the present development (Machnaik 2002).

2.6 Concept of Teaching

Education is seen as a means of creating preferred changes in the conducts of individuals. It comprises the method of instructing individuals to learn what has been designed for them. It is also seen as training or instructing people through imparting a set of knowledge to them. Teaching remains one of the vital aspects of formal education; hence, it plays a crucial role in education since it functions as a channel for transferring knowledge from one generation to generation. In all educational processes, the element that is most important is the learning and teaching process, whereas learning is concerned with the main driving force of education, alternatively teaching is concerned with the ways through which the objective of how educational process is realized. Teaching is defined by Mellon (2008 p.12) as "a complex, multifaceted activity often requiring instructors to juggle multiple tasks and goals simultaneously and flexible". Cochran-Smith (2004 p.298) adds that, teaching is an intellectual, cultural, and contextual activity that requires skillful decisions about how to convey subject matter knowledge, apply pedagogical skills, develop human relationships and both generate and utilize local knowledge. Teaching cannot be realized without a tutor, lecturer, mediator, an instructor or facilitator. Curzon (1996) describes teaching as the act of causing an individual to acquire skills or knowledge. This implies that teaching and learning are inseparable. Similarly, Brunner (1994) asserts that teaching is the skills that is used in the transference of knowledge to a group of individuals. In other words the activity of teaching is concerned with the facilitation of learning, where the quality of learning is hinged on the output of an undisputable transference of knowledge.

In the approaches to teaching there are three main types of instructors; heutagogy, pedagogy and andragogy (Silva *et al.* 2009). Pedagogy as a process describes teachers as lead role to decide on what to be taught, when how and where. This is noticeably seen as teacher-centered approach of teaching because the tutor's standpoint and experience is more represented than that of the students. Pedagogy differs from the other type of teaching in terms of guidance, supervision and management. Andragogy on the other hand is a strategy in teaching that embraces five rudiments; communicating to learners instructional procedures, supporting them to overcome their individual strivings, inspiring, relating classroom topics to real life experiences and significance of the learning. Again heutagogy permits learners to cultivate the "i-can-do spirit" on their own as learners are able to reflect to develop what have been learnt, examine the environment and visit their personal experiences with also relating with other people. Heutagogy inspires learners to recognize the necessity for humans to learn, become innovative, proficient of relating with the environment and building teamwork. All the approaches of teaching thrive in the manner teachers set their instructions and facilitate the learning-teaching process.

2.6.1 Principles of teaching

Mellon (2008) believes that for effective teaching to take place and be effectual, the requisite groundwork aiding learners' education needs to be set. This groundwork comprises teaching materials, policies, contents and their implementations and guarantee in time and effort. Mellon reiterate that for teaching to be effective, teachers need to have considerable depth of knowledge about the learners being taught. Certain traits of the students must be considered in order to be factored in the instructional methods. In Mellon's research he recognizes some of the traits of the learners as "family

and cultural backgrounds, varied means of tackling difficulties and prior understanding. Collecting these essential data and integrating them into the curriculum aids in addressing the learners' challenges and misinterpretations and afford ways of guiding learners to experience self-tuition. Art tutors are seen as teachers so therefore their instructional methods should be organized and directed in a ways that cater for leaners individual abilities, motivation and interests. All these are centered on the tutors' readiness as this is an essential element in the field of art education (Henry and Lazzari 2007). This readiness on the part of tutors must be seen in their possession of a wider range of content knowledge along with the capacity of sharing this knowledge with varied learners. For an effective teaching to occur Mellon (2008) outlines assessments, instructional activities and learning objectives as the key areas that must be well recognized by the tutor and be well communicated to the learners. Rohrer (2010) asserts that gathering the necessary feedback about ones instructional methods would help bring modifications in the teaching and learning methods through the adjustments of course structures, contents and learning objectives.

2.6.2 Effective teaching

It is imperative for learning to occur without the expectation and a realization of an effective teaching irrespective of the level formal education. Effective teaching lies in the capability of teachers to use certain educational activities to trigger learners learning (Kyriacou 1995). Kyriacou further adds that teaching promote, causes and facilitates learning in enabling learners to comprehend the teaching that is taking place. In ensuring effective teaching, teachers must be able to differentiate the differences among individual students and be aware of that the fact that teaching is need-centered. These measures toward effective teaching should be coupled with making teaching more

interesting, kind and challenging to learners in improving the quality of living for all learners.

2.6.3 Teaching Strategies

Rohrer (2010) posits that abundant literature are available on instructional strategies, but for the sake of this research, strategies that are linked to art inclined pedagogies will be looked at. For effective teaching to take place, the right strategies have to be employed in this regard. Two or more approaches in teaching may be employed in a particular class by a tutor. It is on this premise that Lui (2009) adds that a range of pedagogical methods may be needed in a particular lesson. Some of these pedagogical approaches will be discussed in the ensuing units.

2.6.3.1 Project based method.

In this method, tutors simply direct and advice learners instead of putting them into order. Here, real life problems are posed for the learners to challenge them to work for solutions in order to resolve the problem at hand. This is described by Farouq (2012), as an experience-centered and life-related strategy for teaching. Critical decisions that are geared toward the solution are formulated by the learners and the tutor's guidance only comes in when needed. Rohrer (2010) affirms that the intervention of the tutor is to warrant continuousness and guidelines through questioning students' rational abilities and oral guidance. Students become self-dependent in their interpretation of artistic concepts through project based learning. The main concern of students lie in their developments of personal artistic prospects with suitable media and reference

materials. This approach in art does not portray imitation of other artists' works but serve as works for direction and guidance.

2.6.3.2 Discussion method

Wilson (2009) describes discussion as encompassing a wide range of avenue for unlimited, collective dialogue among students and their instructor targeted at impelling learning, thinking, understanding and problem solving. In this approach of teaching, reading materials are given to students after which students are presented with questions so that their views and interpretations will be solicited. In the area of art, after a critical observation of artistic works, question can stem out for discussion. This approach is seen as a vehicle for the transference of knowledge (Walker 1996). This can be seen when clues are taken from works of art that spontaneously increases ones creativity. In the area of retention in the teaching-learning process, Desmond (2007) opines that discussion helps in a retention rate of 50% by students. Again the discussion approach helps students to obtain discussion and observational skills in art works. This tends to boost their confidence and also refine their ability to reason, analyze and express

2.6.3.3 Group or cooperative teaching and learning.

For this particular instructional approach, students are grouped in both large and small groups by the tutor to allow the sharing of knowledge in order to arrive at a common goal. This method encourages students to cooperate and work with others as a team which as well promotes interpersonal skills and team work. Along similar lines Roger and Johnson (1997) argue that Group or cooperative teaching and learning offer great teaching experience to the students by promoting excellent retention and fast learning.

2.6.3.4 Lecture method

This is an oral delivery with purpose to impart knowledge or convey information on a particular topic. Tamakloe *et al.,* (2005) affirm that the lecture method places the teacher at the center of the teaching process since he usually dominates in this activity. Students are given a minimal opportunity to make contributions and ask questions in class. Mostly the tutor is the repository of knowledge therefore they are able to communicate to the learners. On the contrary, this method has the lowest rate of retention by students comparatively (Desmond 2007). The lecturing method is assumed to be the fastest as against the other methods as the instructor offers sequential and a logical presentation. Since this method is authoritative, it allows the tutor control over the class which thereby makes information delivery constant with the teaching style of the tutor (Paris 2014).

2.6.3.5 Demonstration method

The method of demonstration in teaching employs successive instructions to show students how to do a particular task having the aim of allowing the students to independently perform the same task in question (Eley and Norton 2004). The ultimate goal of this method is to prevent learners from replicating the whole process but to eventually identify how problems are solved when an obstacle or challenge unexpectedly occur. The role of the tutor is to assist leaners in their quest by offering supervision and advice for alternate methods on those tasks assigned to them. The tutor always leads by demonstrating ongoing activities to learners. Demonstration enhances class sessions and offers efficient hands-on and inquiry based learning prospects in the classroom and studios (Eley and Norton 2004). Demonstration is the most appropriate

method of teaching for practical and manipulative activities. This is one of the methods highly recommended in teaching skills since it covers all the essential phases in learning efficiently. Demonstration can be appropriated in all sizes of classes and subject areas; it is most suitable for studio based art courses.

2.6.3.6 The Exhibition method of teaching

This method of teaching uses presentations, projects that students exhibit on what they have learned in order to assess if the set learning objective has been achieved. Tutors ask leaners to publicly display their works on walls for discussion and critiquing. Through this the weakness and strength of their products are brought to bear. The Leaners may visit other ongoing exhibitions in order to observe and learn from the artist exhibiting (Lu 2009).

2.7 Theories of Learning

The psychology of the study of learning is attributed to pioneers like Ebbinghaus, Edward Thorndike and Ivan Pavlov in the late 19th century to early 20th century. The theory of learning are for the purposes of offering enlightenment on learners' behaviour. According to Shuell (2003), these in the long run are acknowledged as behavioural theories. An understanding of pedagogy and andragogy in the manner in which learners learn are deeply embedded in these learning theories. Learning theories are said to be conceptual schemes established for the comprehension of students' absorption, processing and retention of information. IIIeris (2004) asserts that learning theories consider all the environmental influences, emotional, cognitive and previous knowledge of the student and their role in the learning process. Theory as explained by

Shuell (2003) is the combination of numerous variables into a sole system so that the subject of the theory can be explained. Students' learning are active, and often proactive even as acknowledged by present conceptions and theory of teaching and learning. The varied nature of the process of learning is a fundamental influence for instructional interventions and therefore diverse approaches to instructional can culminate into a unified outcome.

2.7.1 The Experiential Theory of Learning

This theory was developed by David Kolb in 1970's, this philosophy allows instructors to precisely and conclusively subjugate learners to a direct and practical involvement in order to clarify values, step up knowledge and improve skills (AEE, n.d.). Allsop (2009) argues that there is a universal agreement in the training of CAD in that, the realization of a successful learning of CAD is hinged on one experiencing it. This experience can be achieved through undertaking assignments, or a step-by-step tutorial. Merely knowing something with one's senses without experiencing it and having a mental model of it makes it impossible to know it (Archer 1992). In other words, learners cannot just observe an instructor explaining how to use CAD and fully master the use of CAD until one uses CAD in reality. It is founded in the theory of andragogy that fully developed learners learn best experientially. According to Sims and Sims (1995), in designing and implementing teaching that improves learning, educators are obliged to know much about how individuals learn and the various learning process. By learning and understanding the models of how individuals learns, learner's capacity to learn would be greatly enhanced.

2.7.2 The Constructivism Theory of Learning

This theory regards learning to be an active process whereby it takes place through ones previous knowledge and understanding. It is explained by Hein (1991) as the theory of learners building their own knowledge individually and/or socially via the construction of the meaning of things in the course of the learning process. This theory obliges the instructor to understand the student's previous ideas and therefore cautiously set certain activities in the right directions that would suit, guide and build up the students. Many hold this notion that constructivism rather compels students to reinvent the wheel, however EBC (2004) argues out that, the theory instead kindles and taps into learners curiosity for them to understand the manner in which things function and implement such mechanism in other fields. The constructivist theory recommends that the student would explore learning materials in order for them to increase their own knowledge grounded on the subject. Through this the learner will be able to employ, contemplate and develop the experiences already stored in the mind, as contradicted to the use of experiences coming from the outside (Sung and Ou 2002). Social constructivism states that learners tend to develop knowledge from other learners via interaction with these peers (Pear and Crone-Todd 2001). However this method has the tendency of learners offering other learners with inappropriate feedback.

2.7.3 The Connectionism Theory of Learning

The connectionism theory defines learning as a product of connections built up among inducing and reacting. This theory was developed by an American psychologist by name Edward Lee Thorndike. His theory suggests that the learning process occurs through associative connections. The concept again asserts that a reaction to a specific signal is developed through an experimentation which forms nervous relationship

between the stimulant and the finest suitable reaction (Encyclopedia Britanica n.d). The theory by Thorndike shows the requirement of rewards and the function of repetition and practice in the course of learning (Pappas 2013). The main purpose of the concept was to be applied in the education of mathematics, reading, spelling, adult learning and measurement of intelligence. Nevertheless, the learning of CAD also makes use of the concept of learning of trial and error in the build-up of skills in the learner.

2.7.4 The Behaviourism Theory of Learning

The theory of behaviourism is grounded on the proposition that the enquiry of behaviour can be undertaken scientifically without resorting to the psychological state. Applying this theory in the area of teaching and learning involves the predominance of the tutor, as found in reform programmes for behaviour; with all instruction concentrated on the control and format of the tutor (Atherton 2013). Therefore, all behaviour is ascribed to an outward stimulus and ones behaviour can be understood without resorting to the student's inner consciousness. It is assumed that the student at all times starts on a clean sheet before behaviour is shaped through negative or positive support (Edmundson 2012). These seek to strengthen the prospect of a recurrence of the behaviour.

2.8 Training in 3-D CAD

A closer look at the related literature indicates that, it is the obligation of art institutions to train product designers in this part of the world as other parts of the world have embraced it. Concerning logistics for implanting the usage of CAD in schools, the procurement of both software and hardware for the learning and teaching of CAD

together with employing experts to teach seem not to be adequate in giving a holistic education in this respect. More importantly, product design students must be urged to practically and efficiently apply the CAD skills acquired in their design problem solving process.

In as much as art and design share some similarities with other fields, its uniqueness lie in its teaching, learning and assessments approaches. The model employed in the teaching and learning of art and design have employed the model of both project-based and studio-based (Patera 2009). As Sara (2006) posits that the studio of art and design is "both a process and place". The studio been a place illustrates where learners physically meet to receive tuition from masters/teachers in their area of specialization, therefore happenings of studio-based model remain indispensable. In a like manner, the studio is a process in that it facilitates interaction and helps in exchanging creative ideas among peers and instructors. Recent studies like these shed new light on the role of studio in product designing, which previous studies had not addressed. Culiffe-Charlesworth (2006) maintained that, in the field of art and design education, studio practice still remains a fundamental place where learners professionally generate creative ideas and concepts to carry out design specific tasks. The art studio is undeniably a fertile ground for effective learning process where acquired skills are shared between students and staff (QAA 2008). More importantly, this makes the studio not just a working space but additionally a spot for sharing basic engagement with teachers and students (Cunliffe-Charlesworth 2006). As a matter of fact Patera, (2009) emphasizes that this model of education found in art and design brings about the practices of an effective teaching and learning. This has paved way for transformations in the methods of working instituted in product design study and profession.

Moreover project-based learning is a main feature of art and design education. Here sets of skills and methods are imparted unto students at the beginning of their practice. Projects in the form of assignments are done by students individually or in groups which are later subjected to critiquing (Patera 2009). As tuition found in the studio is similar to project based learning, a design brief or problem is initially posed for the learner to tackle and resolve. Particularly the student tends to acquire knowledge through an ongoing task or assignment. As a matter of fact a student must be abreast with the basic principle of designing before migrating onto any CAD software which the software are tailored for professionals in the industry. Through personal analysis of a task at hand, knowledge is gained upon getting solutions to a given problem (Sara 2006). Some tutors in art and design admit that tackling a given problem in design through finding alternative solution enhances best practices of learner on the students (Davies 2002).

The curriculum of product design should be able to address every phase and actions in the designing of a new product from conceptual stage to the production and finishing stage. In the current processes of the design cycle, CAD is now the main tool that is virtually used from the conception stage to the final stage of a design. Assessment and testing can be done on a particular product since CAD is able to produce a digital prototype during the initial design stage. This allows viewers to properly critique the product design which subsequently reduces potential mistakes and time spent on the design process whiles also retaining consistency and quality.

Meneely (2017) posits that education in CAD must not solely be centered in the development of the practical skills only; rather CAD must be fused into the process of design in making design concepts into an intense reality. The standard way of thinking about the training of 3-D CAD is the role of the commands features available in the CAD software. The teaching and learning of command features on CAD is a common

place in design education, but Mclaren (2008) contends that the teaching of CAD demands a reconsideration where new approaches would have to be employed.

In the training of CAD, It is argued that class-based training offers much skills and knowledge in CAD technology but informal training offers little (Marucheck 1995 as cited in Wu 2009). It is a widespread phenomenon to notice students in most institutions been taught how to use specific CAD software packages rather than the basics of CAD. Since these CAD software packages are subjected to obsolescence with newer versions been released often, numerous researchers advocate for the tuition on elementary principles of CAD in institutions (Wu 2009). However, it is believed that ever since the inception of CAD there has not been any CAD software tailored for the purposes of teaching as a result, commercial CAD software are continually taught and learnt in the classrooms.

In ongoing discussions regarding the presence of CAD, one controversial issue has been that the conventional studio tutoring and assessment system is lost due to the increasing existence of CAD. Student to tutors and student to student connection which is essential in art education and practice is lost and being superseded by the invasion of CAD (Brown 2009). I believe the face to face shared contact among peers and tutors have been taken away which is a very vital aspect of the holistic design education.

2.8.1 Methods of Teaching 3-D CAD

The teaching of 3-D CAD unlike other modules of teaching varies in its own unique way,with its association with ICT, carefully planned strategies are employed by institutions in running such ICT related programs. Asperl (2005) postulates that the teaching of CAD is a wide-ranging area. He adds that there is no general compromise

in the elements to be added to its curricula, there are differences with regards to the degree and level of its students. Again Chester (2007) asserts that one remarkable characteristic of the teaching of CAD has to do with the variance among strategic knowledge and command knowledge. Here he explains command knowledge as recognizing the tools delivered by the software developer with the process of its usage whiles strategic knowledge is about recognizing the procedures that are employed to achieve a specific task and how to choose one of them. These two characterize an efficient use of CAD in any curriculum and its delivery of its teaching and learning. According to Asperl (2005), one significant area in teaching CAD is the selection of software, these software come with its attendant drawbacks. One of the drawbacks is seen when tools begin to malfunction with unsuitability of the user interface. Computer-Aided Design is seen as one of the emerging high-tech modernization that is imparting considerably the design industry and this has necessitated for advanced methods by institutions due to its fast technological change it is bringing (Duan 2004). For this reason, Field (2004) highlights the essence of a continual advancement in the teaching of CAD and the educational needs of its learners.

2.8.2 Different methods to teaching Computer- Aided Design

According to Allsop (2009), there isn't a single method of learning and teaching of Computer- Aided Design, since the method may possibly differ agreeing to the following:

- The kind of material (classroom-based/distance)
- The background of the material (e.g to visualize 3-D forms/generate an engineering drawing)
- The tutor

- The student

In the methods of teaching CAD, there are many spurs that basically influence the choice of a particular approach because of the subjective nature of the topic being taught and learnt. Allsop (2009) argues that, besides the 'type' of designed material in use, the kind of method chosen is dependent on the subjective inclination of students, learning style of students, the subjective inclination of the tutor and their teaching style. Nonetheless the chosen material must address users of CAD emerging from different learning styles and ages in the higher education structure. In order to apply important pedagogical principles of teaching CAD, it is indispensable in considering the methods of teaching and learning CAD from all perspective.

According to De Porter (2008), accelerated learning proposes that learners will be able to surpass their own prospect of their learning capacity if they are encouraged and taught appropriately. In order to keep the learner encouraged, Keller (1987) proposes suitable motivation model, which are Attention, Relevance, Confidence and Satisfaction.

Attention – having the learner attention first and subsequently sustaining it.

Relevance – persuading the leaner on the significance of a particular material.

Confidence – nurturing confidence in the learner

Satisfaction – boosting the confidence on their achievement.

Although there has been comparatively little research into approaches of teaching CAD, but Allsop (2009) outlines three major approaches which are, 'feature-based' approach, 'overarching' approach and the 'detailed' approach.

2.8.2.1 Feature-based approach

This approach of teaching CAD is employed by all providers of the software and this guides users on how to use the software. It is important to note that the learning experience of this approach thrives on a holistic experience of the CAD system. It offers information and examples on how to use the basic features in the CAD software. Key features of the software are taught or learnt sequentially and often progress gradually to the level of difficulty with some of the features (Zirwas and Koser 2009). According to Rodriguez (1992), a '*generic primitives'* of forms offers modelling strategy that affords a learner visual representation of the individual features in the CAD software. The feature-based approach is said to support the entire CAD-based training and acts as the foundation of learning the basic functionality of CAD features however, it is limited in terms of learning and using CAD into details.

2.8.2.2 'Overarching' approach

Unlike the feature-based approach that merely demonstrates to the user on how to use the basic CAD features, the 'overarching' approach of teaching CAD differs from the feature-based approach in that it entails strategies of modelling a particular product as a whole. This approach comprises of other techniques namely the; 'vertical' strategy, 'skeleton' strategy and the 'duplicate part' strategy. The duplicate strategy under this approach shows CAD users how to produce duplicate parts. This saves time and enables changes to be made speedily when modeling (Toogood 2006). Under the overarching approach are the vertical and skeleton strategies. The vertical strategy refers to producing product design with CAD by way of using the parent/child relationships, whereby each parts are connected and referenced to other parts of the model. However, its limitations lies in its inability to effect changes to the already modelled parts if the

need arises. Users will subsequently have to completely dismantle and recreate the parts again (Solash 2007). It also uses curves in the creation of surfaces from the curves (Brown et al. 2001). Lastly the skeleton strategy comprise of creating a skeleton model that contains all the vital geometry and make references to the other parts.

2.8.2.3 'Detailed' approach

This offers specifics on how to efficiently model using CAD, unlike the other strategies; it considers how and where a feature ought to be used. Bhavnani et al. (1991) outlines the mirror and pattern features as a major part of the 'detailed' approach. They outline the following strategies in this approach as; 'profile-profile' strategy, 'reference-reference' strategy, 'revolve' strategy, 'sweep' strategy and the 'symmetry' strategy. Users of CAD are encouraged to think through other approaches of modelling on CAD that will guarantee the creation of an efficient model in CAD which is able to make changes to designs of would be product. Moreover, much understanding should be gained on how certain specific features are to be appropriately used in a specific context. Notwithstanding, in the approaches of teaching CAD, Wiebe (2003) argues that it is more inspiring to realize that memorization of the tools and features of CAD has minimal worth than those that 'reward higher level thinking'.

A research by Plumed et al., (2013) focused on developing new methodologies and technologies in advancing the relationship between 2-D and 3-D models of CAD and its associated abilities. Due to the innovative improvements of CAD, instructors in the field of design are to alter their pedagogy and incorporate both CAD and the traditional design tools (Keengwe *et al., 2008* and McLaren 2008). This adjustment would bring about a radical change in preparing learners in the ever growing technological era. Emphasis can be made on the need for considerable technological trainings for design educators to be equipped in the wake of the rapid technological advancement. Pektas

and Erkip (2006) postulates that design educators with minute skills in CAD software must grasp the possibilities and benefits technology has in the field of design towards its rapid growth. Then again it is incumbent on designers to recognize the indispensability of technology in their quest to be proficient in their area of expertise and intensify their knowledge in the usage of CAD.

2.8.3 Visualization

Visualization is another key aspect that is indispensable in the realization of CAD (Fisher 1991). One of the successes of a CAD learner is greatly dependent on the visualization in the Computer- Aided Design software as this aids in the communication aspect of CAD. Visualization as a significant concept of design is the generation, interpretation and manipulation of information through three or two-dimensional representation (Dahl 2001). Visualization also described by Pilkaite (2010) is a modern tool for designing which is used to support the representation of object as they are replicated with precision concerning how they are to appear in reality. One of the vital aspects that enable learners to grasp 3-D CAD is the ability of visualizing three-dimensional forms. Since learners learn in diverse ways, one other method that helps in enhancing learning in terms of visualizing forms is by comparing CAD model to physical model. This offers the learner the ability of visualizing the 3-D CAD model and interacting with the physical model. This is done by viewing the physical object from different views and at the same time comparing it to the computer generated model on the computer screen. As a matter of fact, Erdener (2006) affirms that the use of actual models is indispensable in product designing. The strategy of the comparison of CAD models and real objects aids learners in fully comprehending and visualizing 3-D CAD product designs (Richards 1995). Mahoney (2000) also agrees to this principle in that

the comparison of 3-D CAD model with physical models makes it easier for students in visualizing 3-D models. In summary visualization plays a major role in 3-D CAD education in the use of its system and understanding models of 3-D CAD.

2.9 Basic Concepts of Assessment

Taras (2005) concurs assessment to be the relative or statistical ratings accrued from using a definite set of objectives as a measurement for the purposes of judgment. Basically, for an assessment to take place there must be in place a set of objectives which judgement would me incurred from. In relation to this study, Sadler (2005) concedes that assessment is the formation of a decision on the value and degree of learners' accomplishment inferring from the results of their learning. In essence data is collected from multiple sources for analysis throughout the learners' learning practices in order to get a rich insight into their know-hows and capabilities. Assessment can be seen as an indispensable part of the art and design education. According to history, much emphasis has not been placed on assessment in art education, meanwhile assessment forms part of the learning process in art but the art experience of the 21st century has been relegated to the background (Gruber and Hobbs 2002). The authors highlight the necessity to assess the teaching and learning of art and design as it is able to quantify students' learning as an instrument for creativity. But in recent years, educational research has provided ample support for the assertion that the subject of assessment in art and design has turned out to be challenging to be dealt with (Patera 2009).

Assessment in art employs both methods of summative and formative assessment and at times peer and self-assessment (Patera 2009). In summative assessment, leaners' achievements are summed up at the end of a learning programme and standardization

is one of the principles that is used in this method of assessment. Standardizations as defined by Wilson (2009) is a method directed at warranting that all the decisions of assessments are equivalent.

Wilson (2009) posits that assessment forms part of the fundamental elements of the teaching and learning process. Assessment seeks to benefit a number of participants in the educational hierarchy which are:

- Students
- The instructor
- The course team
- Employers
- Higher education
- Institution management

2.9.1 Assessment

The term assessment in education refers to a wide range of methods and tools that are used by educators to measure evaluate and document the learning progress, academic position, and acquisition of skills or educational needs of learners. Assessment is the techniques selected to collect information necessary for making judgement. This implies that assessment aids in measuring the levels of the growth of a programme, projects or learners' knowledge paralleled to draw inferences. According to Wiggins (1997), assessment acts as the pivot of a triangular prism that rotates around three bases: reflection, discussion and feedback. Evaluation and assessment are synonymously used in most scholarly works. Both evaluation, assessment and appraisal estimate the value or quality of a task. Airasian as cited in Benning (2011) believes that evaluation is the

basis for making a decision on what is good or appropriate. Both assessment and evaluation are aimed at collecting, synthesizing information for assessment before an informed decision is reached. Macnamara (2002) believes that evaluation that pertains to education entails collecting in-depth data through examining procedures, experts and outcomes of a programme's objectives. Here the main purposes why an academic institution would undertake an evaluation would be to assess if their programmes' objectives are being met through analyzing the outcomes, results and their personnel. Data is gathered through analysis, observation and other strategies to determine learners' general growth concerning a set of aims. Therefore evaluating the teaching and learning of 3-D CAD in product designing at the Department of IRAI can be categorized under programme assessment since it includes a chosen part of the programme and impacts its quality.

Stassen et al., (2001) posit that programme assessment is an ongoing and a systematic process of gathering, reviewing and using the data collected the purposes of refining learners' education and holistic development. From this, programme assessment does not center on a specific learner but instead lay emphasis on how and what an educational programme is adding to the learning and growth of learners in general. Programme assessment as defined by Huba and Freed (2000) is the method of collecting and deliberating on the information from numerous and varied sources to help in developing an in-depth understanding about what learners are familiar with, understand and be able to do with the skills and knowledge as a result the learners' educational experiences. Through assessment, data is provided for guiding and modifying the programme, enhancing students' likelihood of meeting their desired goals and helping the programme in achieving success.

Assessment as part of this study seeks to collect information on the integration of the 3-D CAD module in the product design course at the Department of IRAI, its system, practices and outcomes in the quest of defining and evaluating the value of the CAD. For this reason data will be collected from lecturers and students on what is involved in the teaching, learning and also producing artistic works using 3-D CAD. This will help make knowledgeable decision on the strengths and weakness of 3-D CAD in the product design curriculum. There should always be a target before an assessment of a programme can be performed which is termed standard. This standard is posited by Lewis (2007) as the underlying support for comparison: something used as a measure, norm or model in comparative evaluation. From this, assessment can be the act of measuring a thing against a standard model. For that reason, for assessment to take place it is hinged on these laid down values by both the university and the Department under review called standards. Moreover empirical data required in making decisions about programmes, educational policies, curricula and students are made possible through assessments. The available evidence from the various scholars seems to suggest that the core aim of programme assessment is in improving the excellence of educational programmes through the improvement of students' learning which finally results in positive changes in behaviours.

2.9.2 Forms of assessment

Various scholars posit different types of assessment, according to Scriven (1981), a popular process of classifying programme assessment is embedded in whether they are summative or formative or the amalgamation of both. Nevertheless descriptions from various studies on assessment suggest that there are four key purposes for assessment thus, to make provisions for policymaking activities, to inform faculty and other policy

makers of the influence of the programme, to offer feedback to expand on an ongoing programme and finally to show faculty, stakeholders, students and staff on the accomplishments of the programme. Hence, the researcher identified a type of programme assessment propounded by Hanna and Dettmer, (2004) as summative, formative and diagnostic assessments.

2.9.2.1 Formative assessment

Black and Wiliam (2004) assert that formative assessment focuses on a vigorous feedback loops that support learning. Formative assessment is used by teachers both for providing students with feedback on their progress and guiding decision about subsequent stages in the course of learning, thus bridging the gap between learners' existing and anticipated state. Formative assessment is defined by Popham (2009) as a deliberate process wherein tutors or students employ assessment-based evidence to regulate what they are presently undertaking. Process in the above description is the operative word, in that the formative assessment happens during the course of the learning as compared to summative assessment which is mostly a one-time occurrence that takes place at the end of a lesson which is subsequently used to assess students' proficiencies. Moreover formative assessment can be said to be a regular and interactive assessment of students' improvement and comprehension towards identifying learning needs and adjusting teaching styles. This type of assessment is a tool used by teachers to measure learners' comprehension of certain skills and topics they are being taught. Kahl (2005) says that formative assessment is a 'midstream' instrument in identifying a particular learner's errors and misunderstanding during the teaching of a material. Usually the information collected from this type of assessment is used to enhance the performance of a programme as well informing the state of teaching and learning.

Shepard endorses the above through describing formative assessment as a type of assessment that is undertaken in the course of an instructional process for the reason of enhancing teaching and learning.

2.9.2.2 Summative Assessment

This type of assessment always takes place at the end of the teaching and learning process where feedback is offered that summarizes the process of teaching and learning along the worth of the programme (Hanna and Dettmer 2004). For this reason, summative assessment usually takes place at the end of a semester or a course. The degree of a students' success in satisfying the assessment criteria in measuring the anticipated outcomes of a programme is determined by summative assessment which also determines the final grades given for a particular course. The functions of summative assessment is in offering information about a pogramme to make modifications to it or continue running it.

2.9.2.3 Diagnostic assessment.

In the diagnostic type of assessment, the assessment takes place before a particular instruction takes place, it usually centers on a single sphere of knowledge. Teachers become aware of learners' individual previous knowledge before the commencement of a class. Programs (2013) describes diagnostic assessment as a method of assessment that supports tutors to develop lesson plans and provide distinguished instructions to satisfy students' desires. Learners' strength and weaknesses, knowledge and skills are determined which is mainly used to diagnose learners' problems in order to direct lesson and curriculum planning. Data gathered on the onset of a programme offer information for the learners and tutors concerning learners' previous skills, knowledge and abilities. Diagnostic assessment maximizes learning through uncovering what learners already know and do not know about a particular subject. This revelation helps

teachers to deal with all the misconceptions and misunderstanding identified in learners' previous knowledge. With summative assessment and diagnostic assessment combined, a value-added educational experience can be determined.

2.9.3 Assessment of 3-D CAD Learning and Teaching

Assessment of the teaching and learning of 3-D CAD is one of the vital areas in art and design education. Assessment methods reviewed in this area are self-assessment, peer assessment and among other forms of critiquing. Art and design education give the learners an opportunity for a self-assessment and peer assessment, Fisher (2006) asserts that self-assessment and peer assessment in a way give learners a point of reference that aid them to juxtapose their accomplishments alongside others. This is seen in learners being involved in informal discussion concerning projects and ideas their contemporaries come up with. A research by Blythman et al. (2007) studied the types of critiquing assessment methods employed in art and design education and acknowledge online critiquing, peer critiquing, group critiquing, industry project critiquing, formative critiquing, and summative critiquing. One of the methods common in the Department of IRAI is the group critiquing where works of students are presented and reviewed by both peers and tutors through giving feedback. The advantages critiquing brings about is to pave way for students to obtain formative criticism, enhancing their presentation skills and expression of their creative thoughts (Blair 2006). By way of contrast students perceive the critiquing assessment as an avenue which does not permit deliberations on the learning processes but instead to defend their course of actions towards a work (Percy 2004).

In the area of evaluating creativity in learning activities, UNESCO (1972) opines that education has a twofold ability to inhibit and also nurture creativity. Craft (2005)

believes that the link between learning and creativity is continually under enquiry but the concept of evaluating creativity in learning activities is complicated. According to Mastracci and Marie-Victorin (2012), evaluating creativity is one of a complex assignment that is likely to cause programme assessments experts to reach diverse conclusions.

There has been an inconclusive debate on whether the method of assessment facilitates a richer methodology for learning as the processes of assessment is centered on the final product of every project. Along similar lines, Davies (2002) argues that, the entire art and design learning process are sidelined and rather marks are given for the caliber of the final artefact produced. The creative processes, and diverse phases mainly associated with a finished artefact are subtly recognized often. In a bit to change this trend, the focus should be shifted from assessing finished art and design products to assessing the processes involved in the learning and designing.

Davies (2002) concurs that marks are given on the quality of artefacts instead of the whole product designing learning process. With regards to this, there is a tendency of neglecting the role of the various design processes and creative engagement that indirectly contribute to the final product (Patera 2009). For this reason attempts are being made to modify the assessment criteria from basically assessing the final product instead of assessing the product design stages and learning method. Conversely formative as a form of assessment in art and design does not assess and grade constant completed assigned projects but offers a constant criticism in the course of a work. In view of this, formative assessment is key in the construction of knowledge in learning in this subject area.

2.9.4 Software evaluation

The evaluation of a software is an integral aspect in the selection of instructional and learning technology for any programme (Tomei 2008). In selecting a software for pedagogical purposes, one key factor to consider is the purpose it is been needed for and how it will be utilized. A comprehension of how students would process data for their respective subject's area projects is imperative in choosing a courseware for tertiary students. It should be determined if students would individually or cooperatively employ the software in their projects. The choice of a software should be in sync with the 15-minute rule maintained by (Asinyo 2009). In this rule, a learner is supposed to comprehend the software within the first 15 minutes of encountering it. In addition, the software should be easily installed by the user and must be very intuitive. Asinyo (2009) proposes the following procedures in selecting a software for discipline-specific coursework.

- Selection should be done in consideration of the curricula of the particular course.
- Views of students, supervisors, curriculum developers, experts, technologists and lecturers should be collated in the decision making.
- Records should be gathered in assessing the accomplishment and its anticipated strategies.
- Provisions for software updates should be included in the curriculum for its usage and evaluation in the future.

Tomei (2008) posits that during the initial introduction of a software in any institution, a quick survey should be done among learners and instructors to ascertain students' engagements, its accessibility, easy usage and its attendant challenges. This step is an integral aspect in the process of selecting modern technologies for the purposes of

teaching and learning. Again it must be in consonance with an ongoing curriculum of the programme. As part of this study, the current 3-D CAD software used in the curriculum of the product design course will be reviewed. Teacher evaluation of produced artefacts includes observing the students' process and the final product; development of students' ability to respond to various art forms and works of art; observe students' struggles with creative problem solving, their willingness to try new things, and their application of critical and reflective thinking. Teachers must observe students over an extended period of time and encourage students' self-evaluation.

2.10 The Conceptual Framework

The conceptual framework for this study has been set to basically provide the emphasis and content which functions as the lens through which the variables that has been identified in the study can be assessed. This section also provides a comprehensive explanation for its formulation and significance to the research.

Kirkpatrick's 4 Levels of Instructional Evaluation

The effectiveness of any training programme is measured through evaluation as it offers good foundation for future advances. Many variables are usually examined in the assessment of the effectiveness of training programmes, which usually necessitates lots of effort. One of several instructional evaluation models is the Kirkpatrick four level of instructional evaluation developed by Donald L. Kirkpatrick in 1954 after which this model was later updated in1975 and 1994 (Manktelow et al., 2016). This is one of the popular and effective models for undertaking assessment on training programmes. According to this model, evaluation is hinged on four successive levels; reaction, learning, behaviour and result. It is habitually noted of instructional evaluators and

instructors for only completing just the first two levels in evaluating training programmes, disregarding the third and fourth levels, which contain substantial amount of information. Formally, instructors and evaluators found it difficult to advance past the first and second level; while considerable amount of significant information is in the third and fourth levels.

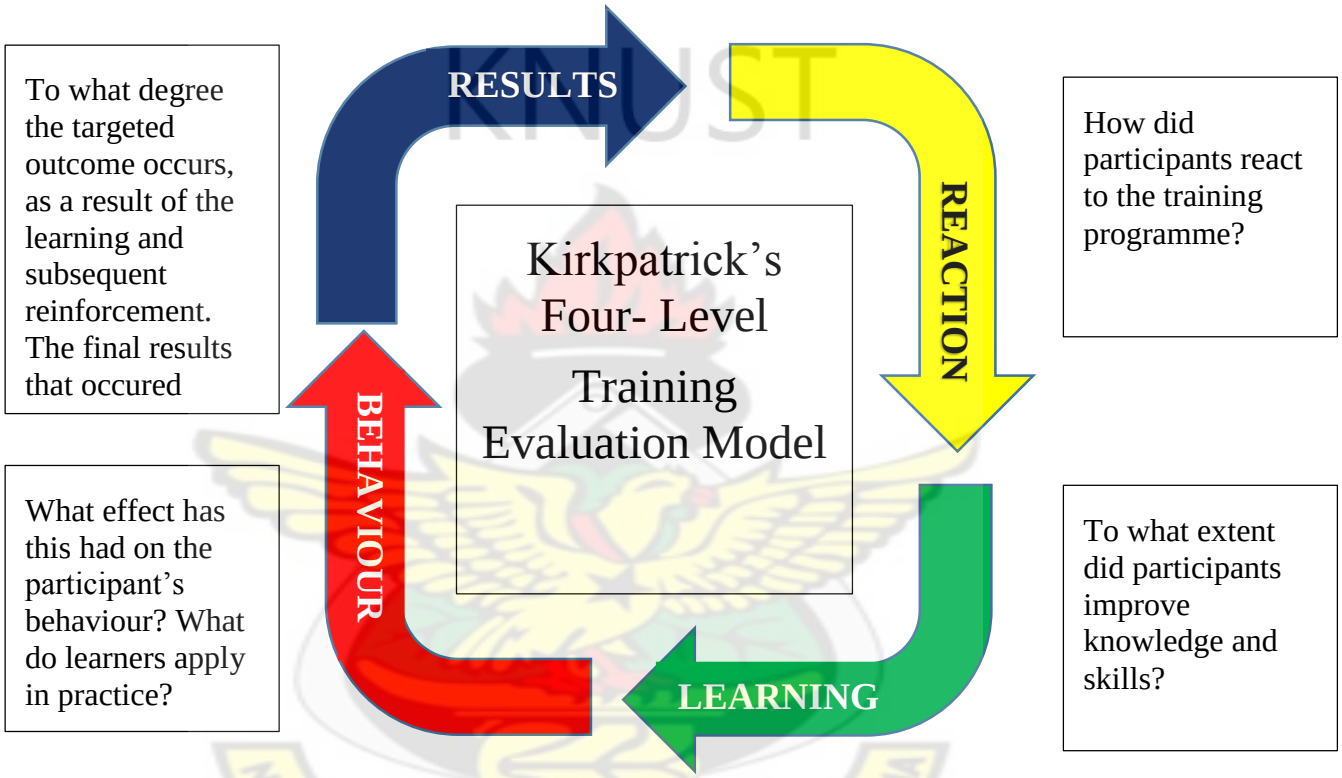

Figure 2. 1 *Conceptual Framework for the Evaluation of the Teaching and Learning of 3-D Computer-Aided Design.*

Source: *Adapted from Kirkpatrick, (1994)*

Level 1: Reaction

In the reaction level, trainee/learners reaction to the exercise are ascertained. This level discovers their feeling towards the instructor, subject, course materials, delivery mode and venue (Manktelow et al. 2016). In assessing this, the evaluators are able to ascertain the response the trainees give to the training program in its early stage. Responses to

questions similar to – did the trainees like the training offered to you? Was the material used relevant to their area of study? Campen (2009), calls this nature of assessment as the "smile sheet". The reaction level of this model is deemed to be the quickest and cheapest to embark on; nevertheless it forms a significant part of the whole assessment process as its results have effects on the other succeeding three levels.

Level 2: Learning

Here, the amount of learning that took place in the activity is assessed. Campen (2009) asserts that the level 2 usually comprises a doubled-faced assessment thus, one prior to the beginning of the training (pretest) and the last, the end of the training (posttest). This level basically assess the disparity in knowledge from the start of the learning to the end of the learning experience; as a result uncovering consequential decrease or increase in attitude and skills. As a matter of fact, it is debatable on how knowledge and skill change can be assessed and the type of research design to define progress. On the other hand, a study by Manu (2014) recommends techniques like, surveys, test, interviews and observations as means of assessing attitude, knowledge and skills.

Six basic guidelines are recommended by Zhu and Zhao (2010) for evaluating learning.

i. Using a control group
ii. Evaluating during both pretest and posttest approaches.
iii. Adopting pencil and paper test in ascertaining changes in attitude and knowledge.
iv. Adopting performance test in ascertaining changes in skills.
v. Striving for 100% response
vi. Using the assessment outcome for appropriate actions.

Level 3: Behaviour

The behaviour level deals with ascertaining the behavioural variations in the learners as a result of the training. This seeks to answer questions on if learners are applying the

newly acquired expertise, knowledge and outlook in their immediate setting. According to Manktelow et al., (2009), behavioural change can only be anticipated in preferably an encouraging surrounding and under good conditions. As a matter of fact, the occurrence of behavioural change can be conceivable once the learners aspire for the said change and their accessibility of suitable results for change (Zhu and Zhao 2016). Consequently a transformation in behaviour or else the unsuccessful attempt of change cannot be attributed to the fact that the leaner has learnt or not. There are seven criteria recommended by Zhu and Zhao (2016) which can be embraced for an efficient assessment of behaviour.

a. Use control group if practical
b. Allow time for behavioural change to occur
c. Adopt both pre-training and post-training evaluation plans
d. Adopt surveys and, or interviews in ascertaining plans
e. Strive for 100 percent response
f. Loop through evaluation at different but appropriate times
g. Cogitate cost versus benefits

In summary, Campen (2009) recommends that ensuring an effective assessment at this level and an enhancement of a behavioural change demands motivation, follow-ups and offering reinforcement.

Level 4: Result

The result level of the Kirkpatrick model deals with ascertaining the results of the imprint and outcome of the training programme and its successive strengthening. In effect this fourth level of the evaluation model summarizes the realization of the training programme in reasonable terms; impact of 3-D CAD on artistic works and

improved product designing skills. Results can only be evaluated if the training programme is targeted at tangible outcomes except cognitive and conceptual skills (Zhu and Zhao 2010). Similarly the evaluation of the result level can be done against the set aims of the training, where there is a tangible proof of existing evidence (Manu, 2014). The researcher further affirms that a positive result originating from the initial levels is likely to guarantee the fourth level that comes with a more positive result. In evaluating results, Zhu and Zhao (2010) offer a criterion for it;

a. Adopting control groups if practical
b. Allowing enough time for achievement of results
c. Evaluating results both before and after training (if practical)
d. Lop through evaluation at appropriate times
e. Cogitate cost versus benefit
f. Be content with evidence, if proof is not possible

Mackman (2016) argues that the results level is somewhat challenging in its evaluation likened to the preceding levels. Nevertheless, Rana (2015) believes that rolling out the result level will help in ascertaining if the training purposes have been realized and whether the outcomes of the training is a true reflection of its results.

Summary

The art and product design field have over the years profited from numerous innovations and developments in the 3-D CAD technology, yet they are underutilized in both industry and in training. Studies indicate that most product designers and tutors poses inadequate technical skills because of insufficient deal in training. The level of adoption even in developed countries like UK, USA is on the low alluding to lack of

experts, information, costs and training as the actual limitations. While study shows that some institutions and industries in Ghana use 3-D CAD technology, minute documentations have been carried out; therefore it is challenging to ascertain the level of 3-D CAD in use. Again the lack of research in this area along with disjointed and incomplete technological support system has affected the adoption process of this technology. There exists a gap in the area of training as few institutions in the country offer training in this field therefore resulting in a small number of graduates trained in the technology of 3-D CAD.

Professionals in the area of design and technology education pointed out that some of the efficient approaches in the area of teaching and learning conceptual understanding and technological literacy is through the process of design.

Several usability studies of CAD software were found, but the concentration in this study was on the use of Rhinoceros, its teaching methods and its control to accomplish the set learning outcomes of the curriculum.

The process of design is viewed as an approach in giving solutions to problems through a methodical approach. The emphasis of the surveyed literature was on the teaching and the role of visualization through the use of 3-D CAD in the product design process and the level to which this integration is enhancing the design abilities of students. In this particular chapter, the definition of key concepts, survey of the literature and a cohesive discussion of the literature were offered. Numerous studies on the significance of 3-D CAD in product design, the impact and some theories in this respect were also reviewed.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter focuses on the methodology adopted in this research. It lays emphasis on the research design and methods, data collection instruments, population of the study, sampling methods, sample used and the method of analyzing the data collected.

3.1 Research Design

According to Degraft-Yankson (2010), research design is basically the structure of any study. The qualitative method of research was employed since the interpretation and outcome of the study is hinged on this type of research design. The qualitative research granted the researcher the ability to acquire in-depth views and details about how the use of 3-D Computer- Aided Design in product designing has fared since its' integration in the Department of IRAI curriculum and its impact of its application on the students artistic works. Qualitative research in its nature describes and explores natural situation's difficult events where no effort is made by the researcher to influence the happenings (Al-mousa 2013).

The qualitative method aided the researcher to know the processes in the teaching and learning of 3-D Computer- Aided Design in product designing. This research design is suitable for the study as it helped the researcher to search for comprehensive understanding on the impact of the teaching and learning of 3-D CAD on students' artistic works and also not only serve as a method of collecting data nonetheless it comprises analysis, classification and interpretation of data. Moreover Fraenkel and Wallen (2002) as cited in Asare-Forjour (2009 p. 58) describes qualitative research as

"studies that investigate the quality of relationships, activities, situations or materials". In effect this method gives the opportunity for a subject understudied to be understood fully through investigating the quality of conditions and happenings. Essentially qualitative research leads to developing new concepts and knowing tendencies in programmes granting a researcher more insights into a field (Osuala 2005).

An evaluation was done on students' knowledge and skills on using 3-D CAD in product designing by the researcher in order to establish the degree of the impact of this technology and the integration's effectiveness. The research design helped achieving the following:

- Acquire in-depth views and details about the use of 3-D CAD and how it has fared since its integration in the Department.
- Investigate the teaching and learning of 3-D CAD in the IRAI curriculum.
- The 3-D CAD resources available in the Department

3.2 Research Method

The descriptive research design was used in this study because; this method deals with the condition that exists in a particular place (Knupfer and McLellan 1996). The choice of this research method is useful as this study sought to examine existing practices, state, disposition of students of the Department of IRAI towards the use of 3-D CAD. Leedy explains that descriptive survey "describes and interpret what is. It is concerned with conditions that exist, opinion that are held, processes that are going on, effects or trends that are developed". In descriptive research, an observation is made on some features of an existing condition for documentation and description to be made on its natural happenings (Amedahe 2002). The descriptive research provides data about a

particular population under study. This method was used extensively to collect and interpret data in order to provide explanations of events and study concepts into details to bring out current applications. It is an evaluation which sought to examine the 3-D CAD software used and how the students use them to enhance their artistic skills in the development and production of their artistic works. So then this method was basically employed to;

- To observe the status quo of academic work in terms of the use of 3-D CAD.
- This method was used to get details on how the process of teaching and learning outcomes of the 3-D CAD programme.
- This method examined the 3-D CAD programme and how the students use them to enhance their artistic skills in production of their artistic works.

3.3 Population for the study

Population as a concept in reasearch methods is defined by Given (2008 p. 644) as " every individual who fits the criteria that the researcher has laid out for research participant". The target population included undergraduate students, and lecturers from the Department of IRAI, KNUST. The accessible population was final year and third year undergraduate students who had registered for the 2016/2017 academic year. Fourth year and third year students of the Department were purposively chosen because of their knowledge and experience which has the tendency of generating data that sufficiently answers the research questions. Also lecturers were purposively chosen because of their position as tutors who handle the product design course and their vast knowledge about this area of study. The above-mentioned merits characterize criteria sampling in which the researcher sought after individuals with characteristics that meet

certain criteria (Palys 2008). The total number of undergraduate students who had registered for the 2016/2017 academic year under the Department of IRAI was 356 and 10 lecturers as table 3.1 brings to bare the breakdown of the population for the study.

Table 3. 1: *Target population of the Department of IRAI, KNUST*

Population for the study	**Number**
Lecturers	10
3rd year students	66
4th year students	141
Total	217

Table 3. 2: *Target and Accessible population of the Department of IRAI, KNUST*

Target population		**Accessible population**	
Fourth year students	141	Fourth year students	141
Third year students	66	Third year students	66
Lecturers in the Department.	2	Lecturers in the Department	2
Total	**209**		**209**

3.4 Sampling Methods

Trochim and Donnelly (2001) explain sampling as the method of selecting units (organization, people) among a population of interest where studies and investigations are conducted on them for outcomes to be generalized fairly concerning the entire population in which they were drawn-out from. The type of sampling adopted was the purposive sampling and proportional stratified sampling. The heterogeneity nature of the accessible population made the researcher to use the proportional stratified sampling that used a strata in identifying each stratum that comes in diverse representation. The purposive sampling technique was used to identify and select learners and lecturers that are of interest for the study thus fourth and third year undergraduate students and lecturers of the product design course. The choices were justified by Agyedu et al.,

(1991) assertion that purposive sampling permits a researcher to intentionally sample only the respondents whose expertise are crucial in understanding the subject under investigation. In portraying a more fair and generalized view of the population, the sample size needs to be no less than 30% of the accessible population which subsequently implies a quality study (Leedy 1974 as cited in Asinyo 2009).

Out of the total population of 366, 10 of them are lectures, year one students totaled 78, year 2 students totaled 71, year 3 students totaled 66 and year 4 students totaled 141. According to Asinyo (2009), for a fair representation of the population for a study, 50% of the total accessible population should be sampled. So 50% of the total accessible population was sampled randomly using proportional stratified sampling for the study. Table 3.3 shows diagram of a stratification of the accessible population (students) into 2 strata. The accessible population totaled 209, of which 2 of them are lecturers, 66 third year students and 141 fourth year students. 106 were randomly sampled out of the accessible population of 209. Table 2 and the proportional stratified sampling strategy chart below show the method of sampling that was used to randomly sample 104 students and the additional 2 lecturers for the research.

***Table 3. 3**: Stratification of Accessible Population (Students)*

Strata	***Target Population***	***Accessible population***
ST-1	3rd year students	66
ST-2	4th year students	141
	Total	207

Summary of the Proportional Stratified and Sampling Technique

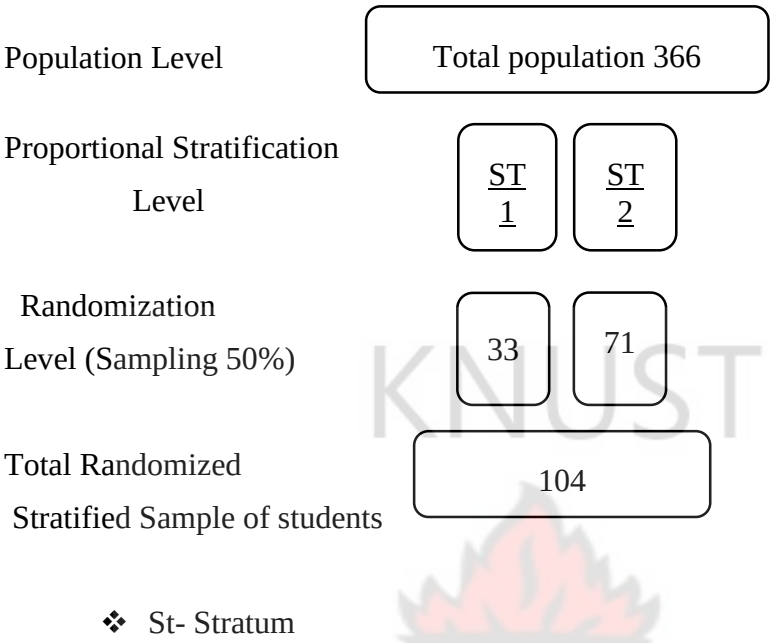

Figure 3. 1: *Chart of the proportional stratified sampling strategy*

Source: *Leedy and Ormrod (2005)*

3.5 Instrumentation

Instrumentation is described as the attempts through which variables of interest are measured by researchers during the process of data collection (Hsu and Sandford 2010). Several research instruments are available in research but appropriate for this nature of research and data necessary are interview, observation, questionnaire and document analysis. These instruments are joined in this study for the purposes of triangulation. Triangulation as described by Guion et al., (2013) is the technique of using two or more methods of data collection instruments during a research for the purposes of increasing authenticity of the data collected.

3.6 Data collection

The primary data gathered for the research centered on lecturers and final year undergraduate students from the Department of IRAI. The main instruments employed by the researcher in the collection of data were questionnaire, personal interviews, document analysis and observation of practical, teaching and some samples of 3-D CAD project works. The secondary data for the research was collected by means of journals, books, published and unpublished thesis, online documents, archives linked to product designing and 3-D Computer- Aided Design portfolio.

3.6.1 Questionnaire:

The use of questionnaire was employed to gather data from students using both close-ended and open-ended questions to cover a wide range of questions. The use of questionnaire gives the researcher the advantage of a less cost in gathering large amount of data from a larger respondent in a relatively short while. Again the use of questionnaire allowed the participants to convey their beliefs, concepts and perception about the use of 3-D CAD and this also helped **c**ollect data on the perceptions, knowledge and skills of students on the integration of 3-D CAD.

The questionnaire has been designed with both the opened-ended and the close ended questions to be able to produce the data needed for the research. In studies that evaluate ICT-based education, questionnaire is one of the effective instruments employed (Romiszowski and Mason 1996 as cited in Asinyo 2009). According to Kvale (1996) as cited in Sewell (2008) interview in a qualitative research is defined as attempting to appreciate the world from the subjects' viewpoint, in order to reveal the implication of persons' experiences and also discovering their immediate domain preceding scientific

accounts. Therefore the questionnaire was structured in five segments as follows: domain

Section one: Demographics.

Section two: Questions on Perception about CAD

Section three: Questions on Teaching of CAD

Section four: Questions on Learning of CAD

Section five: Questions on Facility and resource availability or Support

3.6.2 Interview

According to academia (2014), Brinkmann describes interview as an informal practice wherein knowledge is produced through a communication among an interviewee and interviewer. Using an interview guide, the researcher personally interviewed the lecturers who are in charge of the 3-D CAD training. Using interview also gave the researcher detailed and first-hand information on the application of 3-D CAD by students in product designing and the teaching of it.

3.6.3 Observation

Best and Kahn (2002) simply explain observation in a qualitative study as an instrument that entails thorough representation of happenings, activities, and circumstances regarding happenings and activities. An observation was explicitly made in order to understand the application of 3-D CAD in product designing by students. Again observation was made by the researcher to offer first-hand data regarding the resources and facilities available for the Department and the applications of the 3-D CAD

technologies in their product design practical works. A checklist for the purposes of observation was developed to help the researcher to achieve the above. Both participant and non-participant observation was used by the researcher during their lecture period on the application of 3-D CAD software in product designing.

3.6.4 Document analysis

Document analysis was used to gather secondary data for the study. The Sources of the documents used in the analysis are websites, online repositories and libraries. To analyze the nature of the curriculum of the product design course, document analysis was used to evaluate the 3-D CAD aspect of the product design course. The product design syllabus were reviewed in line with the aims and objectives of the programme to achieve an impartial view of the content and reality within.

3.7 Validation of data collecting instruments

Taking cognizance of the objectives of the study, observation, interview guides and questionnaire were developed and made available to curriculum developments experts for an experts review. Again the whole instruments for the research were scrutinized by the supervisor assigned for this research. Ambiguities and all syntax corrections were brought to bear through this exercise before the administration of the instruments.

3.8 Data collection procedure

During this phase of the study, copies of questionnaire were administered to undergraduate students in person on several occasions after seeking the consent of the Department. Face to face interviews were also used to elicit information from the lecturers in the Department of IRAI. Using a structured interview guide the interview

session was recorded with the lecturers' permission and subsequently transcribed. With observation, the researcher took notes itemizing the resources and facilities available and observed also some of the specific day-to-day activities carried out in teaching and learning of 3-D CAD in product designing.

3.9 Data analysis Plan

According to the Pell institute (2016) data analysis is the interpretation and examination of data to aid in answering research questions laid at the onset of a research. An examination of all the four levels of the Kirkpatrick levels of evaluation was carried out in a realistic setting. Initially the whole data was read to gain a general understanding of the collected data, this according to Creswell (2014) unearths consensus echoed in the ideas of the participants. Subsequently all transcription from interviews, notes from observation and unstructured responses were subjected to content analysis processes for interpretation, coding and identification of themes. The data collected were analysed and the facts were synthesized with conclusions been drawn in order to make essential recommendation. Below is how Kirkpatrick levels of evaluation was used in the data analysis, which will appear in the subsequent chapter four.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.0 Overview

This chapter presents and discusses information gathered with regards to the teaching and learning of 3-D CAD in the Department of IRAI and also presents findings on the evaluation of the module in the curriculum of the Department. The data presented here has been subjected to analytical review and interpretation. To satisfy the first research question, the researcher conducted surveys and interviews on respondents (Students and lecturers) in the Department of IRAI. The working syllabus was also subjected to analysis (Document analysis) to ascertain the goals of various course elements. The Kirkpatrick's four level of instructional evaluation was adopted for the evaluation of the CAD module.

4.1 Respondents Demographics

According to the valid responses obtained, it was realized that there were 67 (69%) female respondents and 31 (31%) male respondents. These statistics indicate a fair gender representation and involvement even though the number of males and number of females are not exactly 50% each. (Figure 4.1)

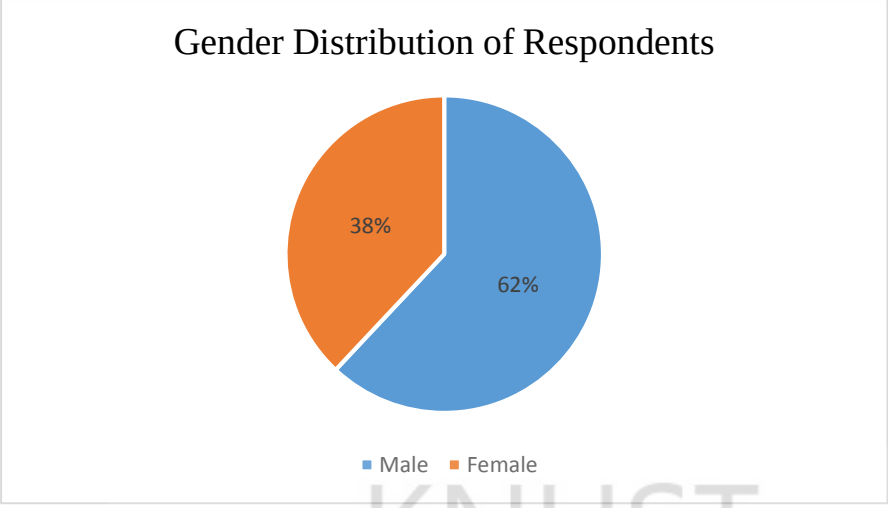

Figure 4. 1: *Respondents' gender*

The minimum age as identified among respondents is 21 years. Aside the tutors, the age range of the students ranges between 21-25years. This age range is suitable for the research since it consists of ICT literates. 62% males and 38% females indicate no partiality in administering the questionnaire but then also echoes the male to female ratio found in Ghana's education system and the use of ICT. Obviously, the male dominance in the sample is reflective of the overall gender composition in the Department of IRAI.

THE NATURE OF 3-D CAD SUBJECT CONTENTS IN THE IRAI CURRICULUM

Objective One: *To identify and describe the nature of 3D CAD subject contents in the IRAI curriculum.*

4.2 Discussion of the Structure and description of the 3-D CAD /Product design module of the Department of IRAI.

The product design course sought to bring innovations in technology and skills from the contemporary art setting into the indigenous art and craft industry. The module aids in designing and producing functional and highly aesthetic products. The description stipulates the learning and teaching curriculum's content as independent modules.

As part of addressing the first research question, it is primarily indispensable to examine the 3-D CAD programme curriculum to elicit a comprehension of the nature of the curriculum. Product design is noticeably a core component of the IRAI programme since it aids to produce physical products from all its individual discipline. The area of product design had been realized to be one of the areas that has its curriculum dwelling on ICT as most of the design stages are computerized. Again in the current processes of the design cycle, CAD is now the main tool that is virtually used from the conception stage to the final stage of a design. Meneely (2017) posits that education in CAD must not solely be centered in the development of the practical skills only; rather CAD must be fused into the process of design in making design concepts into an intense reality. It is therefore indispensable for all existing curricula on product design to meet the present trends and challenges.

The courses structure has been designed in a manner to satisfy certain prerequisites at various stages of the programme. These prerequisites when laid together become at par with the general mission of the Department. The core of the breakdown of these

individual courses match learners' phases of growth, interests, talents, environment, studio practice and media exploration.

4.2.2 Discussion of the Product design/3-D CAD module

The curriculum was developed in 2005 through an MPhil Art Education research work by Mr. Clement Ampah. The curriculum of the product design course is spread within the four-year duration of the IRAI programme. In the first year structure of the course, thus IRAI 165 Basic Design and drawing, basic computer skills and studies are done in the area of elements and principles of art in a compositional structure. In the second semester of year one IRAI 166, Advance Design and Drawing deal with colour relationship, interpretation and application to products; Computer-integrated basic design and Microsoft Word. Students are equipped with the basics of drawing and designs. The drawing is based on studies of models focusing on proportions and anatomy. This module is geared towards equipping learners with sufficient knowledge in both drawing and designing using the computer as well as developing individuals' interests and skills. Much emphasis is placed on basic drawing to prepare learners with abundant expertise and techniques in product designing.

In year Two both semesters are used to equip and train students in the area of advance product design by way of introducing them to the two-dimensional aspect of product designing with both IRAI 265 Computer-Integrated technical drawing and IRAI 266 Computer-Integrated Product design for the first and second semesters respectively. The modules here gradually build students' skills in the area of life and exploratory drawing to Computer-Integrated basic designing. In the second semester, two-dimensional (2-D) design software thus CorelDraw, Adobe illustrator, Adobe Photoshop and AutoCAD become the focus of the teaching and learning where these software are employed to create and edit two dimensional (2-D) drawings. Students are

therefore expected to employ the skills acquired for their semester projects works. The introduction of the year's modules harmonize with the procedural classification of ICT education where by leaners are introduced to computers first among others. Students are provided with a broad introduction into 2-dimensional and 3-dimensional Computer-Aided Design (CAD) which focuses on product designing specific application. Students learn how to use industrial lead CAD software programs thus Rhinoceros 3-D to model product design projects. CAD therefore provide the means of developing design ideas in a 3-D space that seeks to address every issue of design that might have been overlooked in 2-D drawings on a paper.

In the third year level, students embark on an industrial attachment during the first semester in diverse areas of the art discipline, in the subsequent semester students are then introduced to IRAI 365 Research in Product Design, and this explores various approaches for conducting research in the field of product design through some selected themes. Product design research methods are used for researching into non-traditional material areas in order to create products in one or a combination of the non-traditional material areas. This approach builds the research base of students for design and related projects. This level is a grooming stage for identifying and solving problems towards students' final year project/thesis. An advanced tuition in three-dimensional software thus Rhinoceros 3-D is explored further in order to apply the relevant 2-D or 3-D skills for the visualization and execution of projects. There is a strong connection between CAD and other electives subjects taught during the 3rd year. The other courses direct students to present their practical assignment using the CAD software. One main benefit of the previous modules implemented is that, it introduces both methods of product design education and students are able to implement both traditional and CAD methods

of designing when needed. The contents of this module is covered by demonstration, lectures and individual practices of CAD.

One of the fourth year modules, IRAI 465 Influence-Based Product Design deals with exploring the designer's potential to influence users' feelings of attachment towards a product idea. Students espouse the principles of influence as they pertain in psychology by combining product design with the field of psychology to generate dynamic and flexible products which elicit emotions of attachment from users. The 3-D CAD software is employed in generating design concepts that are sustainable through the application of relevant 3-D CAD skills. This is done by the visualization of product design concepts using the Rhinoceros 3-D software.

During the fourth year, students stand in a good position to use most CAD tools nevertheless some employ freehand drawings and designing at the early stages of their design process. IRAI 466 Product Design and Project Work is the final module introduced in the curriculum since most final year projects works proceeding from the Department are tangible artistic products. For this reason, practical approaches and requirement are expected to be met in the product design course. This facilitates students' final year project works in the area of knowledge and skills toward project execution because they apply the product design process as related to their final year project. The role of 3-D CAD is in the area of 3-D virtual modelling and digital imaging where rhinoceros 3-D is used to generate virtual models of would-be products from their final project work.

4.2.2.1 Researcher's Observation from Syllabus

The Product design/3-D CAD syllabus

The product design syllabus is certainly quite an all-inclusive and comprehensive one for the students. It is one of fundamental pillars of the overall aims and objectives of the Department of IRAI. It was introduced with the aim of training and equipping graduates to practice as professionals in the area of developing products by producing resourceful, user-friendly and aesthetic articles. This is geared towards creating a viable future by developing creative methods of product designing. The product design syllabus functions as a full complement to all the other elective courses ran in the Department. The syllabus is quite extensive and imbibes critical, contextual and practical skills. The Department manages its product design curriculum by introducing firstly the traditional method of designing and drawing during the first two semesters, and subsequently tuition in CAD is introduced in the succeeding semesters. The initial CAD course introduced in both year 1 and 2 is focused on giving instructions on the basic features and commands of the software application whereby technical skills can be gained. The CAD components supplement the free hand drawing and designing through the application of similar drawing and designing concepts but using the computer. It was realized that the content of the courses is covered through lectures, class discussions, demonstrations and hands-on computer experience. With the supervision of lecturers, students are introduced to the 2-D and 3-D design world where they study the fundamentals of forms with the elements and principles of design for various compositions. Here the main focus is on the process of design and the end product of the design. The structure of the curriculum at different phases are definitely concentrated on refining very skilled product designing.

4.2.2.2 Researcher's Analysis of the Syllabus

The objectives of the syllabus even though relevant, it seems to merely create awareness in students and offers them rudimentary skills of using a couple of CAD tools. The course should have a well-built empirical module that incorporates practice and theory. Again looking at the structure of the curriculum, there should be a combination of technology, aesthetics and social necessities introduced in certain products around our environment as well as employing logic and creativity to resolve issues of design. Due to the dynamic trend of product design in the 21st century, design instructors are to help update their knowledge of practice by bringing present professional practices to the lecture room and design studio where an exchange of information among students and professional can be facilitated. Due to the changing needs of the product design field, there should be a curriculum that boosts application, integration and unearthing of knowledge outside and inside of the field. Moreover, integrating general and professional studies highlighting applied research and critical thinking should be increased and enhanced focusing on global view points in product designing. This will in part encourage the student to undertake researches that will let them be informed on the modern inventions and trends of design. Mostly students are assigned to create realistic looking models and the task becomes successful if the model produced is an accurate representation of the real-life object.

4.2.3 Mode of assessment

The university provides certain policies on assessment and examinations which is rigorously followed in the Department. Students are assessed periodically through assignments comprising tests, quizzes and project works (group). Among the above, mid-semester and end of semester exams are also conducted as a requirement for

promoting students in their level of study. Assessing students' performance on 3-D CAD product design project works is done through continuous assessment and end of semester examinations. The continuous assessment comprises research works, practical based project works and often time theory based quizzes. In the research project work students are tested on their capacity to ascertain a problem given and their offer of suitable interventions. For the end of semester exam, 3-D CAD objects are projected or physical objects are mounted for students to model a similar one with the rhinoceros 3-D software within a stipulated time to produce an expected fully finished work. The main criteria for this is awarding final marks on the resulting realistic looking model. Marks are awarded per the level of accurateness one has achieved in creating a realistic looking model of the actual psychical model. Criteria for assessing 3-D CAD are the fundamental of elements and principles of design rules that applies to the visual arts. Lastly assessment takes place either by the lecturer, jury or an exhibition of their artworks**.** Here the traditional assessment method is mainly slow and intensely based on tutor's subjective evaluation.

4.2.4 Facility and resource availability for 3-D CAD Product Designing

Instructional materials and 3-D CAD technologies availability were the areas that were observed at this level of the study. From the research it was realized that the technology of 3-D CAD for product designing was available in the Department but without an adequately equipped design studio for practical session. Even though the Department had implemented this particular technology in product designing, acquisition of the necessary facilities and equipment for supporting the training is wholly inadequate. Nevertheless, design studios having the appropriate facilities are essential for an appropriate education in product designing using 3-D CAD (Ryder, 2005). The

availability of an appropriate modern design studio would assist learners to interact with the software and its outputs. The digital technologies identified were categorized into two thus hardware and software used in the Product design/3-D CAD.

4.2.5 Evaluating Computer Hardware and Software Used in the 3-D CAD Product Designing Training

a. Software type

The general software commonly used for CAD in product designing are as follow, the 3-D CAD software identified are Rhinoceros 3-D, with the basics of CAD the 2-D software identified are Photoshop, corel draw and illustrator. Rendering software used after the rhinoceros 3-D software are T-splines, keyshot, keyshot and flamingo NXT. The elementary principle of selecting a software which is the "15-minute rule" was applied in assessing the software available. Considered among the evaluation of the software are its installation and intuitive concepts aside their application in product designing. All selected software in the Department were very intuitive and easy to install which conforms to the "15 minutes rule". Both software concentrated on subject relevance to the IRAI programme as it influenced importantly on students learning and application experiences. However in terms of relevance to the rapidly changing technological era, it is required of the Department of IRAI to update its current 3-D CAD software as new versions are produced and updated considering the dynamic nature of the technological era. Several good and modified versions of 3-D CAD are available on the market which the Department can consider and adopt it into their curriculum. Below is the software application and their various purposes in the product design course.

Table 4. 1: *Available software application*

Software	**Purpose/Use**
Rhinoceros 3-D	It is the application that is able to create 2-D and 3-D designs and aids in the visualizations of computer generated models.
Adobe illustrator	It is the software that is used for creating vector graphics. It is mainly used in creating 2-D works like complex drawings and illustrations using several shapes, effects and colours.
Photoshop	It is the application for creating and editing intricate digital drawings and 2-D images from scratch or to alter existing 2-D images before it is modelled in 3-D.
Corel draw	
Keyshot	This software is for rendering and visualizing 3-D modelled works, it is also used in assigning colours and surface textures to suit the user's colour scheme and requirements.
Flamingo nXt	This is an open source software used as a plugin for the Rhinoceros 3-D modelling software that adds radiosity and raytracing functionalities. It is used in rendering photo realistic 3-D objects.
T-Splines	This is a Rhino plug-in software that aid designers in creating high quality and smooth CAD models in achieving a realist feel within a short time.

Source: *Field data (2017)*

b. Hardware type

Under the hardware, digital technologies that were found are laptop computers and projectors. It was observed that nearly all the students were using their personal computers thus laptops as the respondents indicated that there are few computers available at the Department. The Department lacked relevant logistics such as a well-equipped computer laboratory/ modern design studio, licensed software among others. As a result, computers are provided by each student in order to fully participate in the teaching and learning of 3-D CAD product designing. According to the lecturers interviewed one of the reasons for an absence of a well-equipped computer lab is partly

due to the erratic power supply and its effect on the desktops computers. Due to this students have been encouraged to get their personal laptop computers. With regards to a computer laboratory, the facility in place is just the space with electrical connections for students to bring their own laptops to class. It was also realized that the university has given little attention to the procurement of computer hardware and software in realizing the CAD program.

In the area of securing the software, lecturers provided unlicensed software themselves which are supposed to be purchased by the institution, sometimes students also download pirated version of these software. Rendering as an aspect of 3-D CAD is not taught in the Department due to the insufficient class period that has been dedicated to the teaching of rhinoceros 3-D thus 2 hours a week for practical sessions which is woefully inadequate. In recent times, there has been an emergence of various good modern software that produces state of the art product designs, unfortunately the Department has not ventured into these new 3-D CAD software apart from Rhinoceros 3-D CAD among others. This is a denotation of narrow exposure of students to specific modern CAD software used worldwide, this calls for the Department to effect the needed changes to be at par with the current needs of the product design industry.

4.2.6 Students' Perception Regarding the Resources and Support Systems to Facilitate the Teaching and Learning of 3-D CAD in Product Designing

Issues regarding the availability of resources and support systems in the area of 3-D CAD in Product Designing come in multifaceted dimensions. The supposition that growth in students' population put pressure on the usage of support systems and resources is evident in this study. This phenomenon constantly has an effect on the

implementation of an effective 3-D CAD product design module. Below are some of the common themes that emerged from the students' perception.

The limited resources and poor facilities for teaching and learning were the main concern of the students. Majority of students indicated that the computers were insufficient in relation to the number of students in the Department henceforth accessibility tends to be problematic since few students own personal laptop computers.

Many students wished the Department could provide computers for students who do not have personal computers. The research revealed an unavailability of modern design studios for 3-D CAD practical session and teaching which hampers an efficient training. Students also believed their IT lab should be equipped with adequate teaching aids and the necessary equipment for learning since there is scarcity in this regard. In the area of availability of instructional video tutorials, students admitted that they were not adequately given instructional video tutorials on step-by-step instructions on 3-D designing which can enhance their learning. This can help students practice the skill in 3-D designing outside class hours at their own pace. They revealed that there is less time available to equip students on the technicalities present in the software as a result, motivation for a full participation on the part of students is very low. If more time is given for further explanations it will enhance a faster comprehension by students and increased their interest as well.

Learning materials used for 3-D CAD product designing

In further evaluating the status of the teaching and learning of 3-D CAD in product designing, the accessibility and nature of teaching/learning materials used were analysed. The study revealed that 3-D CAD in product designing typically uses lecture notes, hand-out and the use of online resources was also common among students as a

result of the increased availability of internet provisions in the university. The survey also revealed students' appreciation of the presence of internet services as there is deficiency of up-to-date text books on 3-D CAD product designing. The results indicated that the respondents recognized ICT software/hardware as the most pressing necessity and a higher need for providing adequate teaching and learning resources.

THE CONTENTS AND EXISTING INSTRUCTIONAL METHODS ADOPTED IN TEACHING 3-D CAD IN PRODUCT DESIGNING

Research objective 2: *To examine the contents and the existing instructional methods adopted in teaching 3-D CAD in product design in the Department of IRAI.*

4.3 Teaching of CAD

This section addresses questions regarding the teaching of the Computer- Aided Design, instructor's performances and challenges of students.

a. Respondents views on challenges encountered in the use of 3-D CAD

Pertaining to respondents' challenges encountered in the use of 3-D CAD software in product designing, 36.4% attributed it to poor training session received, 54.5 % of the respondents said complex interface poses a challenge to them, whiles other challenges encountered are lack of in-depth understanding of some of the tools and commands in the software coupled with difficulties in memorizing functions of the various tools and commands in the software.

b. Respondent's ratings of the teaching of 3-D CAD module in the product design course.

From the responses gathered, 51.5% highly rated the teaching as excellent, 36.4% rated it as above average whiles 12.1% rated the teaching as average. This implies that despite the efforts the Department channeled into teaching the module, there are numerous challenges faced by the Department.

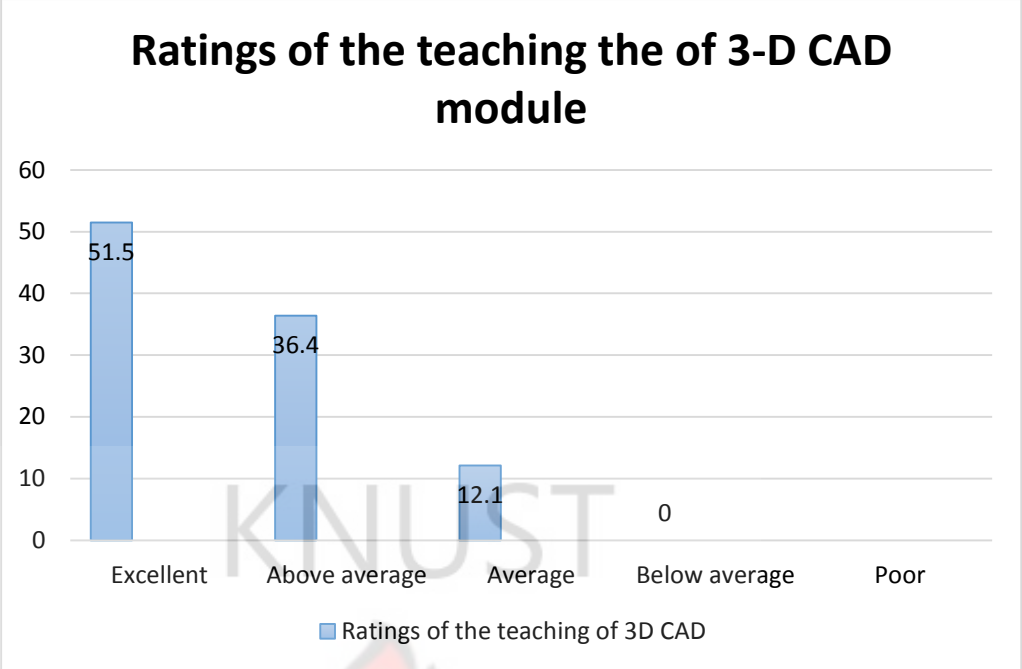

***Figure 4. 2*:** Respondents' ratings of the teaching of 3-D CAD

Source: *Researcher's construct (2017)*

c. Respondents' views on teaching periods allocated for 3-D CAD in the product design course.

Regarding respondents' views on whether the allocated time for the 3-D CAD was adequate, 33% answered yes and 67% answered no. This implies that the limited teaching period that is invested in the teaching of 3-D CAD despite its significance in product designing is inadequate.

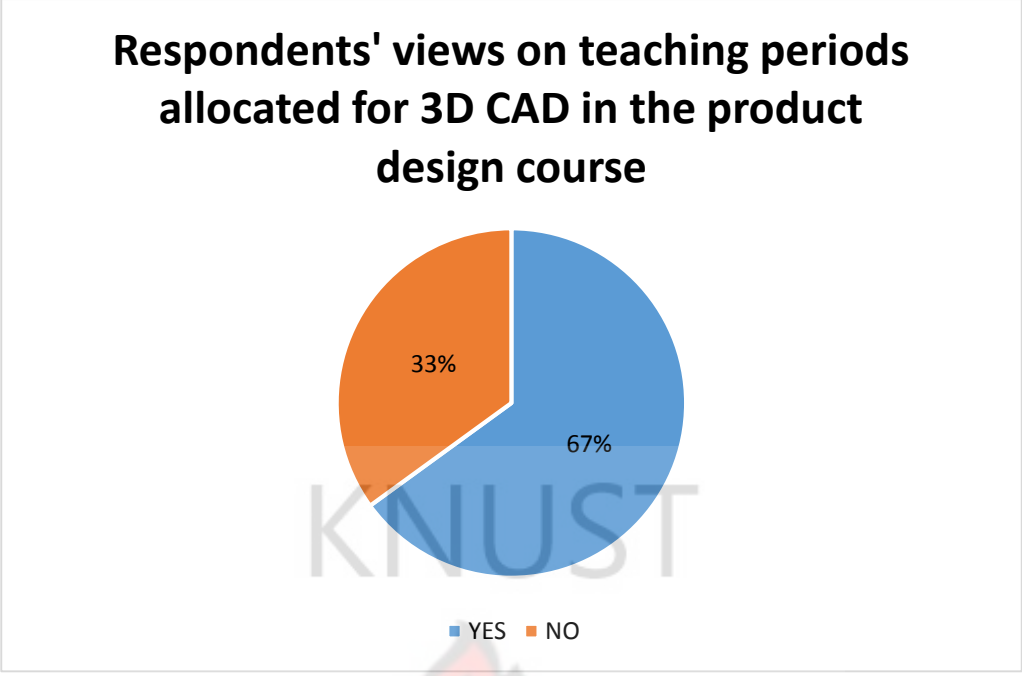

Figure 4. 3: *Respondents' views on teaching periods allocated for 3-D CAD in the product design course.*

Source: *Researcher's construct*

d. Respondents' opinions on when 3-D CAD should be introduced in the Department.

In assessing respondents' opinion on the exact year 3-D CAD should be introduced in the Department, 82% indicated that it should be introduced in year 1, 15.2% indicated that it should be indicated in year 2 whiles 3% indicated that it should be introduced in year 3 and none (0%) indicated that it should be introduced in year 4. Considering the level of skills students acquire before finishing their programme of study it is imperative for this module to be introduced in the early stages of their year of study.

e. Respondents' views on whether instructors clearly presented the skills to be learned.

The respondents were asked if the instructors clearly presented the skills to be learned, 15.1% indicated strongly agreed, 59% agreed that the instructors clearly presented the skills to be learned, 27% were neutral on this whiles only 3% disagreed that the instructors clearly presented the skills to be learned.

f. Respondents' views on whether instructors clearly presented the tools (e.g. material, skills and techniques) needed.

The respondents were asked if the instructors effectively presented the tools needed, 9.1% indicated strongly agree, 39.4 % indicated that they agree, 36.4% were neutral and 12.1% disagreed. This implies that despite the challenges associated with the accessibility of learning materials, instructors efficiently present the few tools available during their delivery of the module.

g. Respondents' views on whether instructors provided meaningful guidance on progress of work and feedback regarding 3-D CAD.

Respondents were asked whether instructors provided guidance on progress of work and the necessary feedback needed, 12.4% strongly agreed, 36.4% agreed, 42.4 % remained neutral whiles 9.1% strongly disagreed. It is obvious that the level of guidance on the part of instructors is very high given more space for students to enhance and further explore their designing skills.

h. Respondents' views on whether instructors used a variety of instructional methods to reach the course objectives.

Regarding respondents' views on whether instructors used a variety of instructional methods to reach the course objectives, 42.4% neither agreed nor

disagreed (neutral), 9.1% disagreed, 12.1% strongly agreed and 12.1 strongly disagreed.

i. **Respondents' views on whether the course instructions (including, manuals, handouts, etc.) were clear.**

Questions were asked if the course instructions (including, manuals, handouts, etc.) were clear to the students, 57.6% neither agreed nor disagreed (neutral), 6.1% disagreed, 12.1% strongly agreed and 24% disagreed.

4.4 General view on the teaching of 3-D CAD in product designing of the Department of IRAI.

The 3-D CAD modules in the product design course comprise a few hours a week teaching in CAD with students' numbers being limited to a maximum of half of each class. Half of the teaching periods of the product design course is allocated to the teaching of the CAD software using a projector. After a thorough exposure to the module, students are given a supervised project in the quest to enhance their skills in CAD. Some of these projects range from artistic products to household items to other vitals gadgets that are part of human sustenance. Students mostly give attention to learning how to apply the CAD tools rather than why to employ such tools. Moreover, the unchanging software that is used in the Department often makes students to frequently find it difficult to shift from one particular software to a new one. It is believed that the computing algorithms in most of the CAD software used similar principles and physics, however only the difference lies in the user interface found in the software. It is therefore imperative to motivate students to understand the general principles concerning CAD software. When the students rightly understand these

fundamentals, it becomes easy in leveraging the CAD skills of students to any different software.

Moreover the approaches in teaching found in the 3-D CAD module are categorized in the following; important amongst them is the traditional lecture and computer laboratory, in-class activities, team-based projects. Face to Face teaching happens to be the regular one used and this particular method demands extra resources. An advatageof this is that students tend to have a straight feedback from the lecturer and also the lecturer can supervise the growth of individual students. The training offered in this respect by the Department puts them at a level where they can produce their individual product designs after they are taught the CAD. Since students learn at various paces thus fast and others slow, for this reason the fast pace learning students usually aid the class to produce high standard works. This method allowed the lecturer to supervise individual learning progress. Below are some of the major findings from the teaching observed at the Department about the 3-D CAD module;

- Lecturers in charge of the product design course help students to nurture their ability to draw and design with CAD applications and again enhance their competences for product designing.
- The tutors realized that drawing and design with 3-D CAD was a vital component of the product design course. For this reason, the initial proficiencies thus capacity to sketch and the skills for designing are what is intensified during the first and second years in the product design course. In their third students are to advance their designing skills through the use of 3-D modelling software.
- The tutors in charge of the course played the roles of facilitators to direct and motivate students in the classroom. They are always seen offering

helping hands to students who wanted help during practical sessions as students were enthusiastic to learn.

- The tutors were resourceful and creative in discovering diverse ways of teaching.
- Most of the 3-D CAD training sessions were hands-on oriented.
- Concerning the teaching methods employed by the lecturers, it was discovered that: lecturers vary their methods of teaching which made the various teaching methods appropriate for the contents of the syllabus and student-centered. When teaching CAD, traditional lecture, demonstration, discussion and problem/practice were all effective if the instructor properly incorporated them.

With regards to goals specified in the syllabus of 3-D CAD in the product design course;

- Lecturers made sure that students comprehended their lesson by allowing them to work in the classroom as well as giving out assignments to them.
- Students were motivated through the assistance of the lecturers as they were encouraged and given the necessary directions.
- During the 3rd year the teaching and learning were basically hands-on oriented alongside appreciation and criticism sessions.
- Students were found to be enthusiastic to learn the skills in product designing using 3-D CAD available to them.

Weakness in the Teaching of 3-D CAD for Product Designing

- Fairly an average number of students had acquired the skills and knowledge that correspond with their level of development; therefore some of them are unable to generate ideas that are relevant to their artistic products.
- The appropriate tools, materials and equipment to ensure efficient teaching of the module are not available in the Department.
- Occasionally the teaching methods did not offer prominence to detailed study.
- Through the observation, it was revealed that certain physical problems like inadequate infrastructure hinder the teaching of this module.
- The course content found in each academic year was relatively overloaded.
- It is also realized that the importance of synergy application of the tools within the product designing process has not being addressed effectively. Often students pay attention to only learning how to use the tools rather than why to employ such tools.
- Lastly detailed scheme for marking which is to guide assessment of students' works is not elaborated. These discoveries indicate that more have to be done in order to improve the teaching 3-D CAD in the Department of IRAI, when this is done lecturers and both students would find a fulfillment in what they practice as product designers.

A KIRKPATRICK EVALUATION OF THE EFFECTIVENESS OF THE LEARNING OF 3-D CAD IN PRODUCT DESIGNING

Objective three: To evaluate the effectiveness of the application of 3-D CAD in Product designing by students in the Department of IRAI.

4.4 The Kirkpatrick's Evaluation Model.

Evaluating the effectiveness of a training programme is very important because it provides good grounds for subsequent improvements. Evaluating training effectiveness often entails using a lot as there are a lot of variables to be examined. The Kirkpatrick's evaluation model has proven to be one of the simplest and effective tools for Instructional evaluation. The model holds that, evaluation is in 4 successive levels; reaction, learning, behaviour and result. Often, evaluators only complete the first two levels in evaluating training programmes, ignoring the 3rd and 4th, which holds significant amount of data.

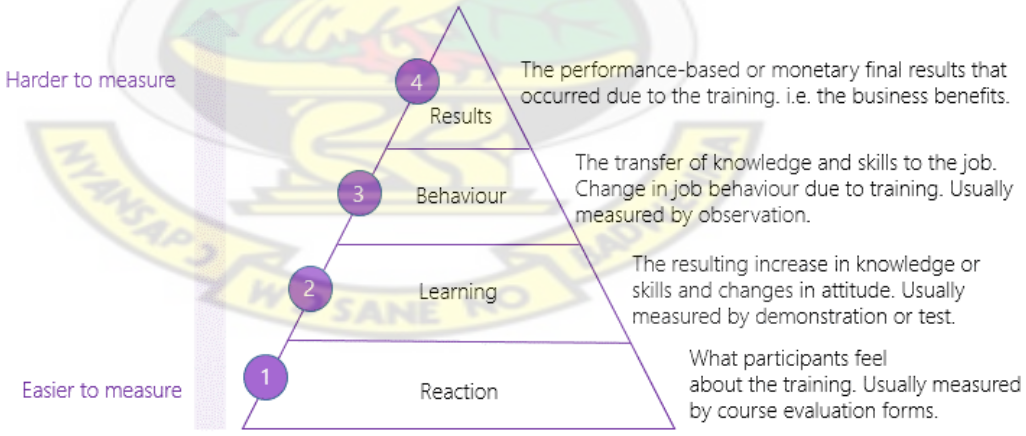

Figure 4. 4: *Kirkpatrick's 4 levels instructional evaluation*

Source: *Mackman (2016)*

The 3-D CAD module for the IRAI curriculum was subjected to this evaluation model in order to ascertain its efficiency and satisfy the third research question. This process involved running the 3-D CAD module and its users through the 4 levels as posited by the model.

4.4.1 Level 1: Reaction

This level's data gathering process employed questionnaire as instruments with the aim of discovering the level of students' feeling towards the instructor, subject, course materials and delivery mode. This level forms a significant part of the whole assessment process as its results have effects on the other succeeding three levels as Campen (2009) calls this nature of assessment as the "smile sheet".

4.4.1.1 Perception about CAD

It was necessary to first gather data on the perception of students. This was to discover if using the 3-D CAD in product designing helped the students to become more proficient at product designing.

a. Respondents first encounter with 3-D CAD in product design

This aspect of the questionnaire analyzed respondents' first encounter with 3-D CAD in product designing. 30.3% encountered it before entering into the university, 24.2 % of respondents had only encountered 3-D CAD in their entry in level 100 whiles 45.5 % of the respondents had encountered 3-D CAD in their 2nd year in the university. This indicates the ICT knowledge gap that exists among visual art

students in pre tertiary level before their entry into the University, this is evident as students' awareness of 3-D CAD is very low before entering tertiary institutions.

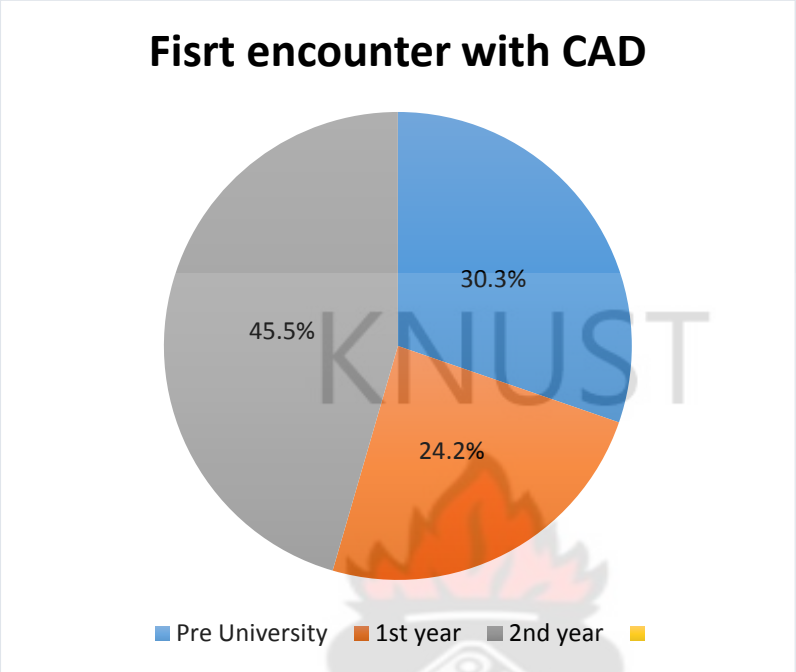

Figure 4. 5*: *Respondents' first encounter with 3-D CAD

Source: *Researcher's construct*

b. Respondents' views on the usefulness of 3-D CAD in their area of study.

With emphasis on relevance of 3-D CAD on students' area of specialization, students were asked on the usefulness of the 3-D CAD in the product designing process. The rating for the usefulness of 3-D CAD in their area of study ranged from excellent to poor putting a strong line between the extremes. As far as usefulness of 3-D CAD is concerned, all respondents saw it as useful. Remarkably 51.5% of the respondents chose excellent because of the benefits they derive from it, 36.4 % above average, 12.1% average and there were no respondents who chose below average or poor regarding the usefulness of 3-D CAD. Respondents' views

affirm the views that, 3-D CAD training in product designing was very useful in the area of art and design education.

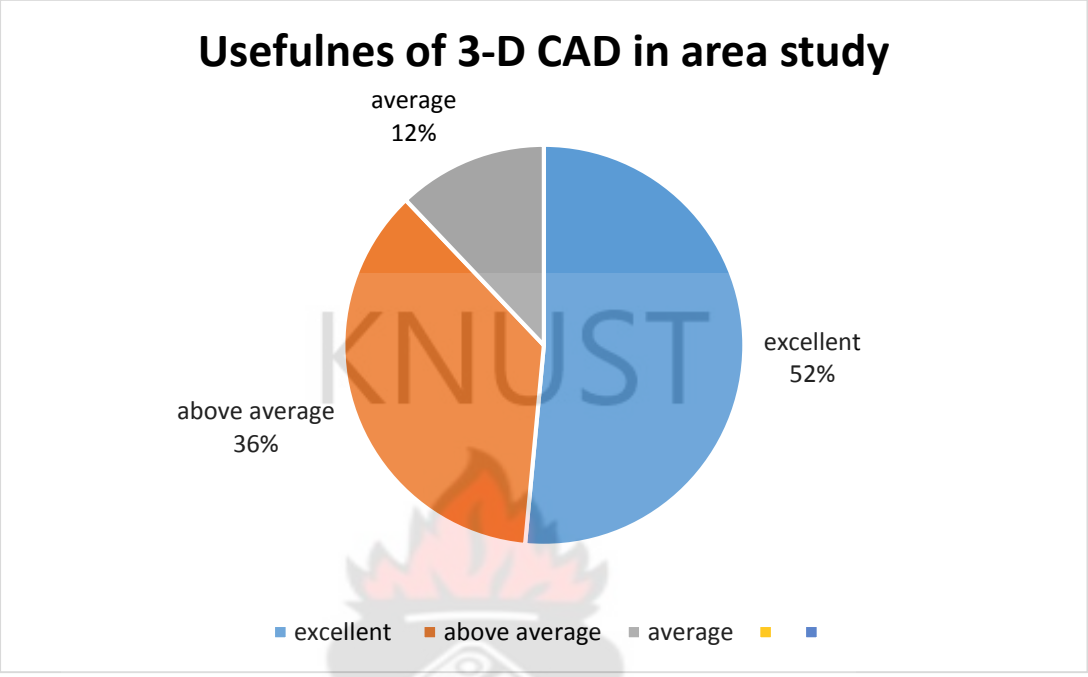

Figure 4. 6*: *Respondents views on the usefulness of 3-D CAD

c. The modalities that pose difficulties to students

Pertaining to respondents' views regarding the modalities that pose difficulties to them, 21.2% of respondents attributed their difficulties to marks, 9.1% indicated lecturers handling the module, 39.4% also indicated lack of interest as their difficulties, 6% of respondents indicated that their difficulty is as a result of the teaching not being clear, 12.1 % respondents ascribed their difficulty to the competition in class whiles 9.1% said that 3-D CAD is difficult. Despite the numerous advantages associated with 3-D CAD it is obvious that students in the Department nonetheless battle with certain difficulties.

d. Impression of respondents on the 3-D CAD in the product design curriculum.

Subsequently, respondents were asked for their views on the nature of the curriculum and if the set objectives were being met. From the responses gathered, 54.5 % appealed that 3-D CAD in the curriculum should be restructured, whereas 42.5 % responded that the curriculum should be maintained and surprisingly only 3% of respondents indicated that 3-D CAD should be removed from the product design curriculum. This denotes that majority of respondents acknowledge the essence of the curriculum but an enhanced one can be very helpful.

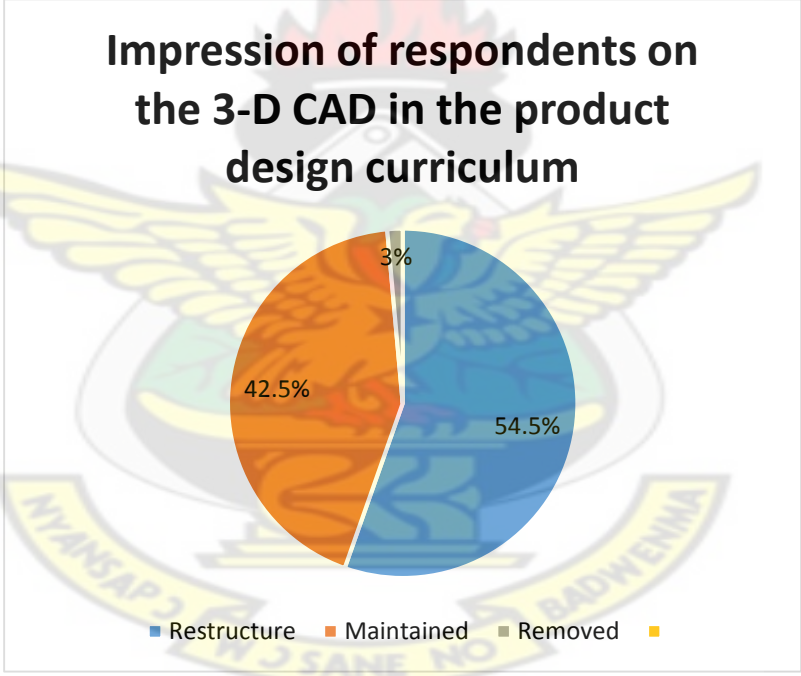

Figure 4. 7: *Impression of respondents on the 3-D CAD in the product design curriculum.*

e. Views on whether the objectives of the 3-D CAD module in the product design curriculum have been met.

One of the main purposes why an academic institution would undertake an evaluation would be to assess if a programmes' objectives are being met. When respondents were asked if the objectives of the 3-D CAD module have been met in the product design course, 65% stated yes and 35% stated no. This implies that a greater percentage of the objectives of the course are being met in the running of the product design course.

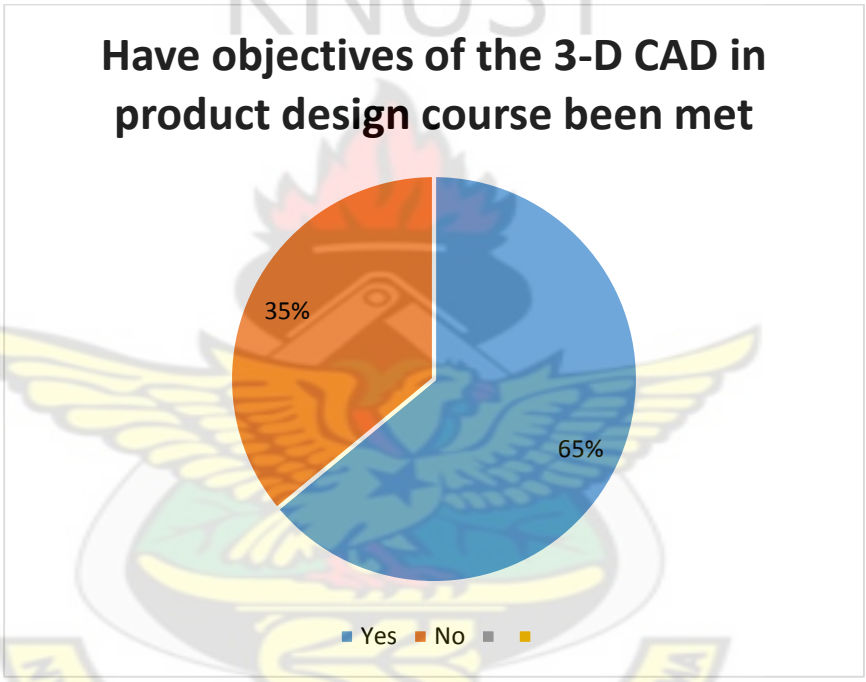

***Figure 4. 8*:** *Respondents' views on whether the objectives of 3-D CAD in the product design curriculum have been met.*

f. Preference between traditional methods and 3-D CAD

With the existence of CAD in the design field some designers still prefer the use of traditional methods for designing whiles others prefer both. In this regard respondents were asked of their particular preference between traditional methods and 3-D CAD. 45.5% of respondents indicated that they prefer 3-D CAD, 45.5 % prefer traditional methods and a minority 9% prefer both the traditional method and CAD. This implies majority of the respondents would either use only the CAD or combine both methods of designing but rarely would one use only the traditional method in their design process.

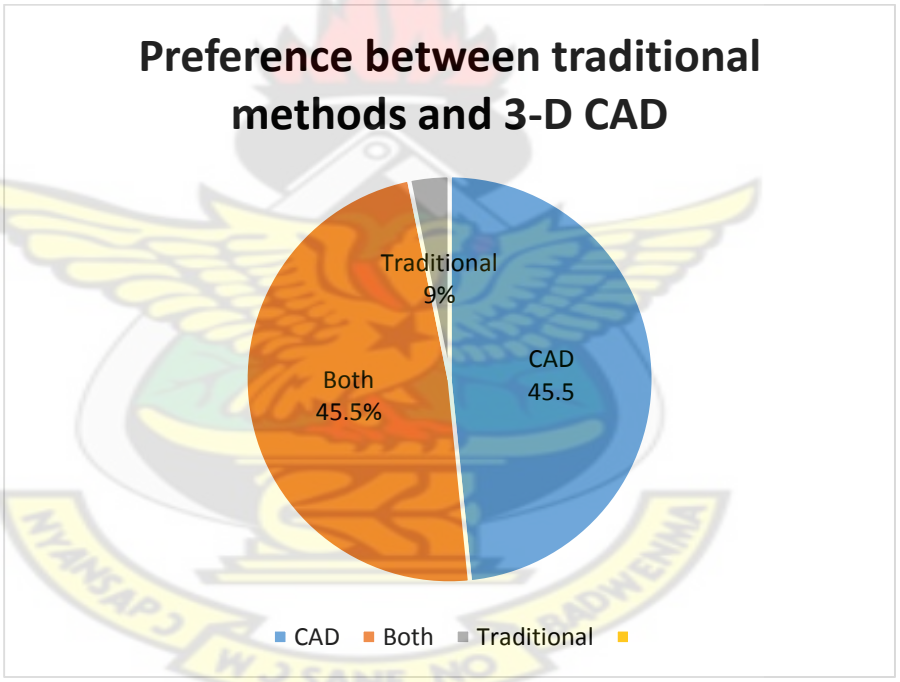

***Figure 4. 9*:** *Respondents' preference between traditional methods and 3-D CAD*

g. Respondent's views on the design time frame for traditional methods compared to 3-D CAD?

Respondents were asked on the time frame of the traditional methods compared to the 3-D CAD in terms of time spent on designing. 33.3% of respondents indicated that the traditional method is faster than 3-D CAD, whereas18.2% indicated that it is indifferent and 48.5% indicated the traditional method is time consuming compared to using 3-D CAD. This implies that using 3-D CAD in the product designing helps finish projects works on time compared to the traditional methods.

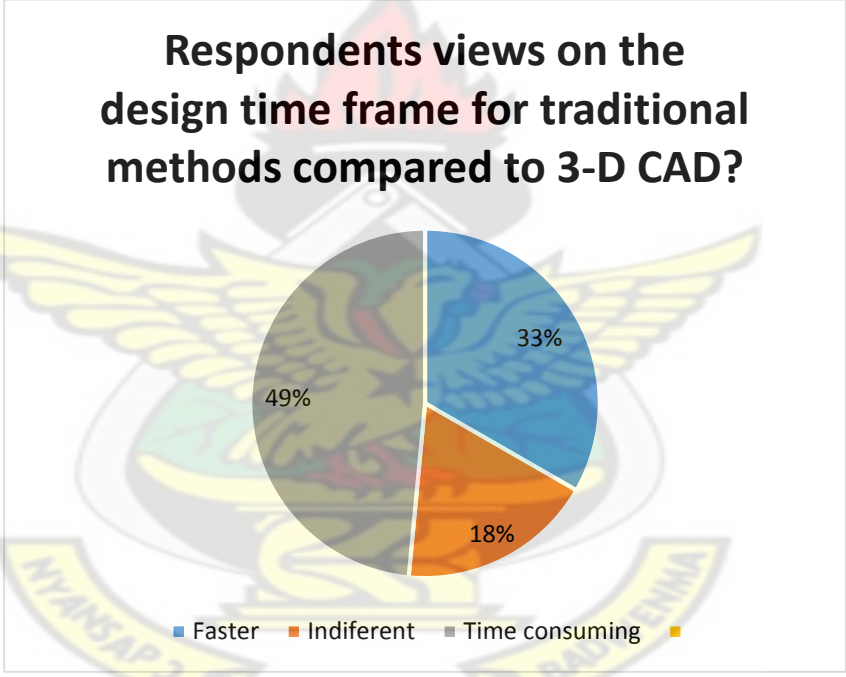

Figure 4. 10**:** *Respondents' view on the design time frame for traditional methods compared to 3-D CAD.*

4.4.2 Level 2: Learning

This level assesses the chunk of learning that went on through the training. This mostly involves a double-faced assessment, one before the training commences (pretest) and the other, at the completion of the training (posttest) (Campen 2009). Learning evaluation measures the variation in knowledge or intellectual ability from "before to after" the learning experience; thus revealing resultant increase or decrease in skills and attitude. Two principal issues here are how knowledge or skill changes can be measured, and the research design to determine improvements. However, Manu (2014), suggested methods like, interviews, surveys, tests and observations as ways of ascertaining knowledge, skills and attitude change.

a) Respondents views on whether they can refer to themselves as designers who can positively and professionally work using 3-D CAD tools.

After acquiring the necessary skills respondents were asked if they can positively and professionally work using 3-D CAD. 30.3% of respondents indicated that they can positively and professionally work, whiles 12.1% said indicated no whiles 57.1% indicated average in terms of working as professional designers using 3-D CAD. This implies that it is just a quarter of graduates who can professionally work using 3-D CAD in product designing. This re-echoes the assertion of a very low level of integration of 3-D CAD in the product design industry in the country.

b) **Respondents views on the 3-D CAD learning methodology used**

Students of the Department of IRAI employ several methods of gaining proficiency in the 3-D CAD software, the respondents were asked to indicate the means by which they gain proficiency in the 3-D CAD software. Their selection was established on these parameters: Departmental course on 3-D CAD, Self-teaching of 3-D CAD software and Organized private classes on 3-D CAD. The table below illustrates students learning methodology used in 3-D CAD. Each learning methodology was assigned a given roman numeral; Departmental course on 3-D CAD=I, Organized private classes=ii, Self-teaching=iii.

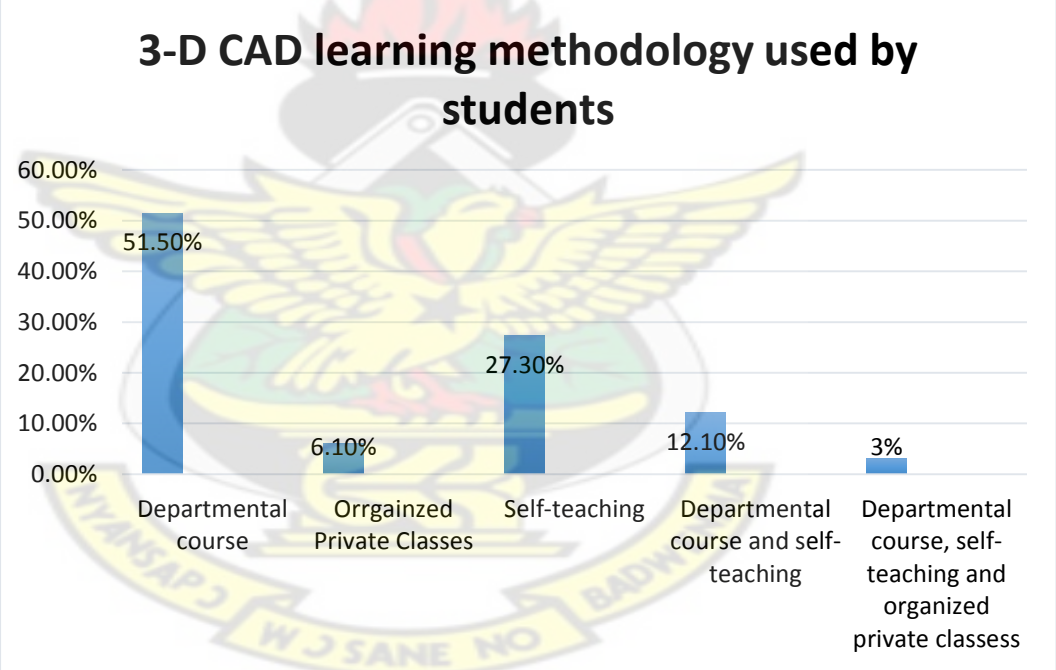

Figure 4. 11**:** *3-D CAD learning methodology used by students*

Table 4. 1: *3-D CAD learning methodology used by students.*

Learning	**Designation**	**Percentage (%)**
Departmental course	i	51.5
Organized private classes	ii	6.1
Self-teaching	iii	27.3
Departmental course and organized private classes	i & ii	0
Self-teaching and organized private classes	iii & ii	0
Departmental course and self-teaching	i & iii	12.1
Departmental course, self-teaching and organized private classes	i & ii& iii	3

c) Respondents views on whether 3-D CAD helped conceptualize and present their ideas in artistic medium.

Students were asked if 3-D CAD helped them conceptualize and present their ideas in their final artistic medium, 33.3% strongly agreed, 42.4% agreed, 21.3% were neutral about that, 3% disagreed. Since the design process is about solving a problem it evolves from conceptualization to the final design solution and the responses indicate that 3-D CAD helps in conceptualizing design ideas to its final stage of the design process.

d) Respondents' views on whether 3-D CAD helped increased their interest in the product design course.

Pertaining to 3-D CAD increasing students interest in the product designing, a majority of 22% strongly agreed and 39% agreed, 27% were neutral on that whiles 12% disagreed that 3-D CAD has increased their interest in product designing. It is evident that 3-D CAD has the tendency of developing students' interest in product designing in the area of art.

4.4.3 Level 3: Behaviour

The behaviour level dealt with ascertaining the behavioural variations in the students as a result of the training. This sought to answer questions on whether learners are applying the acquired 3-D CAD expertise, knowledge and outlook in their immediate setting. Evaluating behaviour entailed interviewing or/and observing the students after the training in order to measure the amount of learning that has affected the students' performance in their related project works. On the other hand, if a student gains knowledge and proficiency in an area of expertise, it is anticipated of the student to utilize or show that new behaviour in given solutions to problems in the area of study. Evaluating the behaviour level was based on observation and assessment of project works. The observation was conveyed in three areas which are psychomotor, affective and cognitive. Since cognitive domain has to do with the human mind and mental actions or abilities, project works of students were examined in terms of how they have applied their cognitive skills. It was established that they had been able to competently and systematically apply the understanding from their acquired knowledge and skills in their project works the researcher observed. On the other hand, students accomplished

a greater territory of cognitive skills as they are able to synthesize, analyse and assess the understanding attained in the periodic assignments and other semester project works. Some of the works of students from the Department are presented in the plates below. The works include 3-D models executed using Rhinoceros 3-D CAD software, T-splines and KeyShot.

4.4.3.1 Sample of students' project works

Plate 4. 1: 3-D CAD model of a chandelier

Plate 4.2: 3-D CAD model of a multi-purpose table

Plate 4.3: 3-D CAD model of a signpost

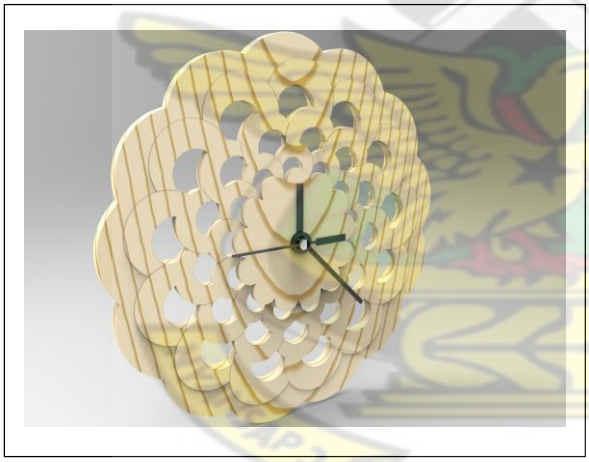

Plate 4. 4: *3-D CAD model of a wall clock*

Plate 4.5: *3-D CAD model of a leather chandelier*

The use of these computer applications have immensely cut down the usage of the traditional processes of solving design problems thus offering students the upper hand of cognitively using these CAD tools in the area of product designing. Comparatively the method of experiential learning found in ICT allowed a number of students to relate psychomotor, cognitive and affective skills in the course of examination. Bloom states

that the affective domain has to do with ones' emotions, which in turn influence the values, appreciation, interest and attitudes. The intensity and growth of students' affective skills is evident as they applied the software skills in developing ideas and rendering complete artefact using the computer executing projects. Substituting the traditional approach of product designing with 3-D CAD technologies improved affective skills of students. The psychomotor domain according Bloom has to do with visual, reflex, auditory and tactile skills using physical abilities, which involves the human-on application. The software interactivity involving the coordination of the mouse, sound, display and keyboard in a particular design activity leverages students' psychomotor skills. Developing physical skills is mostly significant equally to the development of values, interest and attitudes in students. Following these three domains in the course then suggest that the students have received an all-inclusive ICT based training from the learning experience.

4.4.3.2 Application of 3-D CAD in the Design Process by Students

Product designing incorporates lots of conceptual and physical tools in its activities. The design activity that is predominant in the Department follows a particular design problem format which is as follows:

- Problem statement – a scenario and a task are given which the students are supposed to solve.
- Parameters/Limitation– it involves materials and restrictions the solution must fall within and the vital information that affects the final design.
- Brainstorming solutions – series of hand drawn ideas.
- Selection of suitable ones– students' rationale selection is provided.

- Developing and finalizing ideas/prototype – this is the execution phase.
- Evaluating solution– analysis of the design is provided.
- Presentation of final project– finished project is presented to the class for a jury.

The introduction the 3-D CAD in design education in the Department is known to have afforded students the opportunity of exploring the field of designing. Students are offered an adaptive media to enable them to create, refine and evaluate difficult design models that is subsequently rendered into actual products. In the process of finding solutions to design problems, students reveal their intentions and ideas through brainstorming, hand drawing and using 3-D CAD software application. After students are exposed the basic concepts of 3-D CAD techniques, while using current CAD software. They learn how to create geometric shapes, objects, set-ups among others. In addition students are able to perform tasks like creating 3-D and 2-D objects and photo realistic rendering of their product designs projects using CAD software. Students use the technique of surface and solid modelling in creating their final designs for presentations using Rhino 3-D. In addition to using Rhino 3-D for modelling, students learn on their own on how to incorporate animated, rendering and lighting techniques using keyshots and T-splines. This part of the 3-D CAD programme is usually seen in students' works at the final semesters of their 4 year course duration. Students therefore engage in diverse stages of the processes of design taking into consideration the four aspects of product designing according to Press and copper (2002), these are function, aesthetics, ergonomics and value.

It was also realized that students' ability of representing, developing, communicating and presenting ideas successfully was extremely enhanced. This affirms Cil and Pakdil (2007) assertion that the usage of 3-D CAD aids in developing students' design

perceptual skills. The study also brought to bear Bonnardel and Zenasni (2010) affirmation that the creative thinking skill of students are developed through the provision of effective evaluation and communication tools. Nevertheless, looking at the vast potential of these design tools, it is evident that the creative possibilities of 3-D CAD has not been thoroughly developed.

4.4.3.2.1 Difficulties encountered in using 3-D CAD in product designing.

Concerning difficulties encountered by students in the use of 3-D CAD in product designing, several themes emerged which some were:

- Lack of in-depth knowledge on certain 3-D CAD tools due to inadequate teaching aids and materials.
- 3-D CAD is generally complex and mostly demands greater level of skills in using the software. Some students indicated that they are not familiar with most of the commands which subsequently makes designing with some tools very complicated. Common amongst them is replicating certain mechanism such as movements and modelling of rounded figures and objects.
- Majority of students also indicated that the number of period allocated for the tuition of the 3-D CAD module is not enough coupling with insufficient time to learn and practice due to the workload from other elective courses.
- A smaller minority also indicated that the manner in which the contents of the course is delivered inhibits their interest in the module.

- Most respondents indicated that their challenges lie in the rendering of the final model using the adjoining rendering plugins software available.

4.4.3.3 Summary of the behaviour level

In a critical observation of some works of students, it was revealed that all the students managed to bring out the principles and elements of design, which is very vital in the field of product design, this indicates that the transfer of knowledge concerning product designing has taken place satisfactorily in order to alter students' behaviour. And this behaviour has been sustained after a period of time. In the early stages of introducing the students to CAD, only few students employed the basic functions of the CAD software for their product designs. Because most students struggled to apply their new expertise to other projects. Mostly forms created were constrained as a result of limited knowledge of students CAD skills. Some students in improved considerably in the transference of their knowledge of product designing technique to their projects whiles few students did not improve much on their skills. This was seen in some students been able to represent their creative and artistic ideas easily whereas some still had not attained the essential skills for product designing in terms of the creation of visual interest.

The students in the Department especially fourth year had mastered all features of 3-D CAD product designing by advancing their skills and knowledge through the application of appropriate high-tech methodologies. They analytically contemplate on the learning offered in the taught modules and apply the practical and conceptual tools in the course of the design projects. It was obvious that students possessed practical knowledge and the necessary transferable skills that is required of graduates in the product design field.

4.4.4 Level 4: Result

Level four evaluation establishes result of the sessions and outcome of training and subsequent fortification if the need be. In fact, these sum up the success of the programme in understandable terms; increased creativity skills, improved critical thinking skills, and enhanced digital fluency skills. As argued by Zhu and Zhao (2010), if training is targeted at perceptible results other than conceptual and cognitive skills, then results can be evaluated. Manu (2014), also affirms that, measurement of result can be done against core objectives of the training programme, where proof is concrete and evidence is available. He further argues that, Positive outcomes from the early levels can assure a positive level 4 outcome. However, Level 4's outcome does not indicate whether the participant dislikes the training (level 1), proves understanding (level 2), and tell if the participant desires to use the learnt behaviour (Level 3). As noted by Mackman (2016), this level is quite difficult to evaluate as compared to the previous levels. However, undertaking it is a sure-way, for the organization to be able to fully ascertain whether training objectives have been met and whether truly the outcome is the result of the training (Rana 2015).

Since the participants in this case are students in an academic environment, and conducting level 4 evaluation would need more years of study after participants are out of school, it will be prudent to ascribe to the argument of "positive outcomes from the early levels can assure a positive level 4 outcome". Therefore, relying on logical and sequential deduction from the results of level 1, 2, and 3, it is rational and imperative to suggest that Level 4 (Results) yielded a positive signal.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter gives a summary of the findings of the whole study and drawing conclusions grounded on the findings. In addition, it highlights the recommendations by the researcher towards improving 3-D CAD training and future investigations.

5.1 Summary

As part of its vision, KNUST trains topmost workforce for the various areas of study for Ghana's economic system and equip graduates with the knowledge and expertise to support the industrial and socio-economic development of Ghana and the ever-growing technological world. The study sought to gain understanding into the usage and application of 3-D Computer-Aided Design by investigating the benefits and/or downsides and the impacts of CAD on students' practical works and skills. More so, the study offered insightful perspectives into the current 3-D CAD training at the Department of IRAI, focusing on the shortfalls that impede the full utilization and realization of CAD in the product design course.

The main aim of the programme is to equip students with the needed skills to identify and promote the indigenous art and craft of the traditional Ghanaian heritage. The role of the integration of Computer-Aided Design was to help in teaching, learning as well as equipping learners with the relevant practical skills particularly in the area of product designing. It eventually advances the students' knowledge in technology integration. Obviously the availability and technical expertise of CAD and other hardware tend to influence the designing and execution of artefacts by students.

5.2 Conclusion

Having scientifically completed this study, the following conclusions where deduced after analyzing the data accumulated:

1. The 3-D CAD module is hinged on the Rhinoceros 3-D software and its implementation is as catalogued below;
    a. The main 3-D CAD tool adopted in the Department is the Rhinoceros 3-D software for the product design course. The tools help students to create a visual form of complex models when designing.
    b. The study showed that, the traditional methods of designing and solving problems have made way for new technologies thereby giving students the impetus to cognitively and creatively use modern technology to solve problems in the area of product designing. The module tends to encourage students to be very creative by applying 3-D CAD software in generating virtual models of would-be artistic products.

2. Utilizing the Kirkpatrick's Instructional Evaluation model, the 3-D CAD as implemented in the Department of IRAI has been very successful and useful in meeting its purpose. Despite the limitations in the implementation of the 3-D CAD module in the Department of IRAI, the benefits tremendously outstand the hitches identified. Nonetheless, the success of the implementation of the module is accompanied with some unresolved hitches as detailed below.

    a. Although most students have adequate skills in the 3-D CAD technology, the skills received by few graduate is not satisfactory in preparing them to easily relate 3-D CAD with existing industrial environment.

b. It was also realized that suitable teaching and learning resources were absolutely insufficient in enhancing the training of 3-D CAD in product designing. This makes both practical and theoretical training in 3-D CAD problematic.

c. The topic of congestion of the product design syllabi and the inadequate time allocated to the course burdens instructors to forcefully blend numerous lessons in a single project.

d. The product design curriculum provides adequate tuition in 2-D designing for product designing in its first four semesters, nonetheless additional period of time is required to teach the 3-D aspect of designing. Reaction from students revealed that they desired to have more training in using 3-D CAD software: the 3-D CAD software are mostly complex and the period dedicated to it in the curriculum is very little.

e. Product designing had evolved through different stages from the conventional to digital approaches and the transformation seen in the Department is not radical nevertheless in the near future a massive improvement would be realized as 3-D CAD would completely substitute the traditional methods of designing.

f. Furthermore, the results showed that the teaching of 3-D CAD focused on basic introductory course in the early years of the students disregarding specific industry and professional related modules.

Some notable successes of the module are as indicated below:

a. One of the enormous benefits realized from the adoption of CAD in the Department's curriculum is seen in the improvements of students' project works as they match-up with standardized works worldwide.
b. Although they are few challenges in the area of resources, students are noted to be self-motivated to learn the 3-D CAD programs with little or no assistance. Students have found the study of 3-D CAD inciting and helpful, as the course had empowered them to gain expertise in using 3-D CAD software in their project works.

5.3 Recommendations

After fruitfully completing this study, the following recommendations have been tendered for consideration by the appropriate bodies for the advancement of 3-D CAD in the Department and tertiary institution and Ghana as a whole;

1. Despite the excellent feats of the 3-D CAD module in meeting its goals, the implementation module and robs it of its achievements. Specifically, there is a necessity of enhancing the module to be coherent with real world and industrial production methods. Details of this recommendation are as articulated below:
    a. There is the need for a revision of the contents of 3-D CAD in the product design course structure in order to take advantage of the fast growing technological era.
    b. The appropriate authorities will need to invest more in the infrastructural resources of the Department in order to sustain its strength in meeting up with the changing industrial needs.

c. The delivery of the contents of the 3-D CAD product design course ought to center on bridging the gap in best practices in the professional world and theoretical knowledge in school. Students in the area of product designing are therefore urged to undertake research in newer trends in order to be informed with the current developments in product designing.

d. Also the modules of 3-D CAD should be introduced as early as 2nd year to the final year of the programme. This will help students to early embrace the technological disposition of 3-D CAD to improve the skills and potential of product designing.

2. In the quest to strengthen the linkage between traditional methods of producing Ghanaian indigenous art and craft and the modern methods of product designing, more research in the area of CAD by practitioners and students should be encouraged to refine the existing contents of the 3-D CAD in product design curriculum. This would broaden their skills and knowledge in terms of the usage of new 3-D CAD tools for product designing and also facilitate the unleashing of students' creativity. Moreover infrastructural investment must be intensified as well to make learning environment conducive for students. Specifically,

    a. The presence and use of electronic books, online video tutorials and other interactive education systems should be increased in the teaching and learning process. This would offer students the opportunity to be aware of the global trend and improvements in 3-D CAD product designing.

b. A conducive environment and a well-equipped state of the art computer design studio should be created to enhance students' experience of the teaching and learning of 3-D CAD in product designing.

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APPENDICES

Appendix A: Course Structure for the four (4) years duration

Year One Semester one		**T**	**P**	**C**
IRAI 165	**Basic Design and Drawing**	0	4	2
	Total	**0**	**4**	**2**
Year One Semester Two		**T**	**P**	**C**
IRAI 166	**Advance Design and Drawing**	1	2	2
	Total	**1**	**2**	**2**
Year Two Semester one		**T**	**P**	**C**
IRAI 265	**Computer- Integrated Technical Drawing**	0	2	1
	Total	**0**	**2**	**1**
Year Two Semester Two		**T**	**P**	**C**
IRAI 266	**Computer-Integrated Product Design**	0	2	1
	Total	**0**	**2**	**1**
Year Three Semester one		**T**	**P**	**C**
IRAI 365	**Research In Product Design**	1	3	2
	Total	**1**	**3**	**2**
Year Four Semester one		**T**	**P**	**C**
IRAI 465	**Influence-Based Product Design**	1	3	2
	Total	**1**	**3**	**2**
Year Four Semester two		**T**	**P**	**C**
IRAI 466	**Product Design and Project work**	1	3	2
	Total	**1**	**3**	**2**

Source: *Field data (2017)*

Appendix B: Course Description for the four (4) years duration

Year One semester one

IRAI 165 Basic Design and Drawing (0, 4, 2)

Studies in elements and principles of art in compositional structure; Introduction to Typography; Introduction to the Computer and Basic Computer skills. Compositional drawing and Handling general art materials for drawing and painting.

Year one semester two

IRAI 166 Advance Design and Drawing (1, 2, 2)

Computer-integrated basic design; Microsoft Word processing Basics. Life drawing based on studies of models. Exploratory drawing of landscapes, beach scenes, forest

Year Two semester one

IRAI 265 Computer- Integrated Technical Drawing (0, 2, 1)

Introduces the use of advanced Microsoft Word Processing; Introduction to 2-D Digital Designing; Introduction to CorelDraw.

Year Two Semester Two

IRAI 226 Computer-Integrated Product Design (0, 2, 1)

Advanced designing in CorelDraw; Introduction to Adobe Illustrator; Introduction to Adobe Photoshop.

Year Three semester One

IRAI 365 Research in Product Design (1, 3, 2)

Design history; 3-D visualization techniques; Digital imaging; Introduction to the Craft Industry; Organizing production;

Year Three semester two

Industrial attachment.

Year Four semester One

IRAI 465 Influence-Based Product Design (1, 3, 2)

Designing your product; Design trends, trend prediction, advanced 3-D digital imaging;

Year Four semester Two

IRAI 466 Product Design and Project work (1, 3, 2)

Packaging Design; Advanced 3-D Digital Imaging; Product Presentation

Appendix C: Questionnaire for Students

Questionnaire of the Evaluation of the Teaching and learning of 3-D Computer - Aided Design in the Department of Integrated Rural Art and Industry, KNUST

The research seeks to gain understanding into the teaching and learning of 3-D Computer-Aided Design (Rhino 3-D), its benefits, downsides and the impacts on students works in the Department of IRAI,

Please go through this questionnaire and provide the appropriate responses for each of question prompts.

Absolute confidence is assured and please tick correct answer appropriately in the box provided

Please check, mark [√] or fill in the blanks that best apply for each category below.

Demographics

Gender: Male [ ] Female [ ]

1. Which of these age range do you belong?
- 16-20 [ ] 21-30 [ ] 31-40 [ ] 41-50 [ ] Other (Please Specify) [ ]
2. What is your area of specialisation?
   …….

Perception about CAD

3. When was your first encounter with CAD in product design?
- Pre University [ ] 1st year [ ] 2nd year[ ] 3rd year[ ] 4th year [ ]
4. Rate the usefulness of CAD in your area of study? from 1-5

5	4	3	2	1
excellent[ ]	above average[ ]	average[ ]	below average[ ]	Poor [ ]

5. Can you list some of the modalities that pose the difficulties
- Marks [ ] Competition in the class [ ] Lack of interest in 3-D CAD [ ]
  Lecturers handling 3-D CAD [ ] Because 3-D CAD is difficult [ ]
  Because the teaching is not clear for me [ ]
  Other……...
6. What do you think about 3-D CAD in the product design curriculum?
- The 3-D CAD in the curriculum should be restructured [ ]
- The curriculum should be maintained as it is [ ]
- It should be removed from courses taught [ ]

7. Do you think the objectives of 3-D CAD have been met in the product design course?
- Yes [ ] / No [ ]

8. What difficulties do u encounter in the 3-D CAD integration in product designing?

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

9. What is your preference between traditional methods and 3-D CAD?
- Computer- Aided Design [ ] Both [ ] Traditional methods [ ]

10. What is the design time frame for traditional methods compared to 3-D CAD?
- Faster [ ] Indifferent[ ] Time consuming [ ]

Teaching of CAD

11. What are the challenges you encounter in using the 3-D CAD software in product designing?
- Poor training session [ ]
- Complex interface [ ]
- No challenge [ ]
- Other……...

12. How will you rate the teaching of 3-D CAD in the product design course studied?
- Excellent [ ] Very high [ ] Good [ ] Average [ ] Low [ ]

13. Do you think the teaching periods allocated in the product design course for 3-D CAD adequate?
- Yes [ ] / No [ ]

14. When in your opinion should 3-D CAD be introduced in the Department?
- Year 1 [ ] Year 2 [ ] Year 3 [ ] Year 4 [ ] Not all [ ]

15. The instructor clearly presented the skills to be learned.
- Strongly Agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly Disagree[ ]

16. The instructor effectively presented the tools (e.g. materials, skills, and techniques) needed.
- Strongly Agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly Disagree[ ]

17. The instructor provided meaningful guidance on progress of work and feedback on my 3-D CAD works.
- Strongly Agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly Disagree[ ]

18. The instructor used a variety of instructional methods to reach the course objectives (e.g. group discussions, student presentations, etc.)
- Strongly Agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly Disagree[ ]

19. The course instructions (including, manuals, handouts, etc.) were clear
- Strongly Agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly Disagree[ ]

Learning of CAD

20. What are the 3-D CAD learning methodology you use?
- Departmental course on 3-D CAD [ ]
- Self-teaching of 3-D CAD software [ ]
- Organized private classes on 3-D CAD [ ]

21. 3-D CAD helped me conceptualize and present my ideas in my artistic medium.
- Strongly Agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly Disagree[ ]

22. 3-D CAD increased my interest in the product design course.
- Strongly Agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly Disagree[ ]

Facility and resource availability or Support

23. What do you have to say about resource and technical support regarding 3-D CAD?

    ……
    ……
    ……

    Thank You for Your Time and For Your Valuable Feedback.

Appendix D: Interview Guide for Lecturers

1. Are works produced from product design in line with the vision of improving the indigenous art industry in Ghana?
2. In your opinion, would the skills developed using CAD be of any significant benefit to students in the other subject areas.
3. Would you prefer students had more individual time with hand-on experience of CAD programs?
4. Do you exhibit student work for appreciation?
5. What are the steps you follow in teaching students how to create product design with 3-D CAD?
6. What are some of the problems militating against your 3-D CAD lessons?
7. What do you think is the problem with students as far as 3-D CAD concerned?
8. In your opinion, how has previous and subsequent attitudes of students been towards 3-D CAD project works?
9. Has there been any improvement so far in works produced by students with the introduction of 3-D CAD in product design?
10. In what ways are 3-D CAD product designing changings the ways student produce their practical projects.
11. In what ways is the use 3-D CAD affecting the creativity of students.
12. If you were to be given the mandate to change something with regards to the usage and application of 3-D CAD in product design, what would you change?

Appendix E: Observation Check List

EVALUATION OF THE TEACHING AND LEARNING OF 3-D COMPUTER-AIDED DESIGN IN THE DEPARTMENT OF INTEGRATED RURAL ART AND INDUSTRY, KNUST

Computer laboratory available

Digital technologies available

Design studio

Equipment

Computer Hardware

Software

Learning resources

Teaching resources

Are there materials that guide lecturers in teaching 3-D CAD?

Lecturers teaching strategies observed

Appendix F: Kirkpatrick's levels of evaluation (1998)

Kirkpatrick's levels of evaluation (1998)

Level	Kirkpatrick's examples	Kirkpatrick's examples	Evaluation tools used:
1. Reaction	"evaluation on this level measures how those who participate in the programme react to it" (1998:19)	'Reaction sheet' (1998:25-38)	Questionnaire and interview
2. Learning	'Learning can be defined as the extent to which participants change attitudes, improve knowledge, and/or increase skills as a result of attending the programme' (1998:20)	Use of the sampled group	CAD model analysis Questionnaire Interview
3. Behaviour	'behaviour is the extent to which change in behaviour occurs because the participant attended the training programme' (1998:20)	Use of the sampled group	CAD model analysis Questionnaire Interview
4. Results	'results can be defined as the final results that occurred because the participant attended the programme (1998:23)	use of the sampled group	CAD model analysis CAD model exercise

Source: Kirkpatrick's levels of evaluation (1998)