International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 2, March-April 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Modeling of 2-D Computer Aided Drafting Application for Teaching and Learning Engineering Drawing

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ABSTRACT

With non-availability of the required equipment, teaching engineering drawing to a class of over 1000 students and retaining their interests and attention from the beginning to the end of a lecture period was of big concern to the engineering drawing courses lecturers in the Faculty of Engineering, Nnamdi Azikiwe University, Awka. This work is aimed at designing and developing animated Microsoft Office PowerPoint teaching applications named 2-D Computer-Aided Drafting Applications (2-D CADA) that eliminate this problem. This paper presents a sample of the Applications which demonstrates clearly to the audience's pleasure how to mount, set and hold a drawing sheet on a drawing board before actual drawing commences. It also shows how to manually draw boarder lines on the drawing sheet. Similar programs can be written and used to show to engineering students how to manually draw most of the figures specified in their schools' curricula using engineering drawing instruments. Many of this Application have been written on various topics in engineering drawing in line with the global trend of drudgery reduction in man-machine systems. These Applications are already being deployed in teaching engineering drawing in the Faculty of Engineering, Nnamdi Azikiwe University, Awka, Nigeria. The benefits of employing 2-D CADA in teaching and learning engineering drawing are overwhelming. 2D-CADA relieves a teacher the mental and physical stresses that go with manual production of drawings on a chalk board. It drastically improved the attention, interest and understanding of students during drawing lessons. A well written 2D-CADA can be replicated and deployed to a personal computer for self-study plans as well as to group-based students' workstations for group teaching.

How to cite this paper: Chukwumuanya Emmanuel Okechukwu | Abonyi Sylvester Emeka | Amaefule Desmond Okechukwu "Modeling of 2-D Computer Aided Drafting Application for Teaching and Learning Engineering Drawing" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-2, April 2023, pp.1011-1021, URL: www.ijtsrd.com/papers/ijtsrd55150.pdf

IJTSRD55150

KEYWORDS: *Development, Computer aided drafting, model, and engineering graphics*

1. INTRODUCTION

The world is fast developing. This development comes as a result of man and/or nature providing temporal or permanent means of solving various problems encountered by man in his environment. The roles of engineers in contributing immensely towards providing these solutions will continue to be appreciated. In this regard, an engineer is seen as a "creator", who converts his/her imaginative thoughts into physical realities. Conversion of these thoughts, with possible alternative means of solving or satisfying the identified need(s) of man, involves some physical, chemical and/or other processes. These processes are dependent on the type and nature of the prevalent need(s). Engineers are specialists when it comes to applying the principles, discoveries, experiences, techniques, and methods derived from ages of research, experimentation, trial and error, and invention. It really takes some doing to determine which elements of this vast storehouse of knowledge apply to the situation at hand. Developing the best combination of principles and procedures into a highly desirable plan and/or product is an engineer's business and it is a tough work (Harrisberger, 1982). Engineering, therefore, entails the utilization of materials and forces of nature for the benefit of mankind. A careful look reveals that almost all the physical items: buildings, vehicles, books, roads, food growing and processing, railways, medical care, recreation, etc around us have been created or their creation influenced by some engineers.

Meanwhile, manufacturing of machines and other engineering contrivances requires the prior adequate description of what is to be produced, how it is to be produced and what it should be produced with. Every engineer must have a working knowledge of engineering drawing; the diagrammatic tool and language used for such graphic description. This makes engineering drawing a critical component of engineering education, and its teaching and learning very important activities of any engineering undergraduate curriculum. Producing engineering drawing manually is time-consuming and demands considerable mental and physical tasks input. In computer-aided drafting, the process is usually integrated with computer-aided design (CAD) thereby reducing the drudgery that is greatly encountered in drafting engineering designs.

In Nigerian academic institutions, be it primary, secondary or tertiary, manual method of drawing figures on black or whiteboards during class lessons is the common practice. In higher institutions where engineering drawing is taught as a compulsory course to engineering students and as a borrowed course in some other faculties, the number of students that attend the lectures is usually high, about a thousand per lecture on the average. Unfortunately, there are no enough spaces and personnel to meet up with Nigerian University Commission's minimum bench mark for teaching engineering drawing. Absence of public address systems to assist the resource lecturer aggravates the problem. During manual drawing lectures, the lecturer blocks the views of many students as s/he draws on the board. Besides, there is a limit to the visibility of the drawn objects which the students can see, depending on the student's position, eye conditions and distance from the board. As one moves away from the front seats to the back seats, the lecturer's voice also diminishes. All these pose as problems to many students, making them lose interest in the lecture shortly after commencing. The only students whose interests may last long in a lecture series are the students sitting close to the lecturer and to the board. This problem called for something to be done to capture the interests of the other students in the class who did not enjoy privilege of seating in the front seats.

Therefore, there is the need to deploy a teaching and learning technique that portrays the graphic sequences encountered during engineering graphics production with reduced human efforts and drudgery. Such a computerized technique should afford students access to the program during personal or group study or review. This work is therefore aimed at the modeling for a two dimensional (2-D) computer-aided application (2-D CADA) for teaching and learning of engineering graphics. By achieving this fit, the drudgery involved in drawing an object while teaching will be greatly reduced; the drawing teacher will exert less mental and physical efforts, with reduced fatigue in discharging his/her duties while increasing productivity. The ease of use of a 2-D CADA will also allow students easy recall and review of lessons and images crafted in the slides

2. BRIEF REVIEW OF SOME BASIC CONCEPTS

2.1. Industrial Engineering

From the foregoing, it can be understood that the essence of engineering is to design. One of the areas/branches of engineering that has so much influenced and assisted greatly in improving the standard of living and quality of life of people today is the Industrial Engineering. Industrial engineering has been variously defined in literature. However, only two of the definitions have been adopted for the purposes of this work. Wikipedia, defined industrial engineering as, "a branch of engineering that deals with the optimization of complex processes or systems. It is concerned with the development, improvement, implementation and evaluation of integrated systems of people, money, knowledge, information, equipment, energy, materials, analysis and synthesis, as well as the mathematical, physical and social sciences together with the principles and methods of engineering design to specify, predict, and evaluate the results to be obtained from such systems or processes. Its underlying concepts overlap considerably with certain business-oriented disciplines such as operations management." Depending on the subspecialties involved, industrial engineering may also be known as, or overlap with, operations management, management science, operations research, systems engineering, management engineering, manufacturing engineering, ergonomics or human factors engineering, safety engineering, or others, depending on the viewpoint or motives of the user. For example, in health care, the engineers known as health management engineers or health systems engineers are, in essence, industrial engineers by another name."

According to the Institute of Industrial Engineers, industrial engineering uses the methods of engineering and concepts from the sciences and mathematics in designing production systems, studying quality and improving productivity. Industrial engineers work on all aspects of a system, including data, energy, machines, workers and raw materials. They also predict and then evaluate the outcome of various system designs. Industrial engineering as a discipline of engineering seeks to integrate and maximize the performance of man, machine and materials resources through designing and developing the best processes that improve the overall effectiveness of a given organization.

2.2. Engineering Design

The word design was drawn from the Latin "designare," which means to designate or mark out. Design can be taken to mean all the processes of conception, invention, visualization, calculation, refinement, and specification of details that determine the form of a product. Hence it refers to an object's esthetic appearance, with specific reference to its form or outward appearance as well as its function. George Cox (2005) states in the Cox Review, "Design is what links creativity and innovation. It shapes ideas to become practical and attractive propositions for users or customers. Design may be described as creativity deployed to a specific end." In essence design can be considered to be the process of conceiving, developing, and realizing products, artifacts, processes, systems, services, and experiences with the aim of fulfilling identified or perceived needs or desires typically working within defined or negotiated constraints. This process may draw upon and synthesize principles, knowledge, methods skills, and tools from a broad spectrum of disciplines depending on the nature of the design initiative and activity.

According to Eder WE, Hosnedl S (2008) research activities in design engineering follows at least six parallel paths

- The classical experimental, empirical way of independent observing, e.g., by protocol studies, including self-observation, and impartial observation of experimental subjects, etc., describing, abstracting, recognizing, perceiving, understanding, modeling, formulating hypotheses—observations capture a proportion of thinking, usually over short time spans;
- Participative observation, the observer also acts as a member of the design team and thus acts in the observed process.
- A reconstructive, detective way of tracing past events and results by looking for clues in various places.
- Speculative, reflective, philosophical generating of hypotheses, and testing;
- Transfer between practical experience and the insights of knowledge; and
- Development of not-for-profit products Howard T (2011)

These paths must be coordinated to attain internal consistency and plausibility. The theory and methods outlined here were developed from these paths.

Also Eder WE, Hosnedl S (2010), indicated that the theory should be as complete and logically consistent as possible, and refer to actual and will be applicable to design processes. The design methods are intended to guide more or less experienced engineering designers to assist them when their task reaches beyond their level of expertise, can then be derived, and consider available experience.

Eder WE (2009b), emphasized that the graphic models that are part of the theory can be used as guides to design activity and methods in application must remain voluntary, adaptable, and with guarantee of success. They must be learned, preferably on simplified examples, before they can be used on a problem of any substantial importance.

According to Julier G (2000), if a product is intended to be visually attractive and user-friendly, its form like its observable shape is important. Industrial design tends to be primary for consumer products and durables for it emphasizes the artistic elements, appearance, ergonomics, customer appeal, satisfaction, observable properties of a product. The color, line, shape, form, pattern, texture, proportion, juxtaposition, emotional reactions are mainly observable properties of a tangible product Howard T (2011). The task given to or chosen by industrial designers is usually specified in rough terms. The mainly intuitive industrial design process emphasizes ''creativity'' and judgment, and is used in a studio setting in architecture, typographic design, fine art, etc., Industrial designers can introduce new fashion trends in their products.

Eide *et al* (1986) explained that the end result of an engineering effort - generally referred to as design - is a device, structure, or process which satisfies a need. A successful design is achieved when a logical procedure is followed to meet a specific need. The procedure, called the design process, is similar to the scientific method with respect to a step-by-step routine, but it differs in objectives and end results. The design process encompasses the following activities, all of which must be completed. 1. Identification 2. Definition 3. Search 4. Establishment of criteria and constraints 5. Consideration of alternatives 6. Analysis 7. Decision 8. Specification 9. Communication.

Further still, from engineering point of view, design implies "to prepare the preliminary sketch or the plans for (a work to be executed), especially to work out the structure or form of (something), as by making a sketch, outline, pattern, or plans";"to plan and fashion artistically or skillfully" (*Dictionary.com*, nd.). As stated by the Free On-line Dictionary of Computing (2014), a successful design must satisfy a ("perhaps informal) functional specification (do what it was designed to do); conforms to the limitations of the target medium (it is possible to implement); meets implicit or explicit requirements on performance and resource usage (it is efficient enough). A design may also have to satisfy restrictions on the design process itself, such as its length or cost, or the tools available for doing the design. In the software life-cycle, design follows requirements analysis and is followed by implementation (Grady, 1996)

2.2.1. The Design Process and the Role of Design Model

The Free On-line Dictionary of Computing defines design process as the approach that engineering (and some other) disciplines use to specify how to create or do something. All the engineering products we see around us have either been conceived and created from scratch or have evolved from existing ideas. Either way, an engineering design process will have been followed, in one form or another. In essence, design sequence is usually iterative, progressing from some statement of need to identification or specification of problem; search for solutions to development of solution, manufacture, test and use. The approach repeats until a satisfactory solution is achieved. The Design as a generic tool module provides an interesting and comprehensive introduction to engineering and design, so a detailed discussion of the design process will not be included here.

Heroux, Turner, & Pellegrini, (2010), stated that students learn more and be more engaged when learning with an engineering design perspective hence role of design model cannot be over emphasized. And Coryn, Pellegrini, Evergreen, Heroux, & Turner, (2011) explained that students who are taught with engineering design can become more self-motivated, and the effectiveness of the instruction increases when students are more involved in their learning, hence engineering design places the student in the role of scientist/engineer. The student is the scientist/engineer.

If students are not well drilled in engineering design it will result in graduating half-baked students who cannot work effectively in engineering environment Cooper (2013). Hence engineering design qualifies the students to take the position of scientist/engineer, a very engaging perspective for the student, which results in the greater student's achievement. The use of engineering design based on its ability to foster learning at a deeper level, increasing scientific literacy and empowering portions of the population that are historically underrepresented in science and engineering fields Metz (2014).

As published by wikipedia, the free encyclopedia, "Industrial design is the use of both applied art and applied science to improve the aesthetics, design, ergonomics, functionality, and/or usability of a product, and it may also be used to improve the product's marketability and even production. The role of an industrial designer is to create and execute design solutions for problems of form, usability, physical ergonomics, marketing, brand development, and sales (de Noblet, 1993). Although the process of design may be considered 'creative,' many analytical processes also take place. In fact, many industrial designers often use various design methodologies in their creative process. Some of the processes that are commonly used are user research, sketching, comparative product research, model making, prototyping and testing. These processes are best defined by the industrial designers and/or other team members. Industrial designers often utilize 3D software, computer-aided industrial design and CAD programs to move from concept to production. They may also build a prototype first and then use industrial CT scanning to test for interior defects and generate a CAD model. From this the manufacturing process may be modified to improve the product. ... Industrial design may also focus on technical concepts, products, and processes. In addition to aesthetics, usability, and ergonomics, it can also encompass engineering, usefulness, market placement, and other concerns—such as psychology, desire, and the emotional attachment of the user. These values and accompanying aspects that form the basis of industrial design can vary—between different schools of thought, and among practicing designers." (An excerpt from Wikipedia, "Industrial Design", 2014)

After the needs of the customers have been identified, they are translated into technical specifications and the product is designed based on the functional/operational, quality, reliability and cost considerations. The outcome of the product final design and the information obtained from research and development (R&D) are presented in the form of part and assembly drawings and bill of materials (BOM), which serve as input to the process design stage. At the process design stage, the method of manufacture of the product, the type and sequence of operations, tools and equipment required for the manufacture of the product are determined and established.

2.3. Engineering Drawing

Engineering drawing is the common language of engineering and describes the process of creating drawings for any engineering or architectural application. Engineering drawings, produced according to accepted standards and format, provide an effective and efficient way to communicate specific information about design intent. Engineering drawings are typically not open to interpretation like other drawings, such as decorative drawings and artistic paintings. A successful engineering drawing describes a specific item in a way that the viewer of the drawing understands completely and without misinterpretation, David A. Madsen (2011).

In his own definition, Dhawan (2006) sees engineering drawing as the art of representing engineering objects such as buildings, roads, machines etc. on a paper. The term engineering drawing is also known as drafting, engineering drafting, mechanical drawing, mechanical drafting, technical drawing, and technical drafting. Drafting is a graphic language using lines, symbols, and notes to describe objects for manufacture or construction. Most technical disciplines use drafting, including architecture, civil and electrical engineering, electronics, piping, manufacturing, and structural engineering. The term mechanical drafting has alternate meanings. The manufacturing industry uses mechanical drafting, with its name derived from mechanisms. The construction industry also uses mechanical drafting, but the term refers to drafting heating, ventilating, and air-conditioning (HVAC) systems, which is the mechanical portion of an architectural project. You will learn about drafting common to other disciplines later in this chapter. Manual drafting is a term that describes traditional drafting practice using pencil or ink on a medium such as paper or polyester fi lm, with the support of drafting instruments and equipment. Computer-aided drafting (CAD) has taken the place of manual drafting. CAD uses computers for drafting. CAD also refers to computer-aided design when computers are used to design. Engineering drawings communicate a variety of concepts, such as engineering requirements, instructions, and proposals, to a variety of people, such as the many different individuals often involved with a project. An engineering drawing or a complete set of engineering drawings provides all of the data required to manufacture or construct an item or product, such as a machine part, consumer product, or structure David A. Madsen (2011).

The subject of engineering drawing can be categorized from the engineering point of view as follows: 1) Geometric drawing, consisting of plane geometric and solid geometric drawings 2) Mechanical engineering drawing 3) Civil engineering drawing 4) Electrical & Electronics engineering drawing, among others.

2.3.1. The Role/Importance of Engineering Drawing

One of the biggest wrong questions many students usually ask is, "Why passing through the rigorous trainings in engineering drawing practice, instead of focusing on entrepreneurship knowledge?" This question is wrong for obvious reasons. As earlier said, manufacturing of machines and other engineering contrivances requires the prior adequate description of what is to be produced, how it is to be produced and what it should be produced with. More so, before producing an item, the designer needs to design the shape of the product, the shape and model of the wrapper product, the symbols, and any other requirements in the designing of the product. Therefore, every engineer must have a working knowledge of engineering drawing - the diagrammatic tool and language used for such graphic description. This makes engineering drawing a critical component of engineering education, and its teaching and learning very important activities of any engineering discipline's undergraduate curriculum.

Engineering Drawing is one of the subjects in Industrial Engineering that assist/support and equip industrial engineers. Literally, Engineering Drawing is a bright, clear, and precision language used at design stage to visualize a conceived idea about an object, to communicate the idea to others, and to analyze and solve problems associated with the product design. The graphical representation of an object and its structure can be done by freehand sketching (or model drawing) and/or by instrument drawing (including the use of computers as in Computer aided design/drafting (CAD/CADD), etc). Graphics in drawing applications play the role of visualization, communication and makes documentation easier and sustainable.

The main purpose of the engineering drawing in industrial engineering is to impact in the engineering student the ability/skill to read/interpret an engineering drawing made on the components of a designed machine or any other product of manufacturing activity. The most important thing in studying "engineering drawing" is training ourselves on how we can imagine the shape of real life objects existing in the picture form; we also determine the size and give dimensions to the object by proportionate drawing and scaling. Besides, our knowledge of engineering drawing enhances our ability to collect information, generate/ conceive/enhance an idea(s) and to visualize a design.

Meanwhile, Akah *et al.* (2021) reported that manual drafting should be used simultaneously with computer-aided design (CAD) as a fundamental tool in training of undergraduate architecture students. They argued that CAD is only a physical tangible tool which transforms the abstraction of the user into reality on the paperless board just like the old traditional methodology of drafting does too. Manual teaching of engineering drawing is cumbersome and involves a lot of drudgery. McLaren (2008) reported heavy time and energy consumption in the teaching and learning of technical drawing traditionally in most Nigerian universities as a result of the manual equipment used. Inculcating the basic engineering drawing rudiments and skill is necessary for its proper preparation and use. Efficiency and effectiveness are important parameters in assessing any process. Reffold (1998) used a skill-testing technique and group-based students' workstations in teaching CAD drawing to Cranfield University undergraduate students. The students were allowed after lectures, computerized access to the lessons instruction and practice problems via the group workstation. The arrangement was deployed in conjunction with the introduction of an in-house developed self-learning text for 2-D drawing instruction. The students were reported to have enjoyable and easy learning of engineering drawing and achieving good performance approach.

3. MATERIALS AND METHODS

3.1. Materials

Chief traditional instruments used in manual engineering drawings (model drawings) include: drawing board, Tee square, pencils, eraser, set squares, French/flexible curves, scales and paper tapes/clips. 2-D drafting models in this work are computer based and virtual applications and the chief material items used in their development include a PC installed with Microsoft Office PowerPoint ©, high virtual resolution, high RAM capabilities, cam camera and good quality audio set - a microphone and a loudspeaker(s), a projector and a white screen.

3.2. Methods

3.2.1. Model drawing

Figure 1 depicts an example of how drawing in engineering assists in the design and manufacture of a simple crank mechanism. In the figure, the connecting rod, AB, is constrained to pass through a guide at C. The crank, AO, is fixed at one end, O, and rotates with the driving shaft. It is required to draw the locus of the end B and of a point P on the connecting rod for a complete revolution of the crank. AB = 200 mm, OA = 40 mm, OC = 130 mm and AP = 85 mm.

Figure 2 shows how the loci of the given points are drawn in the mechanism design. First, the outline of the given mechanism is drawn as per the given conditions. Procedure adopted in drawing Figure 2 include: **Step 1**: Draw a circle of radius, **AO** = 40 mm and divide it into twelve equal parts and number as shown in the figure. **Step 2**: Mark off a distance of 130 mm from **O** to obtain point **C** and draw a line from each of the numbered points ***A', 1, 2, ...,12*** to pass through point **C** (the guide). **Step 3**: Mark off distances equal to **AP**, 85 mm, from these numbered points moving towards the direction

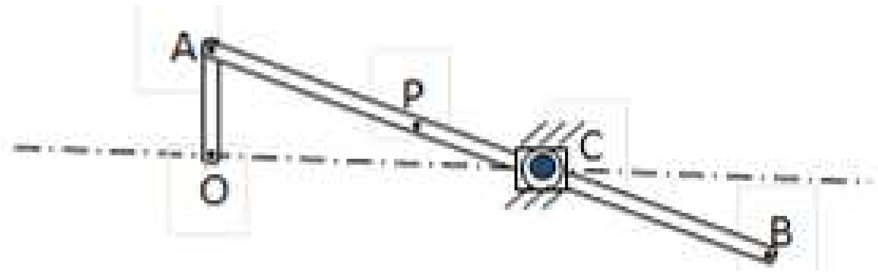


Figure 1: Crank mechanism

of point **C** to obtain points ***1', 2'', ..., 12'***. **Step 4**: Draw a smooth curve through points ***A', 1', ..., 12'***. This curve depicts the locus of point ***P*** as the crank makes a complete revolution. By similar approach, the locus of point **B**, the end of the connecting rod is drawn. Note that the dimensions of the various elements of the mechanism can be determined by means of the drawing.

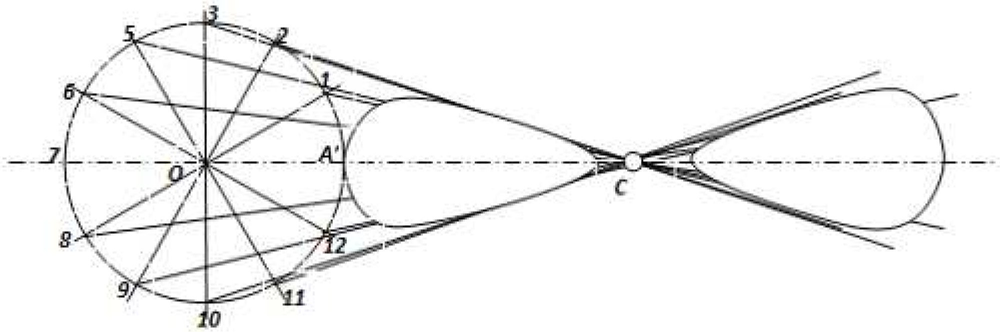


Figure 2: Loci of the required moving points on the given mechanism

Advantages which CADD has over manual drawing include: 1. *At the drafting stage**:** **i.*** Increased drawing speed and accuracy, ***ii.*** Easy manipulation and reversibility ***iii.*** Availability of drawing libraries (documentation). 2. *at the design stage*: ***i.*** Availability of built-in various analysis tools ***ii.*** Easy visualization/presentation - pan, shade, texture, animate, rotate etc.

3.2.2 Development of 2-D drafting models

Microsoft Office PowerPoint Toolbars provide different tools such as insert, draw, delete, import, group, animate object commands for use in creation of different PowerPoint presentations objects.

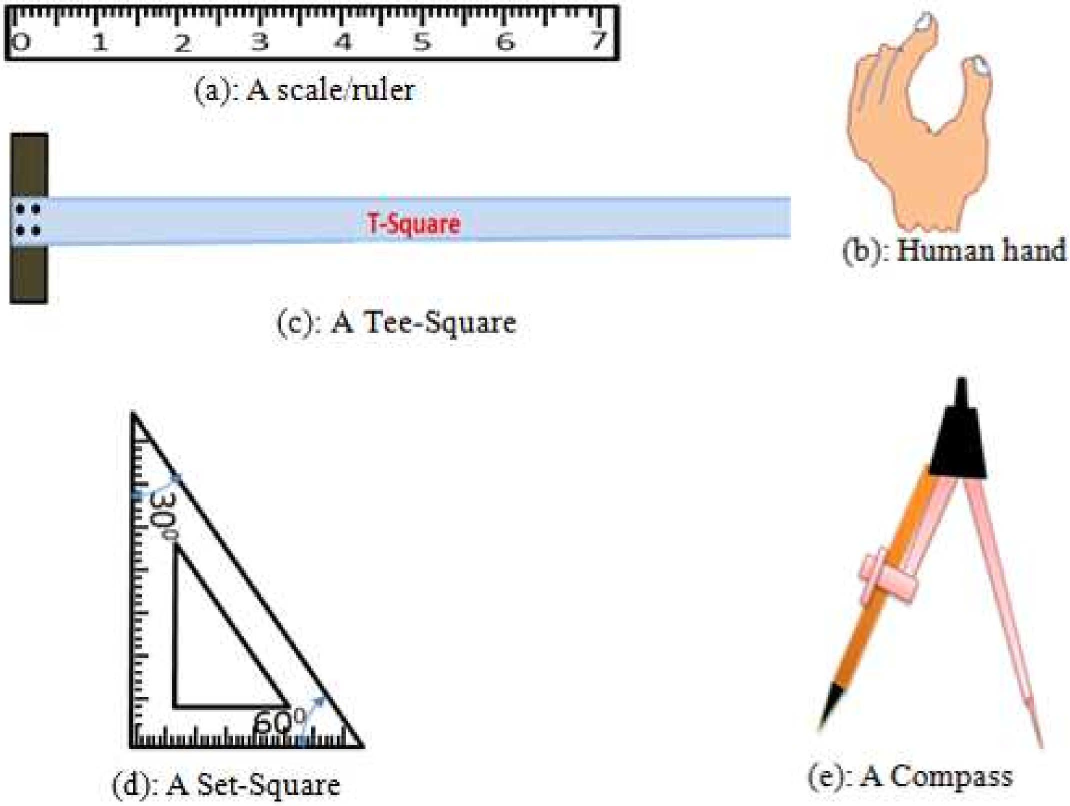
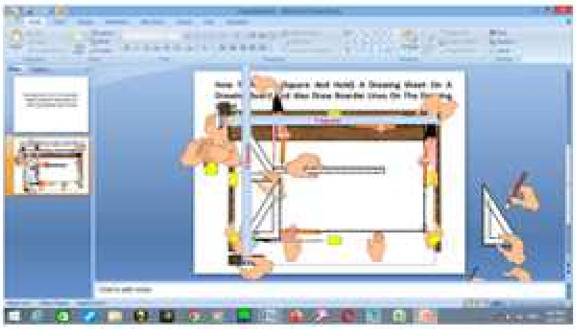


Figure 3: Different 2-D images created as 3-D objects using symbols taken from the Insert menu of MS-PPt © 2007 version to represent the real engineering drawing tools and instruments.

This property enables useful objects from different file formats to be imported into Microsoft Office PowerPoint (MS PPt) environment as part of the 2-D drafting tools. Some of the two dimensional (2-D) objects in the Shapes Menu of the Insert Command were selected and used in building the virtual blocks presented as the drawing instruments in this work. These blocks were manipulated to assume the desired drawing instruments shapes. See Fig 3: (a) - (e). Fig 4a depicts the MS PPt environment and the 2-D CADA virtual drawing instruments in their design static positions. Fig 4b also shows the MS PPt environment with the Custom Animation pane displaying. The animation commands are arranged in steps as contained in the pane to make the 2-D CADA drawing tools of Fig 4a mimic the basic steps employed in traditional methods of generating drawings manually. This enabled the produced images to move or slide virtually according to some predefined orders, showing a comprehensive demonstration of the drawing techniques employed in drawing a desired figure.



a: 2-D CADA drawing elements before animation

b: 2-D CADA drawing elements after animation

Figure 4: The 2-D CADA drawing elements meant to mimic the basic steps in manual process of mounting a drawing paper on a drawing board and drawing the margin/boundary lines on it

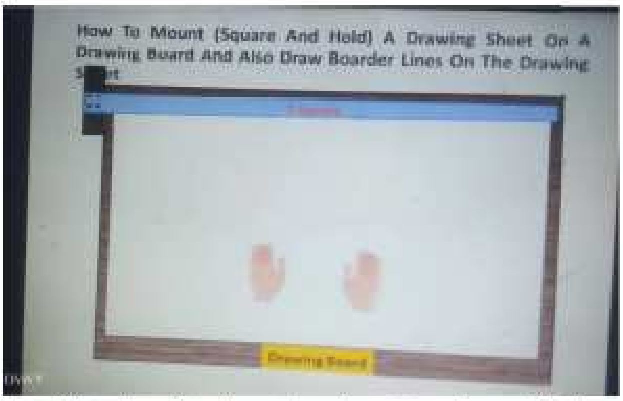
The power point presentation of the demo is then projected on a screen for all the students to see. Audio explanations of the processes in producing the required drawing are given. Public address system will be needed for a large class. The entire presentation can be replicated and deployed to a personal computer as well as to group-based students' workstations.

4. Results and Discussion

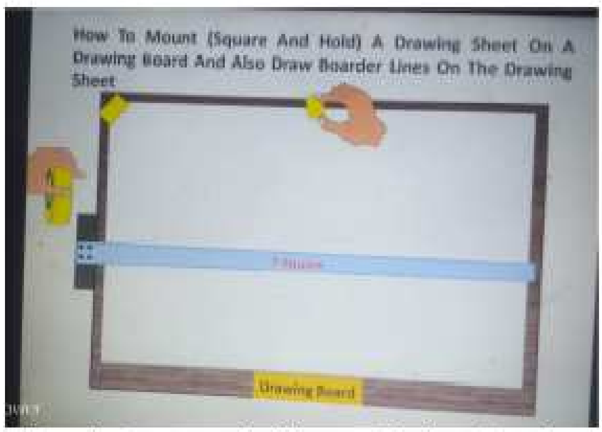
As a sample demo, the 2D-CADA was made to draw boarder lines on a drawing paper displayed in the computer screen. The computer screen was shot at intervals of time as the demo ran. The demo shots are shown in Figure 4: (a) – (i). Fig 4a shows the CADA drawing board; Fig 4b shows a drawing sheet being placed on the drawing board. Other parts (Figs c to h) of Figure 4 contain self-explanatory notes. Various versions of this application for drawing different figures have been developed and deployed in teaching engineering drawing courses, namely Engineering Drawing I (FEG 213) and Engineering Drawing II (FEG 214) in the Faculty of Engineering, Nnamdi Azikiwe University Awka. Students' interests and attention were always aroused and sustained throughout the lecture/teaching sections. Also lecturers handling the courses were relieved of the drudgery involved in drawing figures on the chalk board.

a: 2-D CADA drawing board

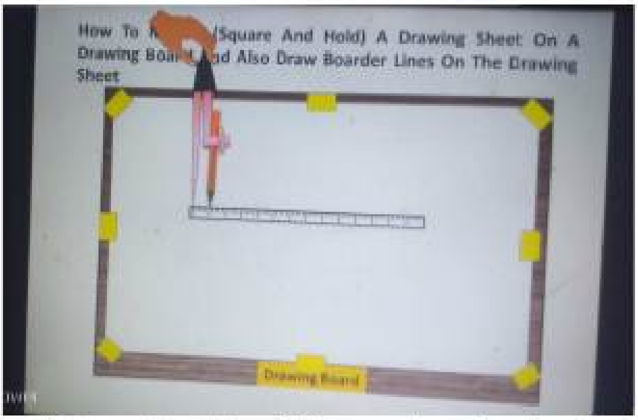
b: Mounting a drawing sheet on the 2-D CADA drawing board



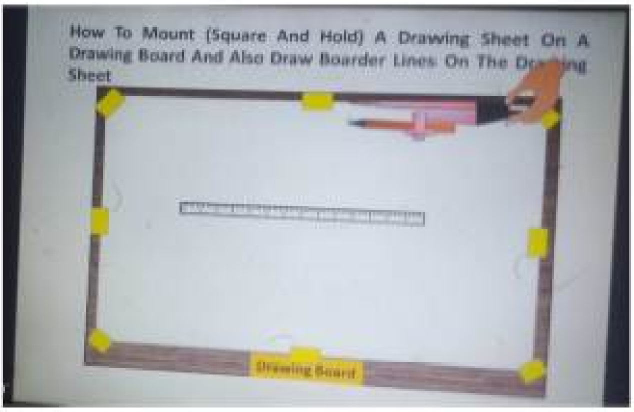
c: Adjusting the drawing sheet to align with the top edge of the 2-D CADA T-square



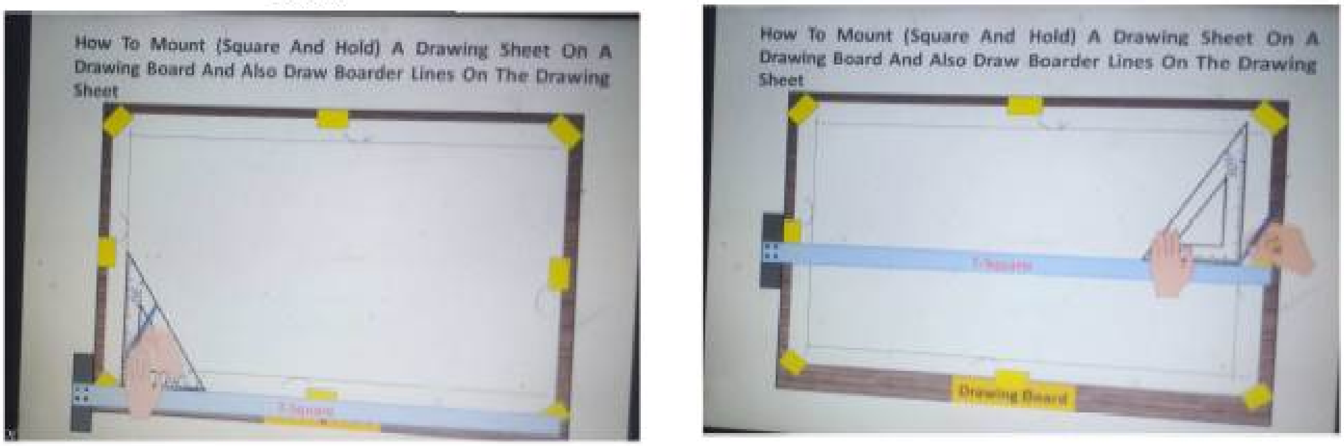
d: Applying paper holders on the drawing sheet on the 2-D CADA drawing board



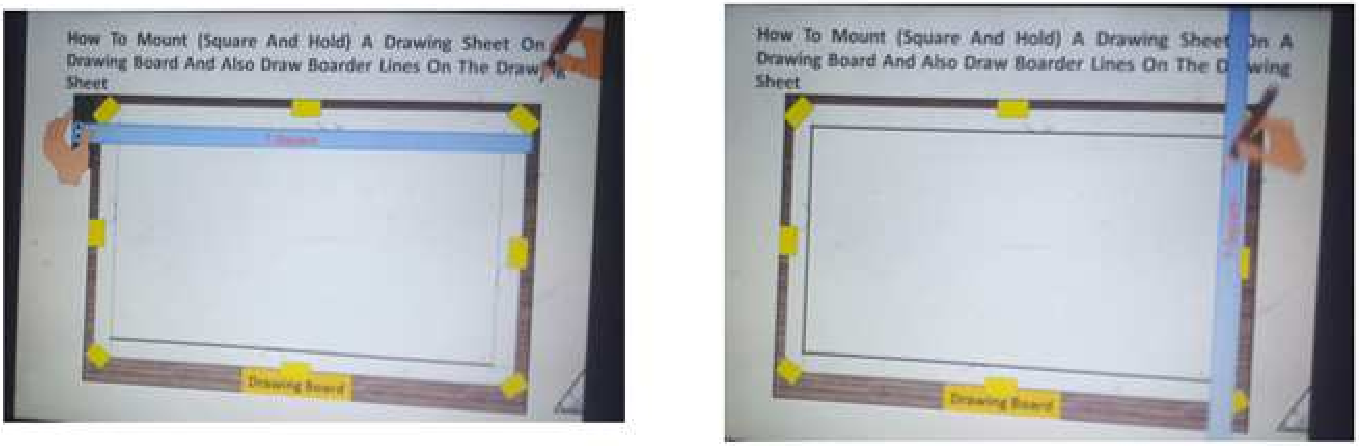
e: Determining size of the margin on the drawing sheet



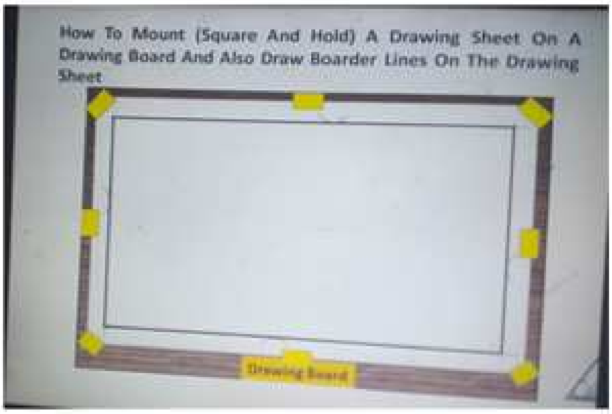
f: Marking off sizes of the margins on the drawing sheet



g: Drawing the boarder lines on the drawing sheet



h: Defining the actual outlines of the boarder lines on the drawing sheet



i: Boarder lines drawn by the 2-D CADA

Figure 4: Stages in the process of drawing a border line by the 2-D CADA

Capabilities of the developed and deployed 2-D CADA include following:

- ➢ It uses its 2-D models to represent 3-D drawing instruments and materials as depicted in Figure 3.
- ➢ Its elements can be made to mimic the actions taken by physical drawing instruments during traditional drawing tasks. Snap shots of the paths traced by CADA drawing tools are presented in Figure 4.
- ➢ It relieves a teacher the mental and physical stresses that go with manual production of drawings on the chalk board.
- ➢ Its drawing objects can be deployed to show how a given figure can be drawn manually when they are activated to mimic the use of tangible drawing instruments in real life situation.
- ➢ It can quickly attract the attention, deepen the interests and improve the understanding of students during drawing lessons.
- ➢ Voice note can be introduced and blended with its demo presentations.
- ➢ It can be replicated and deployed to a personal computer for self-study plans as well as to group-based students' workstations for group teaching.
- ➢ By claim VIII, deployment of a 2-D CADA model allows for a remote teaching and/or learning of drawings.

5. Conclusion

In summary, Engineering Drawing is a universal language of engineers. Foregoing discussions reveal that the role of drawing and design in solving engineering problems cannot be overemphasized. David A. Madsen (2011), published the six uses of the act of drawing as follows: 1. To archive the geometric form of the design. 2. To communicate ideas between designers and between the designers and manufacturing personnel. 3. To act as an analysis tool. Often, missing dimensions and tolerances are calculated on the drawing as it is developed. 4. To simulate the design. 5. To serve as a completeness checker. As sketches or other drawings are being made, the details left to be designed become apparent to the designer. This, in effect, helps establish an agenda of design tasks left to accomplish. 6. To act as an extension of the designer's short term memory. Designers often unconsciously make sketches to help them remember ideas that they might otherwise forget. It should be noted that a good engineering drawing of a given item/component must clearly and completely give all the vital information required for the part's manufacture. And to create such a drawing, the proper line weights and styles, necessary views and proper places of dimensions, and where necessary, the appropriate section techniques should be selected and applied. More so, even though using CADD software in drawing makes a better drawing presentations, it should be noted that a designer or draftsman making use of the software will not achieve this fit without understanding and applying the basic drawing concepts.

Finally, modeling for development of 2-D computer aided applications meant to assist instructors in teaching art of engineering or technical drawing/graphics in our schools, seminars and workshops has been reported in this work. Different versions of this model application have since been developed and deployed in teaching engineering drawing courses in the Faculty of Engineering, Nnamdi Azikiwe University, Awka. These computer aided drafting applications have solved a number of serious problems encountered in teaching engineering drawing as a general course in the said faculty. One of such problems was attending to a class of over 1000 students/audience at a sitting in a manual drawing lesson. By developing and deploying 2-D CADAs during engineering drawing lectures, the course lecturers were relieved of the strenuous efforts expended in manual methods of drawing engineering figures specified in the school's curricula, students got more attentive in class and many developed interested and love for engineering drawing.

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