

Comparative effects of two and three dimensional methods of graphics in AutoCAD on spatial ability of national diploma students in engineering graphics

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Abstract

This study was designed to determine comparative effects of two and three dimensional methods of graphics in AutoCAD on National Diploma students' spatial ability in engineering graphics. The study was a pretest, posttest, non-equivalent control group quasi-experiment which involved groups of students in their intact classes assigned to treatment groups. Two research questions and three hypotheses, tested at 0.05 level of significance, guided the study. The sample size was 227 ND I mechanical engineering technology students in the polytechnics in the south-west geo-political zone of Nigeria from which 108 students constituted treatment groups assigned to AutoCAD 2D method, and 119 students constituted another treatment groups assigned to AutoCAD 3D method. The instruments used for data collection was Purdue Visualization of Rotation Test (PVRT). Mean and ANCOVA were used to analyzed the data collected. The study found out that AutoCAD 3D method is more effective for improving students' spatial ability in engineering graphics than AutoCAD 2D method. There was a significant effect of Gender on students' spatial ability in engineering graphics favouring males. The study found no significant interaction effects of AutoCAD methods and gender on spatial ability of National Diploma students in engineering graphics. Hence, irrespective of nature of gender, learners will record improved spatial ability in engineering graphics when AutoCAD 3D method is employed for teaching.

Keywords: AutoCAD (2D and 3D) methods; National Diploma Students; Engineering Graphics, Computer-Aided Design (CAD), Spatial Ability.

Introduction

Engineering graphics is one of the core courses for National Diploma students studying mechanical engineering technology in the Nigeria Polytechnics. Engineering graphics involves construction of different geometric figures and shapes, orthographic projections, orientation of objects in space, developments of objects and intersections of regular solids and planes (National Board for Technical Education (NBTE), 2003). These contents of engineering graphics facilitate the development of skills related to technical graphics, design/drafting concepts, creativity, and spatially related problem-solving abilities in the students.

Over the years, demonstration with drawing instrument on the chalkboard is predominantly used by lecturers to teach engineering graphics to National Diploma students in the Polytechnics. Apart from the fact that demonstration method is teacher-centred, it does not provide students with learning environment that facilitates better understanding of spatial properties and relationship of objects and space. Another major limitation of

demonstration method is the problem of presenting three-dimensional spatial information in its two-dimensional format (Mackenzie and Jansen, 2005). Accordingly, many students taught graphics with the method have difficulty in comprehending the graphics representation of three-dimensional objects (Scribner and Anderson, 2005). Spatial visualization is an established element of engineering graphics and is integral for success in graphics and engineering as a whole (Strong and Smith, 2002). Recent attention to spatial ability in engineering graphics, according to Basham (2007), is largely due to the vast changes in computer technology and computer-aided design (CAD) software packages. Well-known among the CAD packages available for graphics design in Nigeria is AutoCAD. The need to develop mechanical engineering technology students' spatial ability in engineering graphics has necessitated NBTE to include courses on CAD into the mechanical engineering technology curriculum and introduced AutoCAD to be used for teaching engineering graphics in Nigeria Polytechnics.

AutoCAD is an interactive drafting software package developed in the early 1980s by Autodesk incorporation for construction of objects on a graphics display screen. One aspect of AutoCAD and as in many other CAD software is that geometric construction relies on the understanding of the Cartesian Systems (2D and 3D) and the ability to relate it to objects in space. The 2D and 3D Cartesian coordinate systems, commonly used in mathematics and graphics, locate the positions of geometric forms in 2D and 3D space respectively. This system was first introduced in 1637 by a French Mathematician, Rene Descartes. The coordinate geometry based on these systems theorize that for every point in space, a set of real numbers can be assigned, and for each set of real numbers, there is a unique point in space (Bertoline and Wiebe, 2005). The 2D coordinate system locates the positions of geometric forms in 2D space using absolute coordinate (x,y) , relative coordinate $(@x,y)$ and polar coordinate $(@distance, angle)$. The 3D coordinate system locates the positions of geometric forms in 3D space using absolute coordinate (x,y,z) , relative coordinate $(@x,y,z)$, spherical coordinate $(@ distance < angle < angle)$ and cylindrical coordinate $(@distance < angle, distance)$

The two-dimensional (2D) and the three-dimensional (3D) Cartesian coordinate systems are the methods of graphics for locating the positions of geometric forms in AutoCAD 2D and 3D space respectively. Specifically, the two-dimensional (2D) method in AutoCAD involves the use of two-dimensional Cartesian coordinates system for graphics construction in AutoCAD whereas, three-dimensional (3D) method in AutoCAD involves the use of three-dimensional Cartesian coordinates system for graphics construction (Bertoline and Wiebe, 2005; Finkelstein, 2002). With these two methods of graphics in AutoCAD, users of AutoCAD have option of using any of the two methods for graphics construction to achieve the same tasks. Construction of geometric figures with the Cartesian systems provides learning environment that facilitates better understanding of spatial properties, and relationship of objects and space, and provides students with cognitive abilities associated with visual imagery, as well as the ability to perceive number and space configurations. According to Lemut, Pedemonte and Robotti (2000) construction of objects in AutoCAD promotes a deep understanding of

the meaning of geometric construction in that, during construction process, students have to think about the definitions, properties of the geometric figures and geometric relationships with space.

In addition, before the advent of Release 10 version of AutoCAD, it was a fully self-contained two-dimensional CAD software. The advent of Release 10 capable of 3D coordinate system marked a remarkable turning point in AutoCAD methods and applications (Texas Academic and Management Consult, 2000). With this development, AutoCAD software package has both two-dimensional and three-dimensional methods of graphics and capable of applications such as animation, solid modeling and virtual reality. According to Strong and Smith (2002) the impact of high performance rendering and animation software, solid modeling packages, virtual reality, and online testing opens a number of doors for spatial visualization research and measurement.

Spatial ability is the intellectual ability primarily used to function and operate in 2- or 3-dimensional space (Bannatyne, 2003). It is a cognitive function that makes it possible for human being to deal effectively with spatial relations, visual-spatial tasks and orientation of objects in space (Sjolinder, 1998). Basham (2007) refers to spatial ability as one of the human intelligences used to formulate mental images and manipulate the images in the mind. One of the widely publicized aspects of spatial ability is the apparent differences between genders. Gender, refers to a psychological term, which describes behaviours and attributes expected of individual on the basis of being a male or a female (Uwameiye and Osunde, 2005). Several studies (Nemeth and Hoffmann (2006), Burin, Delgado and Prieto (2000), and Medina, Gerson and Sorby (2000) conducted on gender differences in spatial ability have shown measurable differences in spatial ability of male and female. Generally, most of the studies found out that male have better spatial ability than female. However, Branoff (1998) pointed out that females could benefit as well as males from spatial training programs. Besides, research findings by Keller and Hart (2002), Kaufmann, Steinbugl, Dunser and Gluck (2005) and Baldwin and Hall-Wallance (2001) have indicated that spatial ability can be improved in both children and adult. A potential benefit of improving spatial ability is the improvement of students' achievement in areas of mathematics, engineering and sciences (Mohler, 2006; Baldwin and Hall-Wallance, 2001).

With the adoption of AutoCAD for improving National Diploma students' spatial ability in engineering graphics, many polytechnics have AutoCAD laboratory, and engineering graphics lecturers in the Polytechnics in Nigeria have been trained in the use of the 2D and 3D methods of graphics in AutoCAD as part of Information and Communication Technology (ICT) initiatives for academic staffs' development. It is deemed necessary that engineering graphics lecturers in all Polytechnics in Nigeria adopt the methods of graphics in AutoCAD for teaching their students. However, there is dearth of empirical data on the effectiveness of AutoCAD (2D and 3D) methods of graphics on the spatial ability development of students in engineering graphics in Nigeria, which could serve as a directive to engineering graphics lecturers and other educators. The differences in the use of 2D and 3D methods in AutoCAD may have different effects on students' spatial ability development when learning

engineering graphics. According to Gall, Gall and Borg (2008) education might be greatly improved if more efforts were made to match instructional methods and programs with the students who are best able to learn from them. Hence, what are the comparative effects of AutoCAD (2D and 3D) methods on National Diploma Students' spatial ability in engineering graphics?

Purpose of the Study

The major purpose of this study was to determine comparative effects of two and three dimensional methods of graphics in AutoCAD on spatial ability of National Diploma students in engineering graphics. The study also determined the effect of gender on the spatial ability test scores of students (male and female) taught engineering graphics with AutoCAD (2D and 3D) methods.

Research Questions

The following are the research questions formulated for this study:

1. What is the effect of using AutoCAD (2D and 3D) methods of graphics in teaching engineering graphics on students' spatial ability?
2. Is there effect of Gender on the spatial ability test scores of students (male and female) when taught engineering graphics with AutoCAD methods of graphics?

Research Hypotheses

The following null hypotheses tested at .05 level of significance guided this study:

HO₁: There is no significant difference between the main effect of treatments (AutoCAD 2D and 3D) methods of graphics on students' spatial ability in engineering graphics

HO₂: There is no significant difference between the main effect of gender (male and female) on students' spatial ability in engineering graphics

HO₃: There is no significant interaction effect of treatments given to students taught with AutoCAD and their gender with respect to their mean scores on the spatial ability test

Theoretical Framework of the Study

Cognitive Interaction learning theories is a means of understanding the learning process for improving students' spatial ability with AutoCAD methods. The cognitive interaction learning theory and experiential learning theory are very closely related. The interactive exchange of action and feedback from the AutoCAD provides a students-centred interactive learning environment (Figure 1).

The cognitive interaction learning theories assert that learning occurs when cognitive function interacts with the meaningful psychological environment around it. There are two forms of cognitive interaction theories namely: linear and field (Bandura, 1993). The linear and field forms of the cognitive interaction theory are very similar in nature. The linear form of cognitive interaction beliefs that perception and behavioural changes (learning) occur in sequence; while the field version of cognitive interaction states that there is a simultaneous interaction occurring between the learner and their psychological environment (Bigge and Shermis, 1998). This theory could explain the phenomena of the quick learning that children exhibit with video games. The theory indicates that the learner actually learns by doing and

adapting to new conditions and perceptions. The same conditions would apply to the learner using AutoCAD (2D and 3D) methods, animation and solid model in a virtual environment provided with AutoCAD.

Learning by doing provides the interaction that is present in the interaction learning theory. As shown in the Figure 1, if the learner is able to interact with the computer by specifying coordinate either in 2D or 3D, view animation and solid model in AutoCAD, then according to the cognitive interaction theory, by extrapolation the learner should be able to improve depth perception and increases conceptual ideas through the development of mental models which in turn improve his/her spatial ability. The interaction between the learner and AutoCAD methods and the animation provide immediate information to each other. When the learner key in the coordinate of points, and controls the animation in AutoCAD, AutoCAD provides the learner with immediate feedback allowing the learner to see the results of his actions. The learner is then able to gain knowledge through experience. The function of the teacher in this model is to help control the learning situation and to act as a learning model for the student. The teacher is able to evaluate the action/reaction of the learner and provide the necessary stimulus for the continued experience of the learner.

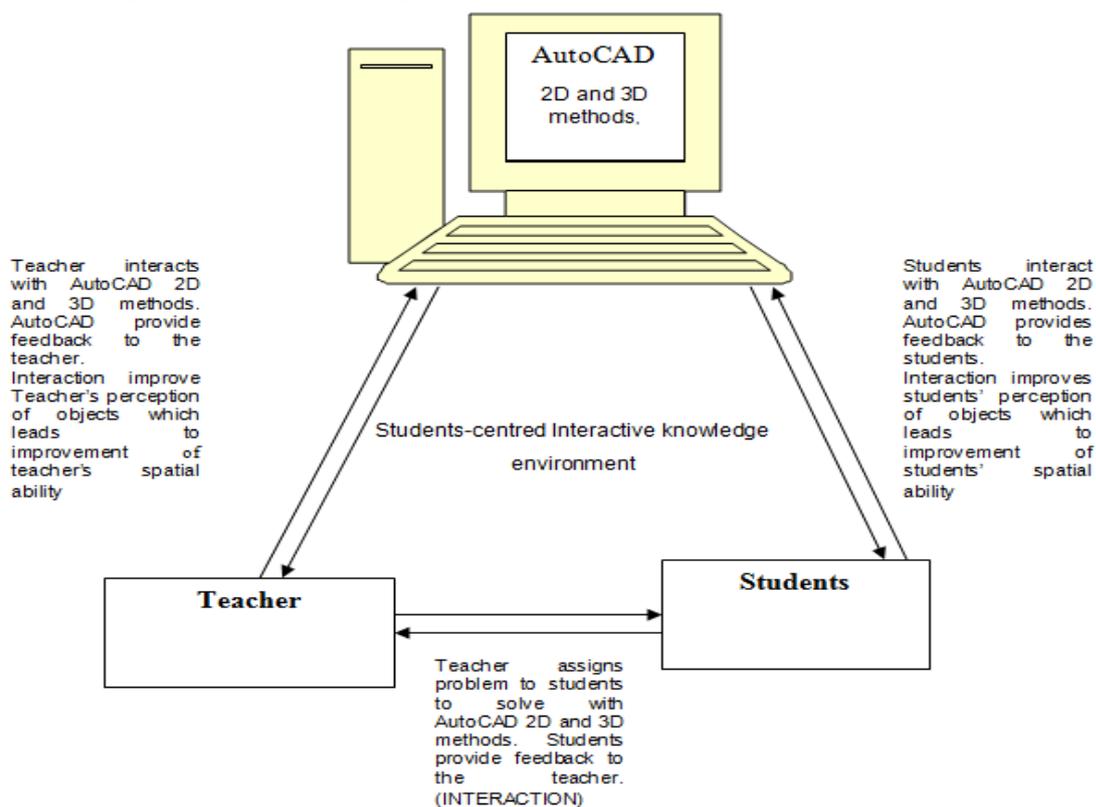


Figure 1: Schematic diagram of the theoretical framework of the study.

Research Method

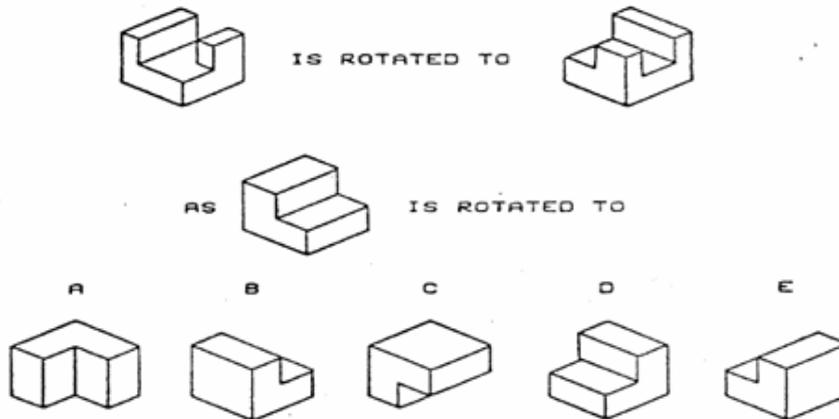
The study adopted the quasi-experimental research design. The non-randomized pretest posttest control group design was used. The study was conducted in NBTE accredited polytechnics offering mechanical engineering technology in South-West Nigeria. The sample size was 227 ND I mechanical engineering technology students. Non-proportionate stratified random sampling technique was used to select two Federal and two State polytechnics.

Each of the Federal and State Polytechnics was randomly assigned to the treatment conditions. 108 students (98 male and 10 female) constituted the treatment group assigned to AutoCAD 2D Method, while 119 students (108 male and 11 female) constituted the treatment group assigned to AutoCAD 3D method. Purdue Visualization of Rotation Test (PVRT) developed by Bodner and Guay (1997) was adopted as instrument for data collection. Permission to use the test was granted free by the test developer. The PVRT consisted of 20 multiple choice items designed to test how well students can visualize the rotation of objects. In each question, The instruction on the PVRT tells the student to: (1) study how the object in the top line of the question is rotated, (2) picture in their mind what the object shown in the middle line of the question looks like when rotated in exactly the same manner, and (3) select from among the five drawings (A, B, C, D, or E) given in the bottom line of the question the one that looks like the object rotated in the correct position (Figure 2). To restrict analytical processing, a time limit of 10 minutes was strictly enforced for the 20-items version of the test as recommended by the test developers. Construct validity of PVRT had been established (Bodner and Guay). The reliability for the PVRT was reported by Bodner and Guay, to have test values of .80, .78 and .80 for samples of 757, 850, 1273, respectively using Kuder Richardson 20 Internal consistency test and Split Half reliabilities were reported of .83, .80, .84, .85, .82 and .78 for samples of 757, 850, 127, 1273, 1648 and 158 respectively. However, to account for varied cultural and social context a trial test was carried out on the PVRT for determining its reliability coefficient in Nigeria. The PVRT was administered on equivalent sample of ND1 Mechanical engineering technology students in a Polytechnic in North-central geo-political zone of Nigeria. Split Half reliability was computed to be .82 for sample of 39. The data collected with the PVRT were analyzed using Mean, to answer the research questions while ANCOVA was used to test the three hypotheses formulated to guide this study at 0.05 level of significance.

Do NOT make any marks on this exam.
Mark your answers on the separate answer sheet

DIRECTIONS

This test consists of 20 questions designed to see how well you can visualize the rotation of three-dimensional objects. An example of the type of question included in this test is shown below.



For each question, you should:

- I. Study how the object in the top line of the question is rotated.
- II. Picture in your mind what the object shown in the middle line of the question looks like when rotated in exactly the same manner.
- III. Select from among the five drawings (A, B, C, D, or E) given in the bottom line of the question the one that looks like the object rotated in the correct position.

What is the correct answer to the example shown above?

Answers A, B, C, and E are wrong. Only drawing D looks like the object after it has been rotated. Remember that each question has only one correct answer.

Figure 2: Sample of Purdue Visualization of Rotation Test (PVRT)

Control of Extraneous Variables

To reduce experimental bias, the regular engineering graphics lecturers in the participating polytechnics taught their own students. Hence, the researcher was not directly involved in administration of the research instruments and the treatments. To control invalidity that could be caused by teacher variability in the development of the teaching guide (lesson plans) and to ensure uniform standard in the conduct of the research, the researcher personally prepared the teaching guide (the lesson plans) and organized training for participating lecturers. Two types of Lesson plan were developed by the researcher, namely: AutoCAD 2D lesson plan and AutoCAD 3D lesson plan. The AutoCAD 2D lesson plan incorporated use of AutoCAD 2D method of graphics while AutoCAD 3D lesson plan incorporated use of AutoCAD 3-D method.

Experimental Procedure

The experiment commenced with the administration of pretest to all the treatment groups. Engineering graphics lecturers administered the PVRT to the treatment groups in their respective schools. The pretest was followed by the treatment. AutoCAD 2009 was used for the treatment. The treatment group assigned to AutoCAD 2D method was taught with AutoCAD 2D method. Engineering graphics lecturers in the participating schools used the

AutoCAD 2D lesson plans as a teaching guide. The use of AutoCAD 2D method emphasized students' active involvement in the classroom activities. Active involvement was achieved through students' interaction with AutoCAD command. The lecturers placed learning in the hands of the students by making the students specify dimensions in AutoCAD using absolute coordinate (x,y) e.g., (1,3), relative coordinate @ (x,y) e.g. @(2,5) polar coordinate @ (distance<angle) e.g @ (50<90), repeatedly to construct objects such as a rectangle, ellipse, parabola, isometric block, Archimedean spiral, cycloid,. (Figure 3, 4, 5 and 6). In addition, the students constructed front view of isometric object in a tiled viewport using AutoCAD 2D method to specify dimensions and converted the front view to the isometric object, by responding to extrude command, repeatedly, converted the object to virtual object and view the object as a virtual object. Further, the students constructed orthographic projection, section views and Auxiliary views of isometric objects with soldraw and solview commands. In all, the treatment group assigned to AutoCAD 2D method was taught 14 lessons. Each lesson lasted for 2 hours and the treatment lasted for 7 weeks.

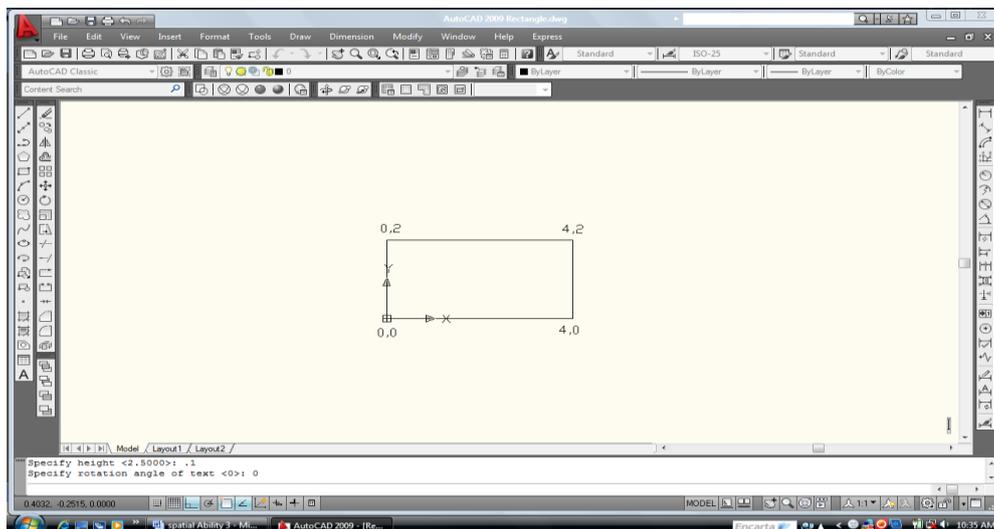


Figure 3: Rectangle constructed with AutoCAD 2D method

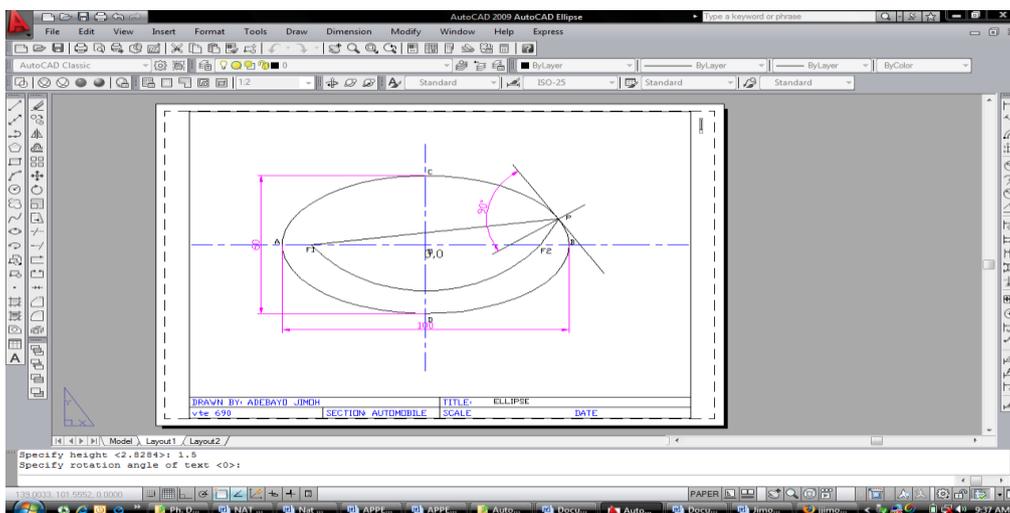


Figure 4: Ellipse constructed with AutoCAD 2D method

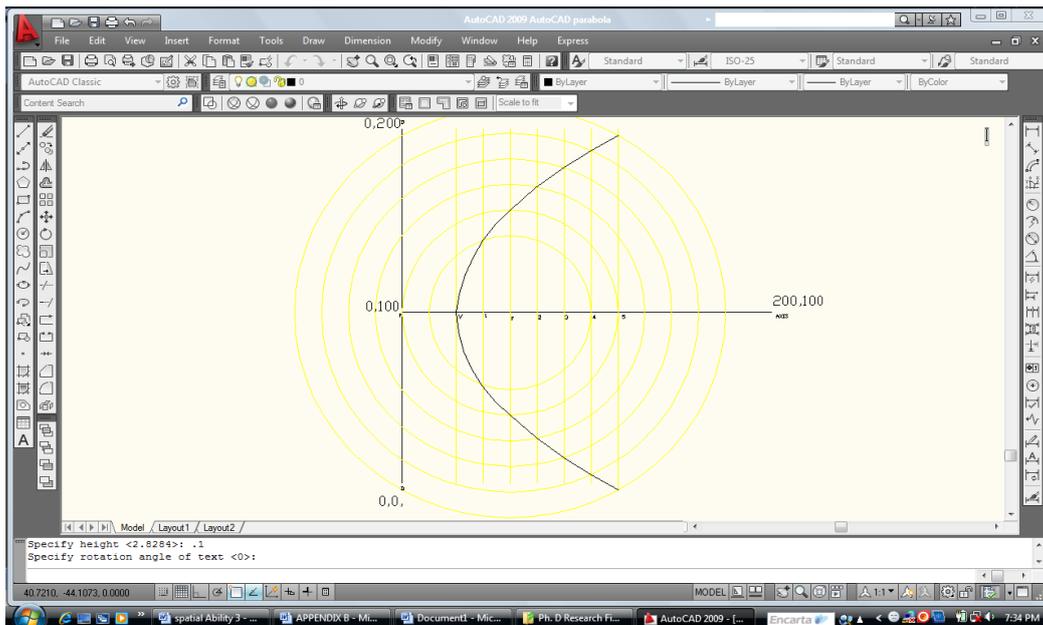


Figure 5: Parabola constructed with AutoCAD 2D method

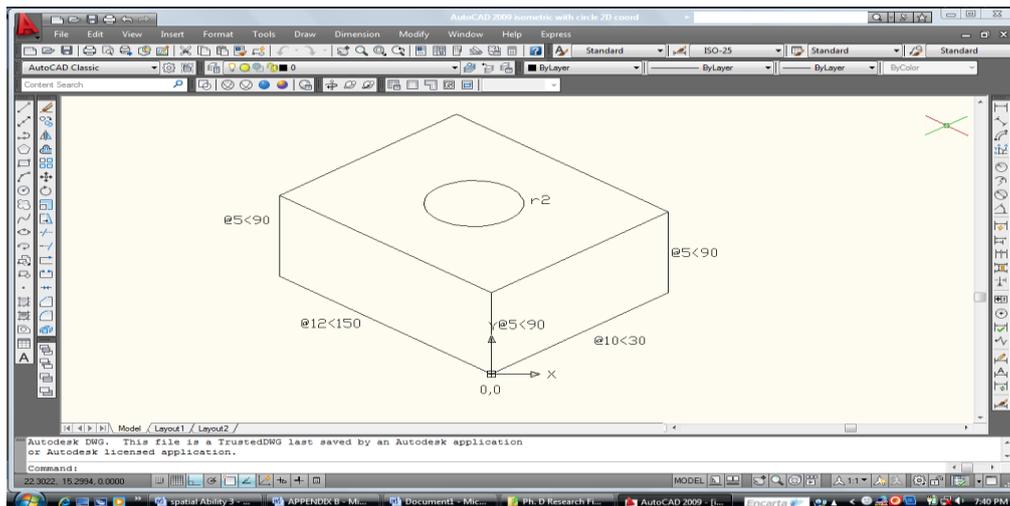


Figure 6: Isometric box with hole constructed with AutoCAD 2D method

The treatment group assigned to AutoCAD 3D method was taught with AutoCAD 3D method. Engineering graphics lecturers in the participating schools used the AutoCAD 3D lesson plans as a teaching guide. Students' active involvement in the learning activities was achieved through students' interaction with AutoCAD command. The lecturers placed learning in the hands of the students by making the students specify dimensions using absolute coordinate in three-dimension (x,y,z) e.g., (1,3,4), relative coordinate @(x,y,z) e.g. @(2,5,6), spherical coordinate system @(distance<angle,<angle) e.g @50<60<30, repeatedly to construct rectangle, ellipse, parabola, archimedean spiral, cycloid. In addition, the students made use of absolute, relative and spherical coordinate to construct isometric block (See Figure 7, 8, 9 and 10). Also, the students constructed orthographic projection, section views and Auxiliary views of isometric objects by responding to soldraw and solview commands under the lecturer's guidance. Furthermore, the students constructed front view of an isometric object in a tiled viewport using AutoCAD 3D method to specify dimensions and

converted the front view to the isometric object, by responding to extrude command, rendered the object and view the object as a virtual object. After which the students interacted repeatedly with the virtual objects in three-dimensional space through use of animation of 3D orbit, 3D continuous orbit and rotation of view point to the objects. The interactions with the use of 3D orbit, and 3D continuous orbit involved panning, twisting, rotating, and rolling of the virtual objects providing multi-point viewing relative to x,y,z coordinate system while interactions with the use of view point rotation involved changing viewers' angle to object in 3D space without changing the object's coordinate system. For instance, a rotation of 300 degree position from X-axis in XY plane and a 35 degree from XY plane is shown in Figure 11.

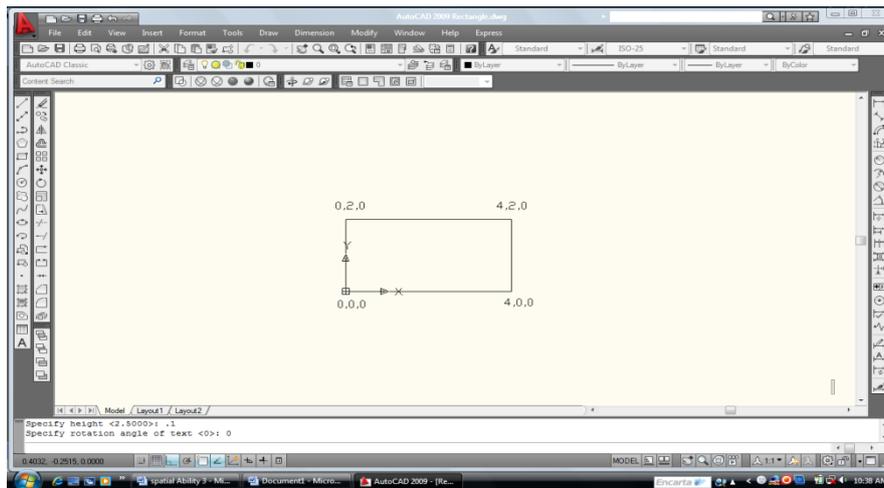


Figure 7: Rectangle constructed with AutoCAD 3D method

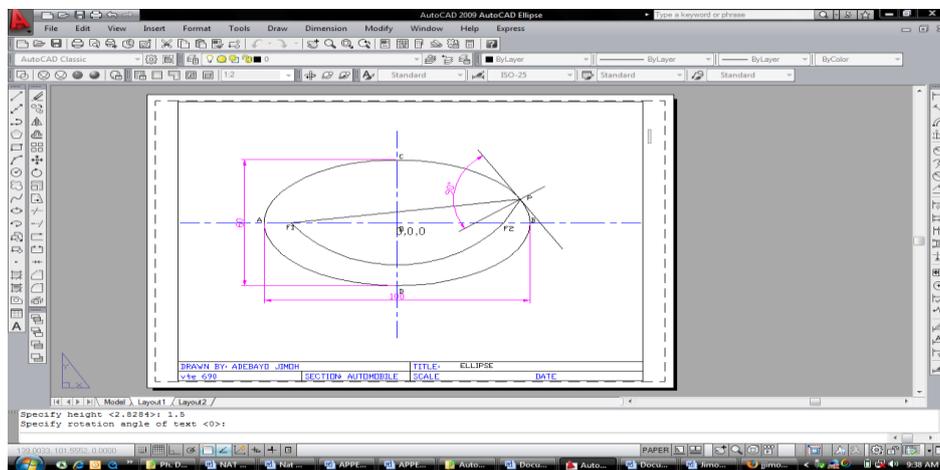


Figure 8: Ellipse defined by absolute coordinate 0,0,0

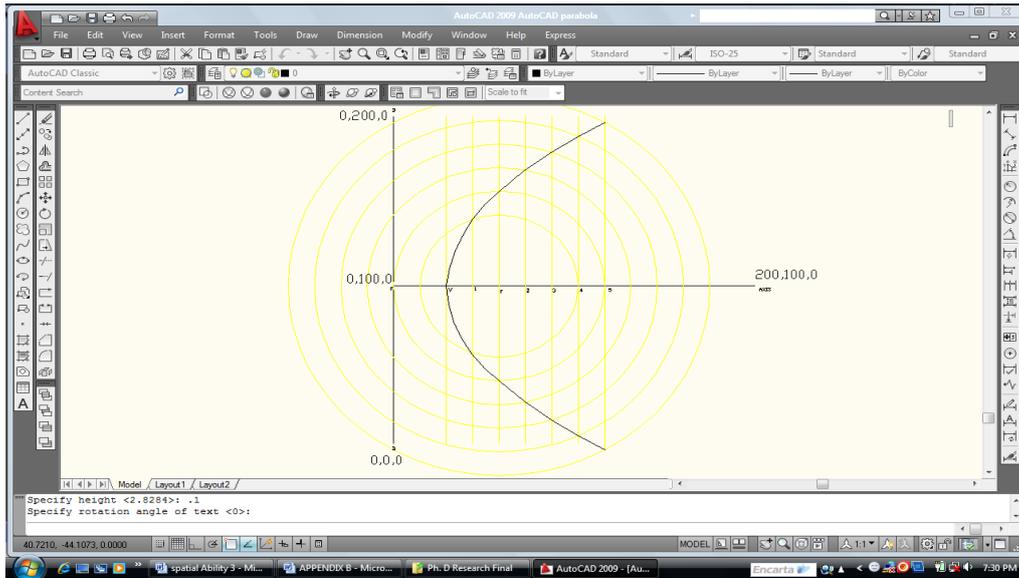


Figure 9: Parabola constructed with AutoCAD 3D method

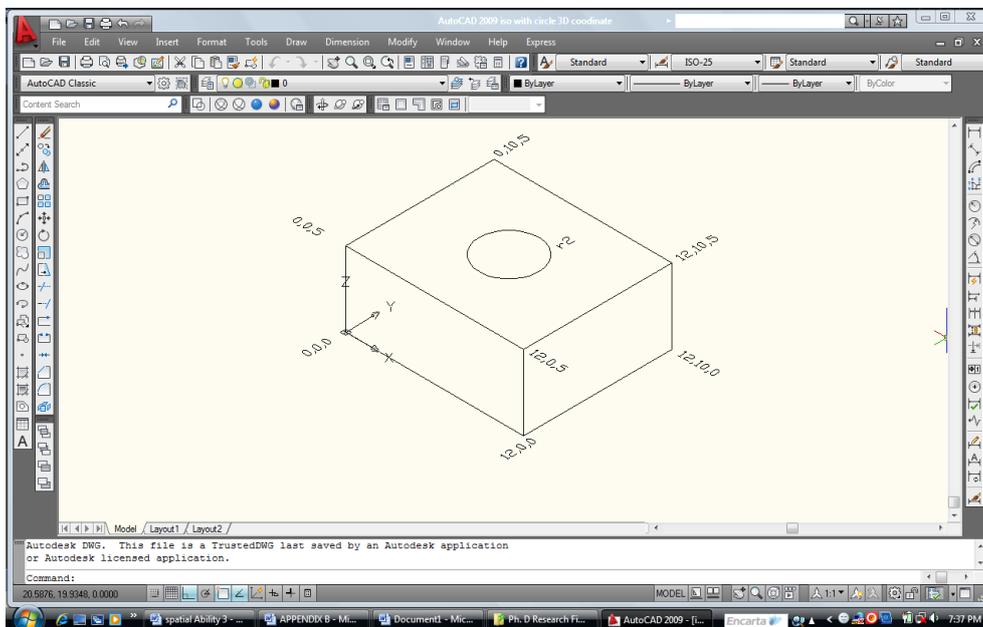


Figure 10: Isometric box constructed with AutoCAD 3D method

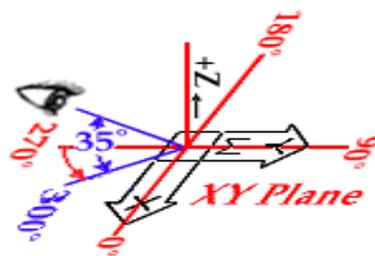


Figure 11: Rotation of View point in AutoCAD Three-dimensional space

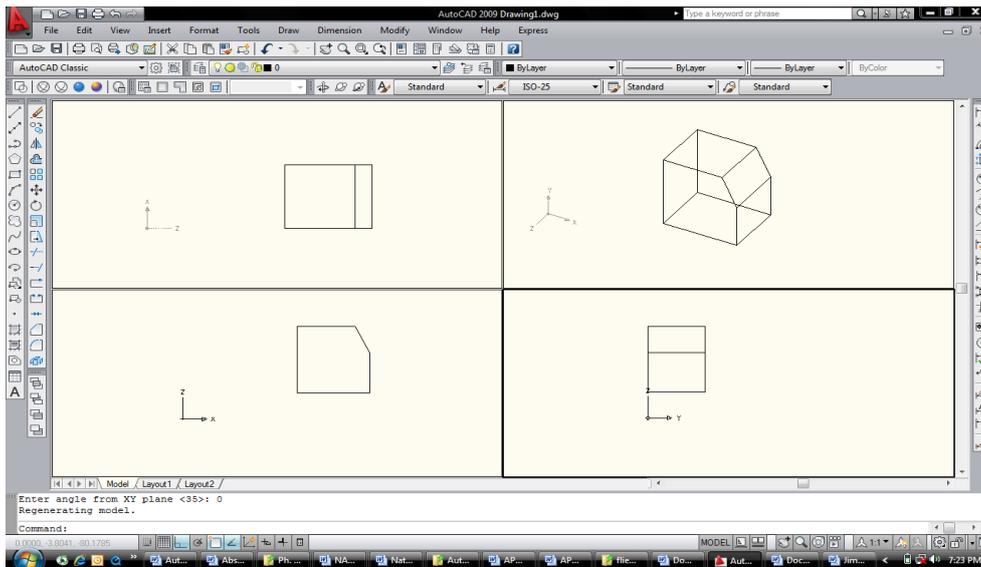


Figure 12: Top view, front view and right side view of the isometric object when rotated with Vpoint command

The students were asked to rotate View point to isometric objects, repeatedly, by responding to vpoint command as follows: view point rotation for 270 degree in **XY** plane from **X**-axis and 90 degree from **XY** plane to view the TOP view of the isometric objects. View point rotation for 270 degree in **XY** plane from **X** axis and 0 degree from **XY** plane to view the front view of the isometric objects. View point rotation for 0 degree in **XY** plane from **X**-axis and 0 degree from **XY** plane to view the Right Side View of the isometric objects (for example see Figure 12). In all, the treatment group assigned to AutoCAD 3D method was also taught 14 lessons, each lesson lasted for 2 hours and the treatment also lasted for 7 weeks.

The posttest was administered to all the treatment groups immediately after the completion of the treatments. Engineering graphics lecturers administered the posttest to the treatment groups in their respective schools. In the posttest, the PVRT was administered on the treatment groups. This exercise provided the spatial ability test scores of the students after the treatment.

Results

Research Question 1

What is the effect of using AutoCAD (2D and 3D) methods of graphics in teaching engineering graphics on students' spatial ability?

Table 1

Mean of Pretest and Posttest Scores of Treatment Groups taught Engineering Graphics with AutoCAD (2D and 3D) methods in the Purdue Visualization of Rotations Test (PVRT)

AutoCAD Methods	N	Pretest	Posttest	Mean Gain
		\bar{X}	\bar{X}	
AutoCAD 2D Method	108	1.87	6.81	4.94
AutoCAD 3D Method	119	1.90	14.68	12.78

Table 1 shows that the treatment group taught engineering graphics with AutoCAD 2D method had a mean score of 1.87 in the pretest and a mean score of 6.81 in the posttest making a pretest, posttest mean gain in the treatment group taught with AutoCAD 2D method to be 4.94. The treatment group taught engineering graphics with AutoCAD 3D method had a mean score of 1.90 in the pretest and a posttest mean of 14.68 with a pretest, posttest mean gain of 12.78. With these results, both AutoCAD 2D method and AutoCAD 3D method improved students' spatial ability in engineering graphics. Hence, both methods are effective but the effect of AutoCAD 3D method on students' spatial ability in engineering graphics is higher than the effect of AutoCAD 2D method.

Research Question 2

Is there effect of Gender on the spatial ability test scores of students (male and female) when taught engineering graphics with AutoCAD methods of graphics?

Table 2

Mean of Pretest and Posttest of Male and Female Students Taught Engineering Graphics with AutoCAD (2D and 3D) methods in the Purdue Visualization of Rotations Test (PVRT)

	AutoCAD Methods							
	AutoCAD 2D Method				AutoCAD 3D Method			
	Gender	n	Pretest	Posttest	Mean Gain \bar{X}	n	Pretest	Posttest
Male	98	1.93	7.08	5.15	108	1.99	14.93	12.94
Female	10	1.20	4.20	3.00	11	1.09	12.18	11.09

Table 2 shows that the mean gain of male students taught with AutoCAD 2D method was 5.15; meanwhile, female students taught engineering graphics with AutoCAD 2D method had mean gain of 3.00. Also, male students taught with AutoCAD 3D method had mean gain of 12.94; whereas, female students taught engineering graphics with AutoCAD 3D method had mean gain of 11.09. With these results, male students taught engineering graphics with AutoCAD methods had higher mean scores than female students in the Purdue Visualization of Rotations Test (PVRT). Thus, there is an effect of gender on spatial ability of students taught engineering graphics with AutoCAD (2D and 3D) methods.

Hypotheses

HO₁: There is no significant difference between the main effect of treatments (AutoCAD 2D and 3D) methods of graphics on students' spatial ability in engineering graphics

HO₂: There is no significant difference between the main effect of gender (male and female) on students' spatial ability in engineering graphics

HO₃: There is no significant interaction effect of treatments given to students taught with AutoCAD and their gender with respect to their mean scores on the spatial ability test

Table 3

Summary of Analysis of Covariance (ANCOVA) for Test of Significance of three Effects: Main Effect of Treatments, Gender and Interaction Effect of Treatments on Students' Spatial Ability in Engineering Graphics

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Covariates	51.396	1	51.396	11.790	.001
Pre-test	51.396	1	51.396	11.790	.001
Main Effects	1340.067	2	670.034	153.707	.000
Treatments	1187.999	1	1187.999	272.529*	.000
Gender	184.015	1	184.015	42.213*	.000
2-way Interactions	.014	1	.014	.003	.954
Treatment*Gender	.014	1	.014	.003	.954
Explained	3705.403	4	926.351	212.507	.000
Residual	967.733	222	4.359		
TOTAL	4673.137	226	20.678		

*Significant at sig of F < .05

Table 3 shows F-calculated values for three effects: treatment, gender and interaction of treatments and gender on students' spatial ability in engineering graphics. The F-calculated value for treatments is 272.529 with a significance of F at .000 which is less than .05. The null-hypothesis of no significant difference between the effects of treatments AutoCAD (2D and 3D methods) on students' spatial ability in engineering graphics was rejected at .05 level of significance. This result confirmed that, the observed difference in the effect of AutoCAD 3D method on students' spatial ability in engineering graphics which is higher than the effect of AutoCAD 2D method is statistically significant. The F-calculated value for gender stood at 42.213 with a significance of F at .000 which is less than .05. The null hypothesis was therefore rejected at .05 level of significance. This result confirmed that there is a statistically significant effect of gender on students' spatial ability in engineering graphics. The interaction effect of treatments and gender has F-calculated value of .003 with significance of F, .954 which is higher than .05. With this result, the null hypothesis of no significant interaction effect of treatments given to students taught with AutoCAD and their gender with respect to their mean scores on the spatial ability test was accepted. Therefore, no significant interaction effect of treatments given to students taught with AutoCAD methods and their gender with respect to their mean scores on the spatial ability test.

Discussion

The data presented in Table 1 provided answer to research question one. Findings revealed that both AutoCAD 2D method and AutoCAD 3D method improved students' spatial ability in engineering graphics but the effect of AutoCAD 3D method on students' spatial ability in engineering graphics was higher than the effect of AutoCAD 2D method. Analysis of covariance was used to test hypothesis one (H_{01}), Table 3, at the calculated F- value (272.529), significance of F (.000) and confidence level of .05, there was a significant

difference between the main effect of treatments (AutoCAD 2D method and AutoCAD 3D method) on students' spatial ability in engineering graphics which confirmed that the difference between the effects of AutoCAD 3D method and AutoCAD 2D method on students' spatial ability was statistically significant. This implies that AutoCAD 3D method is more effective than AutoCAD 2D method in improving students' spatial ability in engineering graphics. This finding compared favourably with the finding of a research conducted in United States by Thomas in 1996 reported in Scribner and Anderson (2005). Research by Thomas tested the benefits of three-dimensional CADD instruction over instruction using two-dimensional CADD. Results showed the three-dimensional CADD method of instruction was more effective than the two-dimensional CADD method. This finding could be explained by the fact that the three-dimensional coordinate system provides the three physical dimensions of space-height, width and length (Branof, 1998). Basham (2007) noted that drawing in three-dimension have significant communication advantage by representing form and space more realistically.

Spatial ability is multifaceted. Alias, Black and Grey (2002) pointed out that providing diverse activities is the key to enhancing overall spatial visualization ability. In addition to drawing geometry with AutoCAD 3D method, the participants assigned to 3D method were able to solve spatial tasks by interactions with animation and virtual objects through panning, twisting, rotating, and rolling of the virtual objects in 3D space and with the use of view point rotation that involved changing viewers' angle to objects in 3D space without changing the objects' coordinate system, thus facilitating the visual perception and processing of objects in the 3D space. The use of 3D coordinate system and the high degree of interactions with virtual objects and animation in the AutoCAD 3D space had benefited the treatment groups assigned to AutoCAD 3D method since these features are absent in the AutoCAD 2D method. According to Rafi, Samsudin and Said (2008) 3D environment allows real time interactions by means of one or more control devices and involving one or more sensorial perception. In the 3D environment, learners could view objects from close up or from a distance when examining specific and holistic feature of the artefacts thus, concurring with Smith's (2001) study that suggested alternating between interactions and observations was the best way to learn spatial visualization.

The data presented in Table 2 provided answer to research question two. Finding revealed that male students taught engineering graphics with AutoCAD methods had higher mean score than female students in the Purdue Visualization of Rotations Test (PVRT). Analysis of covariance was used to test hypothesis two (H_{02}), Table 3, at the calculated F- value (42.213), significance of F (.000) and confidence level of .05 there was a significant difference between the main effects of gender on students' spatial ability in engineering graphics which confirmed that the difference between the spatial ability test scores of male and female students in engineering graphics was statistically significant favouring male. This finding is similar to findings of several other studies that had been conducted on gender effects on spatial ability of male and female students in engineering and other fields. For instances, one of the important discoveries emerging from studies involving psychometric

testing of spatial ability was the revelation of gender differences favouring male. Male advantages in spatial ability have been established in studies by Nemeth and Hoffmann (2006), Burin, Delgado and Prieto (2000), Medina, Gerson and Sorby (2000) and Branoff (1998), Voyer, Voyer, and Bryden (1995), Linn and Petersen (1985), and Maccoby and Jacklin (1974). Thus, in studies where differences in spatial ability were evident males typically had stronger spatial skills than female. Male superiority in spatial ability than female is supported by Baenninger and Newcombe (1989) who noted that training does not eliminate differences between spatial ability of male and female but rather improve their scores. Analysis of covariance was also used to test hypothesis three (H_{03}), Table 3. At the calculated F-value (.003), significance of F (.954) and confidence level of .05, there was no significant interaction effect of treatments given to students taught with AutoCAD and their gender with respect to their mean scores on the spatial ability test (Figure 13). With these results there were no differential effects of AutoCAD treatments over levels of gender. Thus, AutoCAD 3D method was more effective in improving students' spatial ability in engineering graphics regardless of levels of Gender.

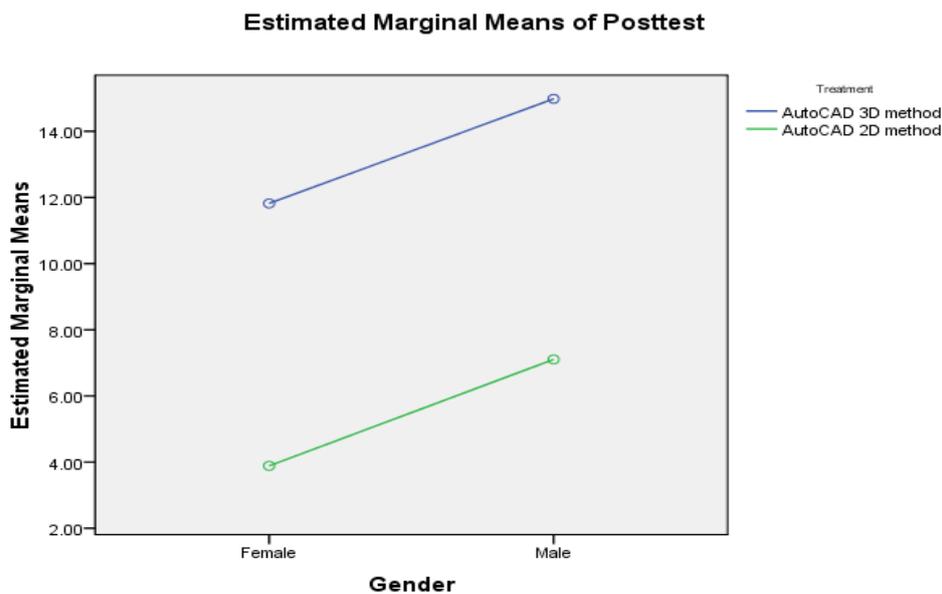


Figure 13: interaction of AutoCAD methods and gender on PVRT

Conclusions and Recommendations

Given the technological advancement which has occasioned ample use of Computer Aided-Design packages such as AutoCAD for graphics design in the industry, the need to find the best method of CAD to assist National Diploma students studying mechanical engineering technology to learn engineering graphics and improve their spatial ability is paramount. This study found AutoCAD 3D method more effective than AutoCAD 2D method and this effect was found to be statistically significant. Also the study revealed that, there was a significant effect of gender on students' spatial ability in engineering graphics favouring male.

However, the study found no significant interaction effects of AutoCAD methods and gender on spatial ability of National Diploma students in engineering graphics. This simply means that the effectiveness of AutoCAD methods on students' spatial ability in engineering graphics does not depend on the levels of gender. Hence, irrespective of nature of gender, learners will record improved performance in their spatial ability, in engineering graphics when AutoCAD 3D method is used for teaching engineering graphics. Furthermore, Computer Aided-Design packages such as AutoCAD available today give engineering graphics lecturers opportunity to engage students in real world engineering graphics designing. It also gives students the opportunity to develop valuable thinking skills in engineering graphics. Since, the use of CAD packages is clearly a strategy that reflects modern business and industry practices and provides students with a learnable tool for creative visualization; if AutoCAD 3D method is used for teaching engineering graphics to the National Diploma students studying mechanical engineering technology, the technicians trained will graduate with engineering graphics skills and spatial ability needed for work in the present world of work.

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