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Keywords: computer aided design (CAD), creative behaviour, design education, curriculum, tertiary institution.

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Appraising the Effects of Computer Aided Design (CAD) on the Creative Behaviour of Design Students in Tertiary Institutions in Nigeria: A Case Study of the Federal University of Technology Akure

E. Bankole Oladumiye [α], Tanimu Hassan A [σ] & Adelabu Oluwafemi S. [ρ]

Abstract- As a result of the advancement of digital technologies, intellectual discourse on the role of innovations in design and what value Computer Aided Design (CAD) brings into the equation has been on the increase. This research sought to appraise the effects of CAD on the creative behaviour of students offering design related courses in tertiary institutions with a focus on the Federal University of Technology Akure (FUTA), Nigeria. From the literatures reviewed, Creative Behaviours Model (CBM) proposed by Musta'amal, Norman, & Hodgson was adopted and served as a framework for capturing the creative behaviour of the target population. This model characterised creativity into seven sub categories namely: novelty, appropriateness, motivation, fluency, flexibility, sensitivity, and insightfulness. A survey method was employed for this study and data were collected using well-structured online questionnaires to elicit responses from both students and CAD instructors in concerned departments in FUTA. The outcome of the study reveals the areas of application of CAD software and the level of engagement of students in CAD related courses. It also shows the assessment of students' performance in CAD related courses from the perspective of the students and their instructors. The study concludes that CAD can enhance student's creative behaviour and more integration of CAD related courses into the curricula of tertiary institutions in Nigeria will lead to higher competency and global competitiveness rating of future professional designers and engineers.

Keywords: computer aided design (CAD), creative behaviour, design education, curriculum, tertiary institution.

I. Introduction

In this era, the quest for innovative solutions and products has grown as time and cost constraints have increased. One of the skills which is increasingly seen as important for dealing with these issues is the ability to be creative in seeking digital solutions to design problems (Musta'amal, Norman, Rosmin, and Buntat, 2014). The introduction of Computer Aided Design (CAD) has brought a new point of history in how designers deal with their design tasks. CAD has gone through a progressive evolution for a wide range of users from those undertaking less complex product design to more sophisticated and complicated design tasks. The technology has enhanced how to facilitate various users' needs in designing activities including sketching tools in two-dimension (2D) and three-dimension (3D) (Musta'amal et al., 2014). Spendlove and Hopper, (2004) suggested that CAD should be seen as a set of tools, which can be adopted and appropriated within the broad creative process.

Global trends and improvements in computer technology have made the production of CAD proficient graduates feasible and imminent even within the spheres of creativity and functionality (Ogunsote, Prucnal-Ogunsote, & Umaru, 2006). CAD software is now well-established and commonly used in the design process. Consequently, it has also been introduced in design education worldwide (Hatib, Amal, Hodgson, and Norman, 2008). Recent studies showed that students displayed their enthusiasm for using CAD in designing as it helped them to present works professionally, visualise their ideas/objects, and work accurately (Hatib et al., 2008). These findings support previous researches which indicated that CAD would enhance the designer in analysing and communicating design work efficiently and creatively.

Although it has been a long debate since the introduction of CAD whether this software has any implications on creativity in designing (Walther, Robertson, and Radcliffe, 2007), there are indications that CAD and creativity are linked (Robertson and Radcliffe, 2009). Nevertheless, a lack of systematic efforts to articulate and clarify what the nature of the links might be has prompted the need for further studies. In the Nigerian context, CAD technology is rapidly gaining acceptance and usage in the design process (Adelabu & Kashim, 2010). The effect of CAD usage on the creative process is hence sought for especially within the scope of school design work at tertiary institutions in Nigeria.

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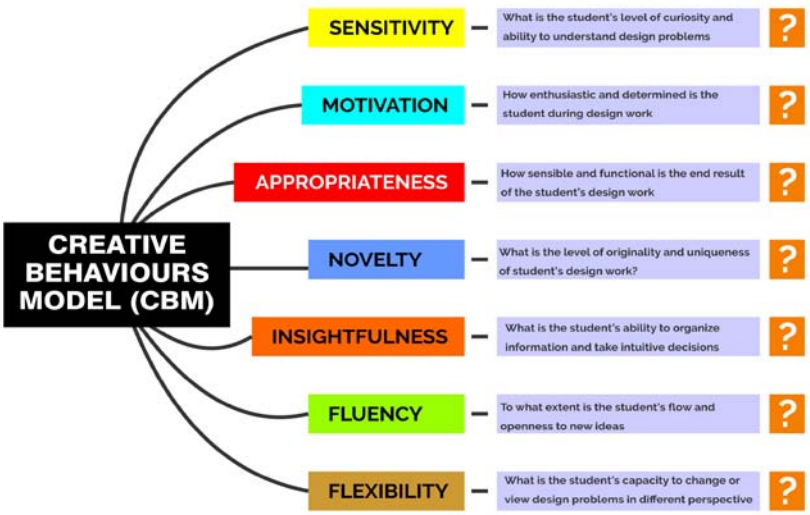
To this end, this study aimed to investigate into the effects of the use of CAD on the creative behaviour of design students in tertiary institutions in Nigeria with a case study of the Federal University of Technology Akure (FUTA). Design students as used in this study cover students in departments offering design related courses such as Industrial Design, Architecture, Mechanical Engineering and Civil Engineering, where the use of CAD is mandatory. The specific objectives advanced for this study were to:

i. Determine how CAD has been implemented in departments offering design related courses in Federal University of Technology Akure, Nigeria;
ii. Examine the level of performance as perceived by students in their CAD related courses; and
iii. Evaluate CAD instructor's perception of students' creativity in design work.

II. Literature

a) *Model For Evaluation of Creative Behaviours*

Musta'amal *et al* (2009) identified seven factors that form the Creative Behaviour Model (CBM) which served as a framework to capture creative behaviour as shown in figure 1. These factors are sensitivity, motivation, appropriateness, novelty, insightfulness, fluency and flexibility. From this model, attempts were made in this study to evaluate the creativity of students offering design related courses in the Federal University of Technology Akure.

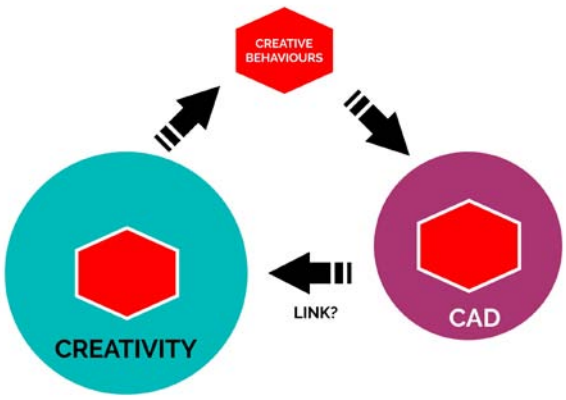


Source: (Musta'amal, Norman, & Hodgson, 2009)

Figure 1: Creative Behaviours Model (CBM) and its Descriptors

b) *Cad and Creativity*

There is a growing interest in exploring the link between CAD and creativity in design and suggestions are that CAD should be seen as a set of tools as illustrated in figure 2, which when adopted and appropriated within the broad design process could give a better chance of creative behaviours that lead to innovative outputs (Musta'amal et al., 2014).



Source: (Musta'amal et al., 2014)

Figure 2: Linking CAD with Creativity in Design

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A study by Robertson & Radcliffe (2009), pointed out that CAD impacts on creativity in design through an enhanced communication and visualization features allow designers to realize and communicate the products of their imagination, thus fostering the flexible development of design ideas. Lawson (2002) added that humans experience design more through visual senses and computers help designers in several ways especially because of their precision, accuracy and speed.

c) Computer Aided Design (Cad) and Software

Ivan Sutherland is regarded the pioneer of Computer Aided Design (CAD). In 1963, he developed Sketchpad, a device that allows the user to interact with the software through a light pen on a monitor (Tornincasa, Torino, & Torino, 2010).

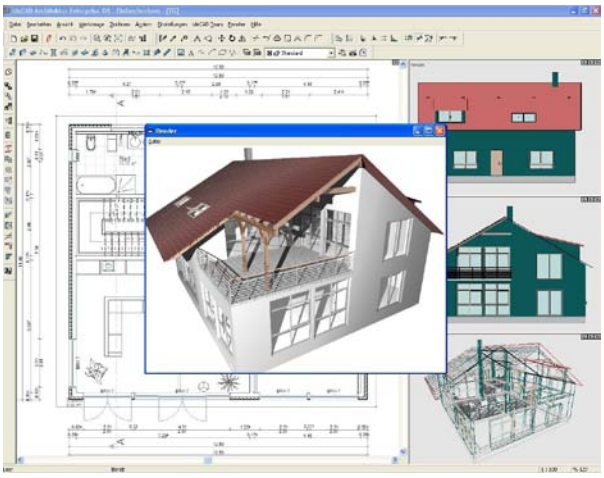
The introduction of CAD may have brought a new era in how designers deal with their design tasks and generate creative ideas. CAD has gone through a progressive technology evolution for a wide range of users, from those undertaking less complex product design to more sophisticated and complicated design tasks. It facilitates various users' needs in designing activities including sketching in two-dimensions (2D) and three- dimensions (3D) (Musta'amal et al., 2014). Design presentations have been enhanced with the virtual reality features in CAD and designers now have efficient environment to communicate their design thinking and express their creativity.



Source: Design generated by the researcher

Figure 3: A screen shot of Computer Aided Design (CAD) in Industrial Design School based work.

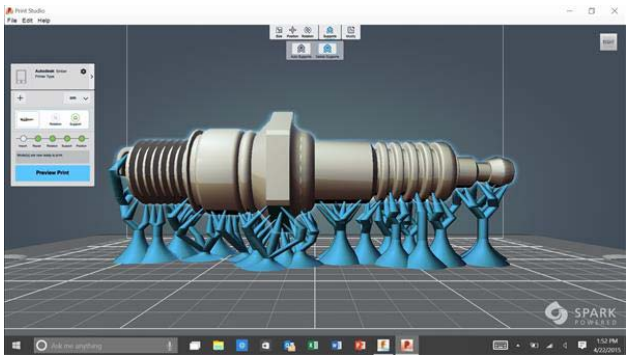
In the last decades, developments in technology and computer science have modified the creative potential of each individual (See figure 3 and 4). In particular, the democratization of the use of computers and the development of fast internet have allowed large numbers of individuals to access a wide range of informational elements and to use new computational tools (Bonnardel & Zenasni, 2010).



Source: (Bilalis, 2000)

Figure 4: A screen shot of Computer Aided Design (CAD) in Architecture School based work.

According to Bilalis (2000), earlier applications were used for 2D-Designs but following the advancement in technology, 3D designs have become popular and accessible.(Bilalis, 2000)



Source: (Hodgson & Fraser, 2005)

Figure 5: A screen shot of CAD in Mechanical Engineering School based work.

Figure 5 and 6 show specification of Computer Aided Design (CAD) in Mechanical and Civil Engineering respectively. Technological advancement has enable designers, architects and engineers to easily interact with software that could help them actualise their various creative ideas.

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Source: (Adejuyigbe, 2010)

Figure 6: A screen shot of CAD in Civil Engineering School based work.

According to a study by Ogunsote et al. (2006), These CAD software are in different categories as found in table 1. It is obvious that there is no particular software that is best for a task; some can be used for multiple purposes e.g AutoCAD and Cinema4D can be used for 3D modelling and rendering as seen in table 1. (Kostic, Radakovic, Cvetkovic, Trajkovic, & Aleksandar, 2012).

Table 1: Category of Computer Aided Design (CAD) Software

Category	Examples of Software
2D & 3D modelling software	Cinema 4D, AutoCAD, Autodexk Architectural Desktop, SolidWorks, Autodexk Revit Building, Pro/Engineer, ArchiCAD, Form-Z, TurboCAD, SketchUP, Lumion
Rendering software	3D Studio Max, Cinema4D, Accurender, ArchiCAD, AutoCAD, Form-Z, TurboCAD, CATIA
Animation software	Amorphium, 3D Studio Max, Blender, Bryce, Flash, Ray Dream Studio, SoftImage, True Space, Maya
Vector software	CorelDraw, Micrografx Designer, Adobe Illustrator
Bitmap software	Adobe PhotoShop, Microsoft Paint, Corel Photo Paint, MicroGrafx Picture
Presentation software	Microsoft PowerPoint, Harvard Graphics
Publishing software	Adobe PageMaker, Microsoft Publisher

(Ogunsote et al., 2006) and (Kostic et al., 2012)

III. Materials and Methods

This research adopted survey research design approach in which both structured (close-ended) and unstructured (open-ended) questionnaires were administered to students offering design related courses and instructors of CAD in the Federal University of Technology Akure, Nigeria. The population for this research comprises students and instructors in Departments of Industrial Design, Architecture, Mechanical Engineering and Civil Engineering within the study area.

According to a pilot study conducted, the data of the students offering CAD related courses in FUTA is summarised as shown in table 2.

Table 2: Numerical strenght of each department

Department	100 Level	200 Level	300 Level	400 Level	500 Level	Total
Industrial Design	51	52	89	56	68	316
Architecture	50	123	103	110	107	493
Mechanical Engineering	141	116	91	86	91	525
Civil Engineering	132	102	72	98	94	498
Total						1832

The CAD related courses as reflected in the official student's curriculum handbook of the selected departments were studied. An electronic questionnaire was designed using the 'Survey Monkey' application to elicit responses from students offering design related courses in FUTA.

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CAD instructors were issued questionnaires with items based on Creative Behaviour Model (CBM) to elicit their perceptions of students' creative behaviour in their school based design work. The data for this research was analysed using descriptive statistical tools such as bar chart, mean, percentile, frequency distribution, median and mode.

IV. Results and Discussion

Objective 1: Determine how CAD has been implemented in departments offering design related courses in Federal University of Technology Akure, Nigeria.

Based on the first research objective, the following data is presented and analysed.

Table 3: CAD related courses offered in selected departments in FUTA

	Industrial Design Department	Architecture Department	Civil Engineering Department	Mechanical Engineering Department
100 LEVEL	*Introduction to 3 Dimensional Design I (IDD103)	Nil	Nil	Nil
	*Introduction to Graphics Design II (IDD110)			
	*Introduction to 3 Dimensional Design II (IDD104)			
200 LEVEL	*Computer Aided Design I (IDD211)	*Architectural Design I (ARC 201)	Engineering Drawing II (MEE 202)	Nil
	*Computer Aided Design II (IDD212)	*Archit22ectural Graphics I (ARC 203)		
300 LEVEL	*Principles and Techniques of Graphics I (IDD313)	*Architectural Design III (ARC 301)	Design of Structures I (CVE 308)	Nil
	*Graphic Design Studio I (IDD317)	*Computer Aided Design I (ARC 303)		
	*Graphic Design Studio II (IDD318)			
	*Using of Computer in Ceramics Modelling II (IDD338)			
400 LEVEL	*Television Graphics (IDD405)	*Architectural Design V (ARC 401)	Nil	Nil
	* Book Design and Production Technology (IDD407)			
	*Film Animation and Cartooning (IDD409)			
	*Advertising (IDD411)			
500 LEVEL	*Advanced Graphics Design Studio I (IDD503)	*Advanced Design Studio I (ARC 501)	*Structural Engineering II (CVE 504)	*CAD/CAM (MEE525)
	*Visual Design and Presentation Techniques (IDD505)		*Design of Hydraulic Structures (CVE 512)	*Vehicle Dynamics & Control System (MEE529)
	* Advanced Advertising (IDD507)		*Environmental Engineering & Design (CVE 516)	*Aircraft Aerodynamics (MEE537)
	*Visual Design and Presentation Techniques II (IDD504)			*Aircraft Design (MEE539)
	*Advanced Cartooning and Animation (IDD516)			

From Table 3, 100 levels to 500 level students in industrial design engage in CAD related courses. In architecture department, CAD related courses are included in 200 levels to 500 levels. All 500 level students in all the selected departments engage in CAD related courses. In 200 and 300 levels, only mechanical engineering departments did not offer CAD related courses.

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Table 4: Number of CAD related courses offered by students in first sem ester

Answer Choices	Responses (%)	Responses (Numbers)	Mean
0 course	35.42%	68	2
1 course	10.42%	20	
2 courses	12.50%	24	
3 courses	19.79%	38	
4 courses	13.54%	26	
5 courses	2.08%	4	
More than 5 courses	6.25%	12	
Total	100.00%	192	

From table 4, 35.42% of the sampled students corresponding to 68 respondents did not offer any CAD related courses. A meagre number of the respondents offer 5 CAD related courses. 6.25% of the sampled students which correspond to 12 respondents offer more than 5 CAD related courses. Only one CAD related course is offered by 20 respondents, corresponding to 10.42% of the sampled students. Two CAD related courses were offered by 24 respondents, corresponding to 12.50% of the sampled students. Three CAD related courses were offered by 38 respondents, corresponding to 19.79% of the sampled students. 13.54% of the sampled students which correspond to 26 respondents fail to offer any CAD related courses.

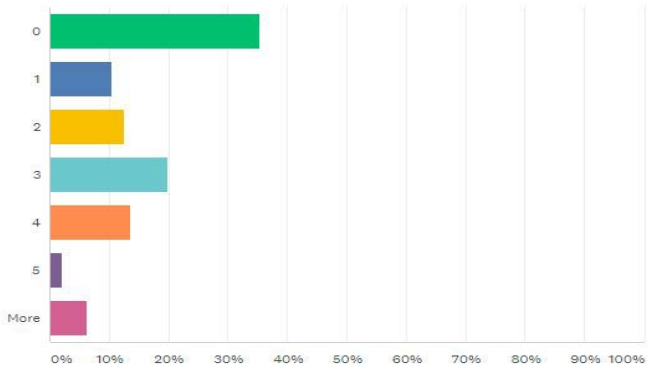

Figure7: Number of CAD related courses offered by respondents in the first semester

From figure 7, the summary of number of CAD related courses offered by respondents in the first semester. Based on overall appraisal of how CAD has been implemented in departments offering design related courses in FUTA, it can be seen from the figure that majority of the respondents which correspond to 68% of the sampled students do not engage in CAD related courses.

Objective 2: Examine the level of performance as perceived by students in their CAD related courses;

Based on the second research objective, the following data is presented and analysed.

Table 5: Preferred medium of creative expression by respondentsError! Not a valid link.

From table 5, 21.35% of the respondents which correspond to 41 agree that pencil on paper helps them to express their creativity more during design process while 19.27% which correspond to 37 preferred Computer Aided Design (CAD) as a medium that helps them to express more creativity in school based design work. However, 59.38% of the respondents which correspond to 114 combine both pencil on paper and Computers to aid their design and boost creativity. Figure 8 shows the summary of Mode of expression of creativity of respondents.

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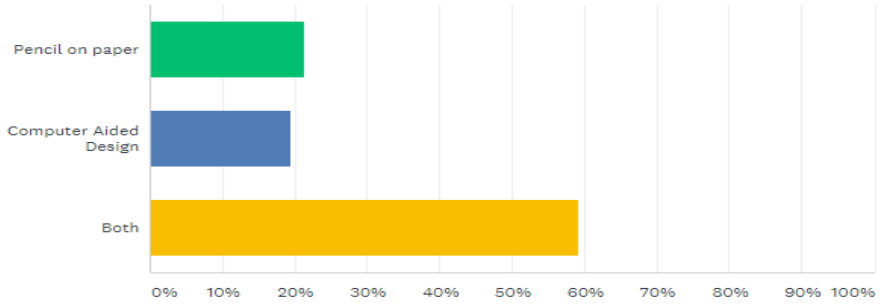

Figure 8: Preferred medium of expression (Creativity) of respondents

Table 6: General performance of respondents in the CAD courses offered in previous semester *Error! Not a valid link.*

From table 6, 2.08% of the sampled students which correspond to 4 responses accepted that that their performance during CAD courses offered in previous semester was poor. 6.25% of the sampled students which correspond to 12 responses accepted that their performance during CAD courses offered in first semester was fair. Moreover, 17.71% of the sampled students which correspond to 34 responses accepted that their performance was average during CAD course. A majority number of 84 corresponding to 43.75% of the sampled students accepted that they had a good performance during CAD courses. 16.67% of the sampled students which correspond to 32 responses accepted that their performance was very good during CAD courses offered in previous semester. The Figure 9 shows the summary of the general performance of respondents in the CAD courses offered in previous semester.

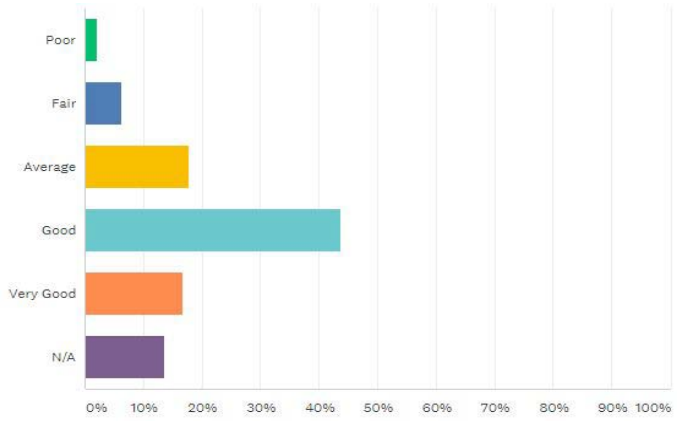

Figure 9: General performance of respondents in the CAD courses offered in previous semester

Objective 3: Evaluate CAD instructor's perception of students' creativity in design work.

Based on the third research objective, the following data is presented and analysed.

Table 7: CAD Instructor's Perception of Student's Creativity for School Based Design Work

	N	Minimum	Maximum	Mean	Sd
Sensitivity	7	3	4	3.57	0.53
Motivation	7	3	4	3.71	0.49
Appropriateness	7	3	5	3.57	0.79
Novelty	7	2	5	3.43	0.98
Insightfulness	7	2	5	3.14	0.99
Fluency	7	3	4	3.86	0.38
Flexibility	7	2	5	3.29	0.95

Likert scale: 5=very good, 4=good, 3=average, 2= fair, 1=poor

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From table 7, CAD instructors' perception of the students' creativity for school based design work was based on CBM (Creativity Behavioural Model). In terms of sensitivity, CAD instructors perceived that the students are curious to understand design problems with a mean score of 3.57 and SD of 0.53.In terms of motivation, CAD instructors perceived that the students are enthusiastic and determined during design works with a mean score of 3.71 and SD of 0.49. In terms of appropriateness, CAD instructors perceived that the students are sensible and functional in their design works with a mean score of 3.57 and SD of 0.79. In terms of novelty, CAD instructors perceived that the students are original and unique in their design works with a mean score of 3.43 and SD of 0.98. In terms of insightfulness, CAD instructors perceived that the students are sensible and functional in their design works with a mean score of 3.14 and SD of 0.99. In terms of fluency, CAD instructors perceived that the students are able to flow with new ideas in their design works with a mean score of 3.86 and SD of 0.38. In terms of flexibility, CAD instructors perceived that the students are capable to change or view design problems in different perspectives in their design works with a mean score of 3.29 and SD of 0.95. Figure 23 shows the summary of how CAD instructors rate the general performance of students in the CAD related course they taught in first semester based on CBM (creativity behavioural model).

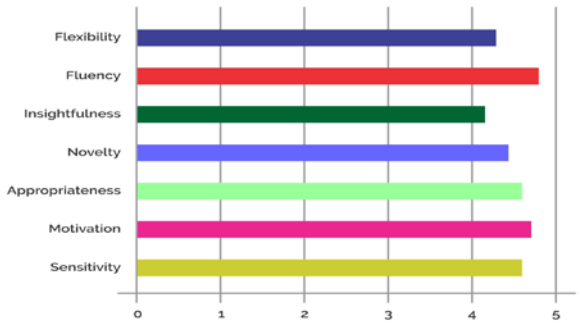

Figure 10: CAD Instructor's Perception of Student's Creativity for previous school based design work

Table 8: CAD Instructors perception of Student's performance this semester

		Frequency	Percent	Mean	Mode
Valid	Average	2	28.6	3.7143	4
	Good	5	71.4		
	Total	7	100		

From table 8, 28.6 % of the CAD Instructors perceived that students' performance are likely to improve at an average level while 71.4% the CAD Instructors envisaged good level of students' performance in CAD Course in second semester.

The discussion on the results of the study as presented is as follows:

From Table 3, all students from 100 level to 500 level in Industrial Design Department offer CAD related courses while Architecture department and others offer CAD related courses from 200 level to 500 level. This implies that some departments implemented CAD more than others in their curriculum. However, there is need for more emphasis of the practical application of CAD related courses in the lower level (that is, 100 level) so as to boost students' proficiency as they progress to higher level.

Even though the highest number of respondents did not offer any CAD related course in their first semester as shown in table 4, the mean score of 2.0 implies that a minimum of one CAD related course was offered by the respondents.

From the results of table 7, which was achieved using the Creative Behavioural Model (CBM); CAD Instructors are of the view that students exhibit a good level of curiosity and enthusiasm towards their design work. This is reflected in the functionality and diversity of their designs with notable traces of innovation. With these results, CAD Instructors foresee an improvement in the performance of students in the CAD related courses they registered in second semester.

V. Conclusion

This study appraised the effect of Computer Aided Design (CAD) on the creative behaviour of design students in the Federal University of Technology Akure, Nigeria. The study revealed that students showed an average level of sensitivity, motivation, appropriateness, novelty, insightfulness, fluency and flexibility in their school based design works and CAD instructors are hopeful that their performance is likely to improve in subsequent semesters. Although each of the departments investigated had CAD software that are distinct and relevant to their respective fields, the response of students revealed that both pencil on paper and Computer Aided Design helped them in expressing creativity in their school based design work. This study also showed that some of the CAD software were relevant to more than one fields and with adequate tutorials are not too difficult to understand. The study concludes that CAD can enhance student's creative behaviour and therefore recommends that integration of more CAD related courses into the curricula of tertiary institutions in Nigeria will lead to higher competency and global competitiveness rating of future professional designers and engineers.

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