CAD-CAM TECHNOLOGY AND TEXTILE MANUFACTURING IN NORTHERN NIGERIA

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Abstract
This study examines the CAD-CAM training received and its usage in the textile industries of Northern Nigeria. Cross-sectional descriptive survey was used in collecting quantitative data. The study was conducted on a sample size of 152 which was drawn from a population of 196 with a response rate of 96.1% (146). Statistical package for social science (SPSS) 20was used in analyzing the data. The study targeted textile industry CEOs, designers, and technologists. The findings revealed a low level (44.2%) on CAD-CAM training and usage. Similarly, 76.0% of the staff lack competency in the use of CAD-CAM technology. Pearson's correlation was also used to determine the direction of associations between CAD-CAM training and CAD-CAM usage in textile industries of Northern Nigeria. Moreso, a linear regression was performed and the result reveales that, a correlational relationship exist between independent variables and the dependent variables. The study hypothesis was tested at $p<0.05$ alpha index, and CAD-CAM training received, indicates that $t=13.179$, $p< 0.020$. This implies that training is statistically significant. The study recommends that textile industries, stakeholders and government should collaborate with other training bodies such as textile training institutes and software developers to improve workers' training and re-training capacity in CAD-CAM through promotion and after-sale training. Industries leaders and government should invest in CAD-CAM technology.

Introduction

Textile, clothing, and their production methods are as old as human history. However, over the years, the textile industry has seen a marked change owing to mechanization and computerization at various stages. Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) are technologies used in digital computers to perform certain functions in design and production with greater efficiency, effectiveness, and precision . The textile industry has profited a great deal from CAD-CAM leading to better efficiency in good designs precision, colour selections, and, more importantly, memory storage for future use (Silva & Rupasinghe, 2016).

Globally, the textile industry has witnessed not only remarkable innovation in technology but also the adoption of CAD-CAM in textile mass production (Mitra, 2014). The innovation has greatly changed the production phase in terms of speed and reduces lead time and product finishing. The acceptability of CAD-CAM usage in textile production is far advanced in countries like the USA, Britain, China, Italy, France, Japan, and Germany . CAD-CAM influence is also rapidly spreading worldwide to other emerging countries in Africa thereby opening new growth prospects in the textile industry (Kossai & Piget, 2014).

In Africa, according to Fukunishi (2014), nations like South Africa, Tunisia, Mauritius, and Madagascar are ranked as the leading countries in CAD-CAM usage. However, a good percentage of textile and fashion industries in Africa are not able to apply CAD-CAM technologies due to several factors such as lack of software and knowledge of its application (Mado-alabi, 2014) .

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According to Kamau (2012), the appropriate software for textile production is very limited in its use in Kenya. CAD-CAM requisite software packages were challenges confronting the textiles and clothing industries in Ghana (Adwoa, Eunice & Biney-adoo, 2014).

In Nigeria, the use of CAD-CAM in textile production is at a very slow pace due to a lack of software and knowledge of its application thereby impeding efficiency (Onuoha, 2013). Even though the manually operated machines are being computerized and programmed to produce textile materials, there is little or no study that has provided data on CAD-CAM training, competency, and usage in textile industries in the area under study.

The current government administration through the Federal Ministry of Industry Trade and Investment (FMITI) started some mock assessments on the state-of-the-art technology in the manufacturing sector (Onyeiwu, 2017). This, if done, would uncover the area where the textile industries need to step up in terms of technology level and training in the Nigerian production sector.

As important as the role of CAD-CAM may be, there seems to be inadequate skilled labour and expertise in the area of software application in Nigeria and Africa at large (Pitan & Adedeji, 2012). The woven textile industries in Nigeria recorded a huge success in the 1980s generating up to the growth of 67%, and providing 25% of jobs for over a million people. However, as the world is moving towards a technology-driven era, there seems to be a disparity between most of the Nigerian textile industries' production techniques and the ones in most of the developed countries.

Studies show that Nigeria's over-dependence on oil, foreign expatriates, and foreign textile at the expense of technology-driven textile industry and upgrade may be responsible for the low production . Hence, the researcher intends to focus on the level of CAD-CAM training received and its usage in the textile industries of Northern Nigeria.

Way CAD-CAM?

In the past years, the textile industry in Nigeria flourished and provided revenue for the government (Makinde, Fajuyigbe, & Ajiboye, 2015). This trend has changed in the last 40 years as more of these industries have shut down or production greatly reduced (Plankensteiner & Plankensteiner, 2016). Various scholars have attributed this change to cheaper competitive textile materials from other regions and poor managerial structures (Pitan & Adedeji, 2012). Also, there is a paucity of appraisal studies that gives a clear view of the type of training received by textiles industries' staff in terms of advance CAD-CAM technologies. Additionally, there is little information on the mode of the training offered that can enable the textile industries in Northern Nigeria to compete favourably. Hence, this study, therefore, assess the computer-aided design and computer-aided manufacturing training received and its usage in the textile industries of Northern Nigeria.

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Background

CAD is the use of technology in the design process which consists of specialized software (depending on the particular area of application) and peripherals that, in certain applications, are quite specialized (Mitreva & Taskov, 2014). On the other hand, CAM is a technology that aids in the manufacturing of a product with greater efficiency, effectiveness, and precision. According to Edelhauser (2014), CAD-CAM technologies are concerned with the use of computer software and hardware in various disciplines to perform certain functions in design and production with greater efficiency, effectiveness, and precision for competitive advantage.

Globally, CAD-CAM has gained acceptance in industries since the early 1970s. In developed countries, CAD-CAM is used in the design for mass production and mass customization to boost production in the textile and apparel industry (Dzikite, 2015). Mao (2015) affirms that CAD-CAM technology is the third phase of the industrial revolution era of mass production. Hence, many developed countries are quick in applying CAD-CAM in most manufacturing sectors to build competitive capacity and a strong economy.

Countries like the USA, Britain, China, Italy, France, Japan, and Germany have embraced these technologies in the various production processes such as designing, production, communication, retailing, advertising, and marketing of goods and services for product value addition (Zhang et al., 2014). These technologies are used as major tools in every human activity by many manufacturing industries. CAD-CAM application by manufacturing industries covers a wide range of processes. These includes automobile industries, ceramic and glass, textile and apparel industries for design and production (Ríos-Zapata, Osorio-Gómez & Mejá-Gutiérrez, 2014).

The Application CAD-CAM by Textile Industries

In developing and low-income countries, studies have revealed that South Africa, Tunisia, Mauritius, and Madagascar are ranked as the leading countries that use computer technologies to some level in design and production (Fukunishi, 2014). In Nigeria, several studies have revealed the need for CAD-CAM integration in textile production (David, 2015). This study, therefore, seeks to fill this gap by ascertaining the level of awareness of the CAD-CAM program in textile industries of Northern Nigeria. This study, therefore, seeks to fill this gap by ascertaining the level of awareness of the CAD-CAM program in textile industries of Northern Nigeria.

Suneel & Moulali (2016) document that CAD assists textile designers in simulating the complete life cycle of textile production from conceptual to parametric design; creation, testing, prototyping, modification, analysis and optimization of a design. Today, many textile industries have found the technology to be very suitable and flexible method for textile production thereby helping them meet the market target, quality, efficiency and competitive advantage.

In recent times, cumbersome traditional textile production processes are now made easier, faster, quicker and smarter by the use of technology (Dzikite, 2015). These technologies have brought a complete turnaround in the textile industries by aiding mass production, mass customization and shortening the product lead time with a focus on customer satisfaction and prompt delivery (Lazarevic, Cosic, Lazarevic & Sremce, 2014). Hence, the use of computer technology to perform some tasks in textile industries has become very crucial. The technology enables textile designers in designing new models, textile engineers at the garment development process and retailers of garments at performing their selling activities. However, these technological innovations and achievements cannot be ascertained in Nigerian textile industries, hence, this study aims at establishing the availability of CAD-CAM program in textile industries of Northern Nigeria.

CAD-CAM adoption in textile design by many industries was as a result of a search for suitable and flexible textile production methods to meet the market target, quality, efficiency and competitiveness (Najy, padhye, Wang & Chatterjee, 2013). CAD-CAM technologies also enable visual presentation between clients and designers without any form of a physical prototype. Aesthetic design modification can quickly be carried out in response to the customer's feedback and market changing demands. Hence, errors and material wastage

associated with the traditional method is highly minimized (Pra, Machado, Del, Netto & Alegre, 2015).

The CAD program takes over the manual designing and creation of imprint process in the textile industry, while CAM programs the mechanical or manual manufacturing aspect. The CAM software needs to analyze the coded CAD design model before it can compose a proper set of fabrication instructions for the production. These technologies are moving in the direction of greater integration of design and manufacturing, two activities which are traditionally treated as a distinct and separate function in production form (Kaiser et al., 2015).

There is a high growing textile and apparel market globally. Therefore, the application of CAD-CAM by the developed countries indicates that the future of the textile and apparel industry depends on its usage(King, 2016). Sinha (2015) affirms that the Organization for Economic Co-operation and Development (OECD), documented textile and apparel as the biggest export, accounting for about US$610 billion and contributing 4.3% of the world's exports worldwide with China on the lead and followed by Hong Kong, Italy, Germany, the United States, and India.

According to experts' prediction, this demand will continually be on the rise. Thus, the employable capacity of the future lies with the textile industries (Ujiie, 2014). These aforementioned countries were able to achieve this economic and employable state as industries because of their effective and efficient use of CAD-CAM technology. However, this cannot be realized if developing and low-income countries continue to run on labour-intensive textile industries.

Fukunishi and Yamagata (2013) documented that in the whole of sub-Saharan Africa, only Madagascar can boast of having a viable textile market in the region. Fukunishi's (2014) study that compares Kenya and Bangladesh apparel industry revealed that lack of technology usage and persistent labour-intensive textile industries are the fundamental reasons for immiseration in the region. Fukunishi et al. (2013) reveal that Madagascar's viable textile and apparel market was as a result of high CAD-CAM usage.

Onuoha's (2013) account of West African textile and apparel market also concurs with that of Fukunishi (2014). However, Onuoha (2013) reveals that the huge population in West Africa was not properly utilized for strategic marketing advantage as used by Asian countries to build a strong competitive industry.

To juxtapose between West Africa and Asia, Onuoha (2013) further observed that the Asian countries made use of CAD-CAM technology to meet the internal demand/consumption of their huge populace. In contrast, a report by Advisory (2017) asserts that the textile industry in West Africa is lagging behind in meeting the vast demand of textile materials in the region. The competitive capacity is also a big challenge due to slow technology implementation (Adwoa, Eunice, & Biney-aidoo, 2014). Hamma-adama, Kouider, and Salman (2018) state that there is sufficient hardware in many establishments in Nigeria, but that they lack the available CAD-CAM software.

Additionally, study findings by Balogun, Otanocha, and Ibhadode (2018) observed that the CAD-CAM technology is gradually becoming available to fabricate parts in other production sectors such as construction firms although the level of its availability is yet to be ascertained. Hamma-adama et al. (2018) study on construction firms further found that there is a significant correlation between software availability and the implementation of CAD-CAM technology. This study, therefore, intends to establish the relationship between the availability of CAD-CAM program and CAD-CAM usage in textile industries of Northern Nigeria.

Method And Materials

This study used a cross-sectional descriptive survey to collect quantitatively data. Purposive sampling was used in selecting the states and industries. Stratified sampling was used to divide the unit of analysis into strata such as CEOs, designers, and technologists. Census sampling was used in selecting eight CEOs. A sample size of 152 was selected from a population of 196. Self-administered questionnaires were shared to CEOs, designers, and technologists with a response rate of 96.1% (146). The data collected was analyzed using statistical package for social science (SPSS) 20. Descriptive statistics were used to generate, group and summarize the data in terms of tables, percentages, means and standard deviation. Pearson's correlation was also used to determine associations between CAD-CAM training and CAD-CAM usage in textile industries of northern Nigeria. Also, a linear regression was performed determine the relationship exist between independent variables and the dependent variables.

Table 1.1: Response Rate

Respondents	Target no. of respondents	No. respondents Achieved	Percentage achieved
Designers	58	55	**94.8%**
Technologist	86	83	**96.5%**
CEOs	8	8	**100%**
Total	**152**	**146**	**96.1%**

Out of the 152 questionnaires distributed, 146 were successfully completed, collated and used for the analysis which accounted for ninety-six points one percent (96.1%). According to Mugenda (2003), a response rate of seventy-five percent (75%) is adequate for analysis and reporting. Hence, a response rate of 96.1% for the current study is therefore considered an adequate rate to base the study conclusions.

Results

Descriptive Analysis of Independent Variables; Identifying the Level of CAD-CAM Training Received in Textile Industries of Northern Nigeria

The study sought to identify the level of CAD-CAM training and CAD-CAM usage in textile industries of Northern Nigerian.

Table 1. 2. Level of CAD-CAM Training Received

S/N	VARIABLES	SD	D	U	A	SA	Mean	SD
1.	Received Training	15.1%	16.4%	22.6%	24.0%	21.9%	3.21	1.36
2.	Formal Training	18.5%	16.4%	20.5%	24.0%	20.5%	3.12	1.40
3.	[illegible]	16.4%	15.8%	21.9%	23.3%	22.6%	3.20	1.39
4.	Collaboration	44.5%	27.4%	0.7%	18.5%	8.9%	2.20	1.40
5.	Cert and Diploma	19.2%	16.4%	21.9%	23.3%	19.2%	3.07	1.39
6.	Degree above	18.5%	15.8%	21.9%	23.3%	20.5%	3.12	1.40

Notes: SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree, M = Mean, Sd. = Standard deviation

The results from table 1.2 indicate that 21% of the respondents strongly agreed that they have received training, 24.0% agreed that they received training. About 22.6% of the respondents were undecided on training received, whereas, 15.1% of the respondents strongly disagreed that they had received any form of training in the CAD-CAM technology and 16.4% said disagreed.

Responses on formal training revealed that 20.5% strongly agreed that they had received formal training in CAD-CAM technology, with 24.0% respondents indicated agreed. Twenty one point nine percent (21.9%) remained undecided while 18.5% of the respondents strongly disagreed that they had been formally trained in CAD-CAM technology where as 16.4% disagreed.

With regards to informal training in CAD-CAM training revealed that 23.3% strongly agreed that they had informal training, 21.9% disagreed that had any informal training.

However, out of 146 respondents, only 20.5% were undecided, while16.4% strongly disagreed that they had not received any informal training and 15.8% said they disagreed. Nearly half of the respondents (44.5%) strongly disagreed that there was any training collaboration between textile industries and the institution of learning or CAD-CAM software developers, 27.4% disagreed on having any form of training collaboration. Zero point seven percent (0.7%) were undecided, whereas 8.9% strongly agreed that there was training collaboration between textile industries and the institution of learning or CAD-CAM software developers and 18.5% agreed that they was training collaboration.

Only 19.2% of the respondents strongly agreed that they had either a certificate, nearly a quarter (23.3%) who said they disagreed that they had a certificate or ordinary diploma in CAD-CAM technology, while 21.9% remained undecided. Furthermore, 19.2% said they strongly disagreed that they had either certificate or ordinary diploma in CAD-CAM technology, 16.4% of the respondents disagreed. Those who strongly agreed that they had either a Higher National Diploma (HND)/degree and above in the CAD-CAM technology were 20.5%, 23.3% agreed that they had either a Higher National Diploma (HND)/degree and above in the CAD-CAM technology, while 21.9% remained non-committed, and 18.5% strongly disagreed that they had possessed HND/degree and above, whereas 15.5% respondents disagreed they had HND/degree and above.

Pearson Correlation Analysis

Pearson Correlation analysis was conducted in order to test the association that exists between the CAD-CAM training as it relate to CAD-CAM usage in textile industries of Northern Nigeria. The study used an F-test statistics to determine whether a relationship that exists among variables could be generalized to the population that was represented in the study sample. The *t*-test was used in statistics to evaluate the individual relationship between each independent variable and as they relate to the dependent variable.

Table 1. 3: Relationship between CAD-CAM Training and CAD-CAM usage

SN	Variables	r	p-value
1.	Received Training	.896**	0.00
2.	Formal Training	.964**	0.00
3.	Informal Training	.883**	0.00
	Collaboration	-0.45	0.59
4.	Training Cert and Diploma	.853**	0.00
5.	Training Degree above	.968**	0.00

Table 1.3 indicates that the result of Pearson correlation of CAD-CAM training and CAD-CAM usage show that CAD-CAM training was positively and strongly associated with CAD-CAM usage (r=0.896, p<0.00). The Pearson table 1.3 also reveals that there was a positive and strong association between formal training in CAD-CAM and CAD-CAM usage (r=0.964, p<0.00), and informal training in CAD-CAM was positively and strongly associated with CAD-CAM usage (r=0.883, p<0.00). The Pearson result for collaboration between industries and learning institution indicated a negative and moderate association with CAD-CAM usage (r=-0.45, p>0.59). The responses of those who have a Certificate or Diploma was positively and strongly associated with CAD-CAM usage (r=0.853, p<0.00). Likewise, for those who have a degree and above, the response was positively and strongly associated with CAD-CAM usage (r=0.968, p< 0.00).

Table 1. 4: Hypotheses Test for CAD-CAM Training .

S/N	Hypothesis by Objectives	Beta	T	p-value	Decision
1.	CAD-CAM Training and CAD-CAM Usage	0.686	13.117	0.01	**Reject Ho_1**

The null hypothesis (Ho_1) states that there was no significant relationship between CAD-CAM Training and CAD-CAM usage in the textile industries of Northern Nigeria. Based on the findings in table 1.4, the t-statistics and the p-value of CAD-CAM Training indicated t=13.117, $p \leq 0.00$, and $p \leq 0.00 \leq 0.05$. This implied that there was a significant relationship between CAD-CAM Training and CAD-CAM usage in the textile industries of Northern Nigeria. Hence, the study rejected the null hypothesis.

Discussion

CAD-CAM Training and CAD-CAM Usage in Textile Industries of Northern Nigeria

CAD-CAM training responses showed that most (45.9%) of the respondents received training, 45.1% of the respondents had received different mode of training; ranging from formal to informal. Prior studies have noted that the growth of a nation depends, to a larger extent, on the level of the resourcefulness of the people which, to a great degree, relates to the quality of the training (Bukar & Timothy, 2013)..

The findings of this study concurs with Bukar and Timothy (2013), because this study has shown that there are more people that received informal training (learning on the job) are less than those with formal training. Among those who had received formal training, 43.8% had a degree and above and 42.5% had certificates and diplomas.

This finding is comparable to other research in different parts of the world. In South Africa, Northern America, Western Europe, Asia/Pacific, and the rest of the world, several studies have revealed that there are textile industries' workers who have received some level of formal training in diverse CAD-CAM packages Makinde, Mpofu, & Popoola, 2014; Wallace, Trkay, Peery, Chivers, & Radniecki, 2018; Thomson, et al., 2018; Zhang, 2014; Yixian, et al., 2014; Afshari et al., 2011). However, the current study disagrees that there was any training or collaboration between Nigeria's textile industries and the institution of learning or CAD-CAM software developers that would help in improving the training of workers in CAD-CAM technologies.

In the Africa regions, for instance, studies in East Africa have revealed that workers in fashion and textile design received different mode of training (Oigo, 2012; Kamau, 2012; Isika, 2014; Massa, 2015: Omondi, et al., 2016). Similarly, studies around North Africa and South Africa on trained textile staff revealed that the workers have received different mode of training such as formal and informal (Dzikite, 2015). Also, studies in West Africa are consistent with the current study findings that textile staff received different mode of training in CAD-CAM program (Eric Bruce-Amartey Jnr, 2014; Kelani & Gado, 2018).

Although the responses showed that there was training, the respondents who received both the formal and the informal training were less than half (45.2%) of the total sample size. This implies that there is the need for more staff to receive a formal training programs in CAD-CAM technology in the textile industries of Northern Nigeria. Related findings also reported that lack of training, capital, and flexibility to change in production methods were reported to be hampering CAD-CAM usage (Abdi & Achache, 2018; Eliassen, 2012; Ibeagha, et al., 2015).

Additionally, it is not surprising that in Africa, a

good percentage of textile industries' workers lack the necessary training in CAD-CAM program (Mado-alabi, 2014). Kamau (2012) notes that there are inadequate training and staff development programs on state-of- the art technologies (CAD-CAM) to undertake a textile and apparel CAD-related program. More so, Fukunishi's (2014) studies on South Africa and Mauritius concluded that lack of availability of CAD-CAM program and CAD-CAM training is still prevalent among most African countries.

A study in South Africa's mining industries on CAD-CAM usage indicates that the industries are marred by inadequate training leading to skills shortage (Makinde, Mpofu, & Popoola, 2014). Similarly, empirical investigations have also shown that the employees of textile and apparel industries in developing and low-income countries lack formal training with the high level of incompatible skills (Staritz & Frederick, 2016). These findings on Nigerian textile industries may probably be explained by the country over-dependency on the oil sector instead of investing in other sectors such as the textile industries CAD-CAM technology (Kraak, 2015).

The correlation analysis of CAD-CAM training indicated a strong and positive association ($r=0.973, p<0.01$) with CAD-CAM usage. This suggests that a unit increase in textile staffs CAD-CAM technology training, would lead to an improvement in their level of CAD-CAM usage. The finding is further supported by Kisato (2014) who opines that a person with higher education stands a better chance of manipulating these advanced technologies than those who are not. This has further been confirmed by Hamma-adama, Kouider, & Salman (2018) who state that there was a relationship between the level of training and CAD-CAM practice.

Findings

CAD-CAM Training and CAD-CAM Usage in Textile Industries of Northern Nigeria

The objective one, to identified the level of CAD-CAM training received and CAD-CAM usage in textile industries of Northern Nigerian. It was also established that most (44.2%) of the workers received either formal or informal CAD-CAM training. There are more workers who received informal training (learning on the job) than those that received formal training. However, there is no training collaboration between textile industries and the institutions of learning or CAD-CAM software developers to help in improving the skills of workers in CAD-CAM technologies. Additionally, among those who received formal training and had a degree and above were (45.8%), while those who had certificates and diplomas were 42.5%. The workers who had received both the formal and the informal training were less than half (44.2%) of the total sample size.

The study has established that CAD-CAM training is strongly and positively associated with CAD-CAM usage. This implies that when training among textile workers improves there will be an improvement in the level of CAD-CAM usage among textile workers in textile industries of Northern Nigeria, hence there is a need for more staff training program in CAD-CAM technology.

Conclusion

Based on the findings, the study concluded that less than half of the workers received both formal and informal training. More of workers had received informal training when compare with those that had formal training. Those formally trained had certificates, diplomas degrees and above. But most of the workers who had informal training were only trained on

the job and not from software developers or any other collaborators. The study also revealed that CAD-CAM training has significant relationship with CAD-CAM usage in textile industries of Northern Nigerian.

Recommendations

Leaders of textile industries should encourage workers to undertake formal training and re-training courses in CAD-CAM technology to improve their efficiency and frequency of CAD-CAM usage and also to get up-to-date knowledge of the latest CAD-CAM technology. Textile industries stakeholder and government should collaborate with other training bodies such as textile institutions of learning and software developers.

The study recommends that;

There is a need to conduct an in-depth study on other factors that are affecting the effective and efficient use of CAD-CAM through incorporating a wider population. Textile workers' union, leaders and staff of Nigerian Federal Ministry of Investment, Commerce and Industries, institutions responsible for training textile designers could be included in the study in order to have their views on other factors affecting CAD-CAM usage in textile industries of Northern Nigeria.

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