The Level of awareness of automation technology in the construction industry.

O P Fadamiro¹ and A E Oke²
Federal University of Technology, School of Environment Technology, Department of Quantity Surveying, P.M.B. 704, Akure, Ondo-state, Nigeria.
E-mail: sefpatty@gmail.com and emayok@gmail.com

Abstract. The rapid development of infrastructure in a developing country like Nigeria may require the construction industry to totally embrace the innovative and advance technique of construction through the adoption of automation technology, so as to make construction project more valuable, enhance projects performance and stay competitive in the global and international industry. This study is strictly tailored towards investigating the level of awareness of the automation technique identified in the literature review section of this study. The study employed a cross-sectional survey design using a quantitative approach. A total of 191 construction professionals which include majorly the Architect, Builder, Engineer and Quantity Surveyor were the respondents for the study using a well-structured questionnaire. The questionnaire was designed on a five (5) point Likert-type scale having 5 sections of question in all. Data analysis were done using MIS, SD, Kruskal-Wallis and SNK Test. Twenty (25) automation techniques were pin-pointed from previous literature and materials that are linked with automation in construction industry. Study revealed that Computer Aided Design (CAD), cranes and Building Information Modelling (BIM) are the top three (3) techniques that are most aware of in the construction industry, while Concrete electric and infrared curing system, Humanoids and Contour crafting robots has the least rating. The study recommended seminars and workshop themes that are tailored towards the benefit of adopting automation in the construction industry. However, this research focused on level of awareness of automation techniques, future research can focus on cost implication of those techniques

1. Introduction
Science and innovative technology is rapidly developing and growing increasingly all over the universe at a level and speed that has certainly not been witness in the time past. The construction industry is well-structured, universal and a very large industry and contribute extensively to the nations international or global finances in areas like job creation, infrastructure, investing in the economy and massive contribution to Gross Domestic Product (GDP) [1]. The construction industry makes up about 25percent of the Gross Domestic Product (GDP) in developing countries and 10percent of the Gross Domestic Product (GDP) in countries that are developed [2]. The season of the countries national buoyancy are commonly linked to the periods where construction activity is at its peak in the country [3]. The level at which the construction industry affect the general environs is being consider through a wide range of its activities. As a result of the impact of construction industry on the environment, the industries have since embraced new and improved technology refer to as automation or industrialization in other to stay competitive and relevant in the international arcade [4]. Industrialization is described to be a broader modernization method of construction by transformation
and the improvement of advanced techniques of manufacturing and innovative technology system, usually manufacturing works [1]. Mechanization and automation in the construction industry are viewed to deliver tasks faster than humans at job sites, construction service providers are also expected to complete tasks in time with high quality of construction product when using these innovative technologies [12]. In order to totally embrace automation in the construction industry. The researches that has been done so far on this innovative and advance technology focus more on the perceived impact and Barriers of automation in the construction industry where it has not been fully exploited. In addition to the previous researches, this study was conducted to fully investigate the level of awareness of construction automation techniques in Nigeria construction industry with an opinion of creating awareness among construction professionals and providing a template for enhancing project performance in the Nigerian Construction Industry through the adoption of automation principles.

2. Overview of Automation in the Construction Industry

Construction has been prevailing since the creation of man. Starting from the well-constructed great pyramids of Egypt and the magnificent Great Wall in China to the most recent projects such as improved method of constructing subways, skyscrapers, bridges and factories [13]. Construction has been a human effort for generations in all parts of the world [5]. The construction industry plays an essential part in ensuring the needs of the country’s infrastructural and economic improvement is met. Approximately seventy percent (70%) of the nation’s funds goes into the construction industry year after year [6]. In many countries the construction industry has, however, attracted criticism for inefficiencies in outcomes such as inferior working conditions, occupational safety, labor shortage, decreasing quality and productivity, all these issues linked with the construction industry have paved way for the possibility of more revolutionary resolutions within the industry in terms of safety of construction workers, quality of construction product and productivity. The prospective competency to achieve higher output of products at a lesser unit cost, with improved quality of construction products could develop universal effectiveness, since the construction industry demands operative construction organizations, well-organized construction procedures and advanced construction procedures to efficiently play crucial role under increasing globalization market competition and technological innovation in the twenty-first century [7]. As a result of the problem faced by the construction industry, the industry has since embraced the innovative and technologically advanced method of construction which is “Automation” in order to remain relevant in the international arcade and in order to achieve better quality of projects. Adoption of automation technology are viewed as a means to solving the problem faced by the construction industry [14]. As a result of the rapid growth and development of computer hardware and software in the earlier years, vital improvement can be pinpointed in areas like monitoring, transportation, localization, mapping, robotic control, sensing, vision and planning of modules. Furthermore, the application of automation in construction industry will result to lesser use of skilled and unskilled labor, timely completion of projects and cost incurred in executing a project will be minimal, thereby eliminating the high level of risk to the lives of the skilled and unskilled labor. The application of Automation has had a remarkable effect in a wide range of industries beyond automobile and manufacturing, where it all originate. According to Vaha [8] important reasons for the use of automation technology was highlighted by some industries applying the technology to their projects and some of the reasons given are: quality and reliability, standardization of components, safety of site workers, improvement of productivity, favorable working conditions for construction workers, reduction in labor costs, minimizing life cycle cost and simplification. The word “Construction Automation” (CA) is simply described as the application of electrical, computerized and machine-driven means in the construction industry in order to accomplish automatic control and smooth operation to ensure occupational safety and wellness of skilled and unskilled labor, increment in quality of construction output, productivity of construction workers and timely completion of projects is achieved [9]. Construction automation are modern type of innovative technology used in the construction industry, this technology involves the combination of electronics, mechanical and computer software to operate robots by using a special code to perform require
functions [6]. In construction industry, the scope for these innovative technologies execution can be broad, cutting across through all the phases of the construction life-cycle, from the designing of the construction projects, through the eventual erection of the structure on construction site, even after the completion of the project, some technologies have been invented for maintaining and operating the edifice, and through to eventual disassembling or demolition of the structure [5]. However, the degree of application of this technologies differs considerably from one construction stage to another, for instance, automation of demolition stage of construction through the use of demolition Robots or the automation of design phase through the application of Computer Aided Design (CAD). It is therefore important to pin-point the automation techniques and different areas of the construction projects life-cycle that is applicable. Some of the automation techniques identify in the literature includes: Demolition Robots, 3D printing robots, Robotic Drones, Bricklaying Robots, Welding Robots, Exoskeletons (enhance a task or ability the human body lacks), Forklift Robots, Repaving robots, Humanoids, Mobile telepresence robots, Hydraulic elevators, Cranes, Repainting robots, Contour crafting robot, Transportation Drone, Surveying Drone, Monitoring Drone, Concrete steam curing system, Automated cutting Grinder, Concrete electric and infrared curing system, Inspection Laser sensor, Global Positioning System (GPS), Computer Aided Design (CAD), Computer Aided Manufacturing (CAM) and Building Information Modelling all this automation technologies and many others helps in smooth operation of construction process [5].

3. Research Methodology
A cross-sectional survey design was used for this study through the distribution of a well-structured questionnaire to construction professionals working with either construction firms, consulting firms, government establishment or client organization in Lagos state, Nigeria. These construction professionals include Engineer, Architect, Quantity Surveyor and Builders. Convenient sampling technique which is a non-probabilistic sampling technique was used to administer the questionnaires. A convenience sample is made up of construction professionals who are easy to reach and have adequate or broad knowledge of automation as well as good knowledge of the construction industry. The questionnaire was designed in two sections: the section A address the important background information of the respondent while the section B part was designed to get information from respondents on the level of awareness of automation technique in the construction industry. Identified automation techniques from literature were pointed-out in a table and 5-point Likert scale was used to seek the views of the respondents. Mean Item Score (MIS) and Standard Deviation (SD) were calculated for each of the identified variables based on the adopted Likert scale, this was used to rank and determine the level of importance of the factors. Kruskal-Wallis test was also employed in analyzing the difference in opinion of respondent based on professional group. Student-Newman-Keuls (SNK) Test was further conducted in this study to further group the sample means that are significantly different from each other.

4. Findings and Discussion
Table 1 shows various automation technique identified in the literature review of the study. Respondents were asked to rate the level at which they are aware of the listed automation techniques. A 5-point Likert scale of Very High, High, Neutral, Low and Very low was used to rate the level of the respondent awareness. Table 1 presents the overall mean and the overall standard deviation result of all the respondent that participated in the study based on their profession. “Cranes” and “Building Information Modelling (BIM) was rated the most by the architect as the automation techniques that is most know to the profession with the mean value of 3.93 and 3.80 respectively while quantity surveyor rated “Computer Aid Design” (CAD) and “Building Information Modelling” (BIM) as the most know techniques. This is partly in line with the opinion of the engineers that believe “Computer Aid Design” (CAD) and “Global Position System” (GPS) are the technique that is most aware of. The builders are of the opinion that “Transportation drone and Cranes” are the most know techniques. According to the overall mean and standard deviation based on professional grouping on level of
awareness of automation, Computer Aided Design (CAD) with (MIS=4.13, SD=1.09, R=1) was rated highest as the techniques that is most aware of. In addition the results showed that Cranes (MIS=3.92, SD=0.99, R=2), Building Information Modelling (BIM) (MIS=3.88, SD=1.17, R=3), Computer Aided Manufacturing (CAM) (MIS=3.85, SD=1.05, R=4), Global Positioning System (GPS) (MIS=3.78, SD=1.20, R=5), Robotic Drones (MIS=3.74, SD=1.10, R=6), Hydraulic elevators (MIS=3.68, SD=1.09, R=7), Transportation Drone (MIS=3.54, SD=1.13, R=8), Demolition Robots (MIS=3.53, SD=0.98, R=9), Surveying Drone (MIS=3.47, SD=1.22, R=10), all these techniques were ranked amongst the top ten (10) techniques in Nigeria construction industry. Other important techniques include Monitoring Drone (MIS=3.45, SD=1.12, R=11), Forklift Robots (MIS=3.42, SD=1.00, R=12), 3D printing Robots (MIS=3.38, SD=1.04, R=13), Concrete steam curing system (MIS=3.38, SD=0.99, R=14), Inspection laser sensor (MIS=3.31, SD=0.98, R=15), Repaving robots (MIS=3.26, SD=0.93, R=16), Automated cutting Grinder (MIS=3.24, SD=1.02, R=17), Repainting Robots (MIS=3.23, SD=1.07, R=18), Bricklaying Robots (MIS=3.22, SD=1.04, R=19), and Exoskeletons (MIS=3.19, SD=1.08, R=20). Furthermore, techniques such as Welding Robots (MIS=3.18, SD=1.11, R=21), Mobile telepresence robots (MIS=3.10, SD=1.16, R=22), Concrete electric and infrared curing system (MIS=3.09, SD=1.03, R=23), Humanoids (MIS=3.04, SD=1.08, R=24) and Contour Crafting Robot (MIS=2.86, SD=1.05, R=25) were ranked as the least technique that is been aware of, in Nigeria construction industry.

Kruskal- walis H test was carried out to determine the difference in the sample means of different groups of respondent relating to the level of awareness of automation techniques. The result of the test showed that there is statistically significant difference between the opinions of the construction professionals because the P-value is lesser than 0.05 (an alpha of 0.05 is used as the cutoff for significance). Chi-square value =9.847; Degree of freedom (DF) =3; P-value =0.020, with a mean rank for Architect 116.50, 87.33 for Quantity Surveyor, 96.81 for Engineer and 80.80 for Builders.

Newman-Keuls (sometimes called Student–Newman–Keuls or SNK) is a post hoc test for measuring differences in means. Once an ANOVA has given a statistically significant result, you can run a Newman-Keuls to see which specific pairs of means are different. The test is based on the studentized range distribution. The second column in the output for the S-N-K post hoc test contains the list of professionals in order from lowest to the highest mean (The mean of the Builder, Quantity Surveyor, Engineer and Architect are 3.2322, 3.3600, 3.4365 and 3.6771 respectively). The third column of the table, identifies the number of subjects in each group. The remaining columns identify the sets of groups that are statistically significantly different from each other. The result from Table 4.4 shows that Quantity Surveyor, Engineer and Architect opinion on awareness of automation in the construction industry are not significantly different from Subset 1 also Subset 2 shows that Quantity Surveyor, Engineer and Architect opinions are not significantly different. The only groups that are significantly different are the Builder and Architect opinion.

Table 1.1. SNK Post-Hoc Test on Level of Awareness of automation.

| Profession         | N   | Subset 1 | Subset 2 |
|--------------------|-----|----------|----------|
| Student-Newman-Keuls |     |          |          |
| Builder            | 33  | 3.2322   |          |
| Quantity surveyor  | 52  | 3.3600   | 3.3600   |
| Engineer           | 62  | 3.4365   | 3.4365   |
| Architect          | 44  | 3.6771   |          |
| Sig.               |     | 0.3128   | 0.0633   |

Based on the ranking using the mean item score (MIS) and the standard deviation (SD), the finding indicated that the Architect are of the opinion that they are more aware of Cranes and Building Information Modelling (BIM) while the Quantity Surveyor are more aware of Computer Aided Design (CAD) and Building Information Modelling (BIM). The Engineer rated high Computer Aided Design
and Global Position System (GPS) and the Builder are more aware of Transportation Drone and cranes. From the overall mean Computer Aided Design (CAD) was rated first followed by Cranes and then Building Information Modelling. The findings are in line with the opinion of Mahbub [10] that described Computer Aided Design (CAD) has a tool that has increased from a mere tool used to communicate and collaborate or design function to encompass improvement in the management and control within all aspects of architectural practices. Computer Aided Design (CAD) gives an image of model towards the design, allows the designer and stakeholder to plan and communicate easily and Information can be kept in the data base to allow for modification by the designers during rectification of error or orders by the client, when change is recommended is easy to change on the computer than starting from the beginning when using paper drawings [11]. The idea of Computer Aided Design is not new in the construction industry, with on-going development constantly providing improvement in the tools used.

5. Conclusion and Recommendation
In order to investigate and examine the benefit of adopting automation in the construction industry in Lagos state, Nigeria, this study has investigated and examine the level of awareness of automation technique. The study on level of awareness of automation techniques based on over mean, standard deviation and ranking of the professional groups revealed that Computer Aided Design (CAD), Cranes, Building Information Modelling (BIM), Computer Aided Manufacturing (CAM), Global Positioning System (GPS), Robotic Drones, Hydraulic elevators, Transportation Drone, Demolition Robots, Surveying Drone, Monitoring Drone, Forklift Robots, Concrete steam curing system, 3D printing Robots and Inspection laser sensor are the top fifteen (15) techniques that are most aware of in the construction industry by the construction professionals while Welding Robots, Mobile telepresence robots, Concrete electric and infrared curing system, Humanoids and contour crafting robot are the least rated automation technique by the construction professionals. These indicate that the construction professionals are not really aware of the last five (5) automation technique. It is therefore necessary for construction professional body (NIQS, NSE, NIOB, NSE) to ensure that some of their seminars and workshop themes are tailored towards the benefit of adopting automation in the construction industry: enlighten them on areas in the construction activity that can be automated and enlighten them on construction automation techniques that are available in the construction industry, in a view to improve project quality and performance through the application of automation technique. The focus of this study was on level of awareness of automation technique in the construction industry. Further research can explain explicitly one of the automation techniques i.e. in terms of mode of application, cost implication and cost benefit. There can also be further research on benefit of the automation techniques in the construction industry.
| Factors                                         | Architect Mean | Architect SD | Surveyor Mean | Surveyor SD | Engineer Mean | Engineer SD | Builder Mean | Builder SD | Overall Mean | Overall SD | Rank |
|------------------------------------------------|----------------|--------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|------------|------|
| Computer Aid design (CAD)                       | 3.66           | 1.01         | 4.88          | 0.32        | 4.33          | 0.98        | 3.13          | 1.20        | 4.13          | 1.09       | 1    |
| Cranes                                          | 3.93           | 0.71         | 4.31          | 0.88        | 3.90          | 1.13        | 3.33          | 0.92        | 3.92          | 0.99       | 2    |
| Building Information Modelling (BIM)            | 3.80           | 0.82         | 4.83          | 0.38        | 3.85          | 1.08        | 2.70          | 1.33        | 3.88          | 1.17       | 3    |
| Computer Aid Manufacturing (CAM)                | 3.61           | 0.89         | 4.31          | 0.92        | 4.08          | 0.97        | 3.03          | 1.05        | 3.85          | 1.05       | 4    |
| Global Position System (GPS)                    | 3.52           | 0.82         | 4.00          | 1.49        | 4.15          | 1.08        | 3.15          | 1.06        | 3.78          | 1.20       | 5    |
| Robotic Drones                                  | 3.39           | 0.99         | 4.10          | 1.00        | 3.92          | 1.14        | 3.30          | 1.10        | 3.74          | 1.10       | 6    |
| Hydraulic elevators                             | 3.58           | 0.93         | 3.96          | 1.24        | 3.84          | 0.87        | 3.09          | 1.21        | 3.68          | 1.09       | 7    |
| Transportation Drone                            | 3.38           | 1.03         | 3.35          | 1.34        | 3.87          | 0.93        | 3.42          | 1.15        | 3.54          | 1.13       | 8    |
| Demolition Robots                               | 3.36           | 0.99         | 3.79          | 0.70        | 3.76          | 0.95        | 2.94          | 1.14        | 3.53          | 0.98       | 9    |
| Surveying Drone                                 | 3.39           | 1.00         | 3.42          | 1.53        | 3.55          | 1.13        | 3.24          | 1.12        | 3.47          | 1.22       | 10   |
| Monitoring Drone                                | 3.44           | 0.88         | 3.25          | 1.03        | 3.85          | 1.26        | 3.06          | 1.09        | 3.45          | 1.12       | 11   |
| Forklift Robots                                 | 3.36           | 0.99         | 3.48          | 1.04        | 3.53          | 0.95        | 3.21          | 1.05        | 3.42          | 1.00       | 12   |
| Concrete steam curing system                    | 3.31           | 0.78         | 3.62          | 0.91        | 3.44          | 1.13        | 2.97          | 0.95        | 3.38          | 0.99       | 13   |
| 3D printing Robots                              | 3.32           | 0.96         | 3.06          | 1.00        | 3.79          | 0.94        | 3.21          | 1.17        | 3.38          | 1.04       | 14   |
| Inspection laser sensor                         | 3.30           | 0.88         | 3.15          | 0.90        | 3.58          | 1.01        | 3.06          | 1.06        | 3.31          | 0.98       | 15   |
| Repaving robot                                  | 3.30           | 0.93         | 3.35          | 0.86        | 3.24          | 0.92        | 3.12          | 1.05        | 3.26          | 0.93       | 16   |
| Automated cutting Grinder                       | 3.48           | 0.90         | 2.88          | 1.06        | 3.55          | 0.91        | 2.91          | 1.07        | 3.24          | 1.02       | 17   |
| Repainting Robots                               | 3.07           | 0.96         | 3.20          | 1.23        | 3.47          | 0.99        | 3.03          | 1.05        | 3.23          | 1.07       | 18   |
| Bricklaying Robots                              | 3.33           | 0.89         | 2.90          | 1.18        | 3.44          | 1.03        | 3.15          | 0.91        | 3.22          | 1.04       | 19   |
| Exoskeletons (enhance a task or ability the human body lacks.) | 3.14           | 1.05         | 3.02          | 1.04        | 3.39          | 1.14        | 3.15          | 1.09        | 3.19          | 1.08       | 20   |
| Welding Robots                                  | 3.30           | 0.98         | 2.92          | 1.17        | 3.34          | 1.03        | 3.12          | 1.29        | 3.18          | 1.11       | 21   |
| Mobile telepresence robots                      | 3.02           | 1.02         | 2.62          | 1.35        | 3.44          | 0.97        | 3.27          | 1.15        | 3.10          | 1.16       | 22   |
| Concrete electric and infrared curing system    | 3.34           | 0.96         | 2.60          | 1.00        | 3.45          | 1.07        | 2.85          | 0.76        | 3.09          | 1.03       | 23   |
| Humanoids                                       | 3.05           | 1.08         | 2.67          | 1.32        | 3.18          | 0.87        | 3.33          | 0.89        | 3.04          | 1.08       | 24   |
| Contour crafting Robot                          | 3.14           | 0.98         | 2.29          | 1.07        | 3.10          | 0.96        | 2.97          | 0.92        | 2.86          | 1.05       | 25   |
References

[1] Kamaruddin S S, Mohammad F M and Mahbub R 2015 Barriers and impact of mechanisation and automation in construction to achieve better quality products Procedia-Social and Behavioral Sciences 111-120

[2] Kim J M, Chi H L, Wang X and Ding X 2015 Automation and robotics in construction and civil engineering Journal of Intelligent Robot System. 79 347-350

[3] Clough R H, Sears G A and Sears S K 2000 Construction project management (Canada: John Wiley & Sons)

[4] Alshawi M and Ingirige B 2003 Web-enabled Project management: Emerging Paradigm in Construction Automation in Construction. 4 349-64

[5] Alexander F 2016 Development of an unmanned autonomous concrete floor robotic trowelling system Proc. Int. symp. Of robotics and automation in construction vol 10 p 79-84

[6] Dantata S A 2008 General Overview of the Nigeria Construction Industry Msc Thesis in Massachusets Institute of Technology

[7] Mahbub R 2008 An Investigation into the Barriers to the Implementation of Automation and Robotics Technologies in the Construction Industry, PhD thesis Queensland University of Technology Quantity Surveying (Australia)

[8] Vaha P, Heikkila T, Kilpelainen P, Jarviluoma M and Gambao E 2013 Extending automation of building construction- Survey on potential sensor technologies and robotic applications Automation in construction. 16 168-178

[9] Hewitt M M and Gambatese J A 2002 Automation Consideration During Project Design Int. symp. on Automation and Robotics in Construction (ISARC) (Washington D.C.)

[10] Mahbub R 2006 Automation and robotics implementation in developing countries: opportunities for Malaysian construction industry Proc. of Int. Conf. on Construction and Real Estate Management (ICCREM) vol 12 p 261-77

[11] Boche F N and Haas C T 2008 Automated retrieval Of project three-dimensional CAD Object in range point cloud to support automatized dimensional QA/QC Information technology in Construction. 13 71-85

[12] Oke A, Aigbavboa C and Mabena S 2017 Effect of automation on construction industry performance Int. Conf. on Mechanics, Materials and Structural Engineering (ICMMESE) vol 102 (Johannesburg: Atlantis Press) p 370-74

[13] Kamaruddin S S, Mohammad F M and Mahbub R 2013 Enhancing the quality of life by adopting IBS: an economic perspective on mechanisation and automation Proc. Association of Malaysian Environment-Behaviour Researchers (AMER) Int. Conf. on Quality of Life (AiCQol 2013). 'Quality of Life in the Built and Natural Environment (Langkawi)

[14] Oke A, Aigbavboa C and Mabena S 2017 Drivers for the application of automation in construction activities Commonwealth Association of Surveying and Land Economy (CASLE-Dar es Salaam) (Johannesburg) p 80-87