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Chapter

Leveraging on Data Sciences: Review of Architectural Practice and Education in Nigeria

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Abstract

Big data sciences demand the significant role of the architect. Particularly, facilitate the birth of an antifragile construction industry and more robust data sciences community of professionals. Skilled community necessary to build sustainable liveable cities with emerging creator's economy. Liveability, well-being, and sense of belonging in the city are connected. Conversely, dismissive attitude by decision-makers towards architectural practice and education, even among architects, in recognizing architecture as data-driven and source of data deserve rethink. Here the chapter demonstrates architects as data scientists and the symbiotic relationship that exist between architecture and 3D computer graphics while highlighting emerging data sciences opportunities and threats. The chapter adopted principally reviews of scholarly literatures, draws from authors' 20-years personal experiences, and industry leaders' views. The language is accessible yet academically concise. The chapter concluded with recommendations, including highlights of big data technologies potential transformation of 3D computer graphics. The implications are policy, design, and education.

Keywords: 3-D computer, graphics, architecture, data science, big data, city, Web 3.0, creators economy

1. Introduction

Do Big Data sciences require any role of the architect? Is there any merit for the dismissive attitude against architectural practice as big data knowledge based? Are the architectural institutions agile and responsive to the transformation opportunities big data sciences are bringing to the architectural education and architects? Is architecture data driven and source of data, including does graphics play any role? The chapter sets out to find the answers. In [1] computer 3D graphics, a term first coined by William Fetter in 1961 to describe his work at Boeing, have played a significant role in the design, engineering, and gaming industry. Nonetheless, the impact on 3D computer graphics, like with all architectural endeavors, of the explosion of big data fuelled by data sciences since 2000 will just be as transformative like the internet (see [2]). While earliest 3D computer graphics can be traced to late 1970s with the 3-D Art Graphics by Kazumasa Mitazawa released in June 1978 is one the earliest [3].

Graphic writing as structured visual expression is not strange in Africa as recognized in [4] “with multiple varied communication tools, including written symbols, religious objects, oral tradition, and body language” deployed in organizing “daily life, enable interactions between human and the natural and spiritual worlds, and preserve and transmit cosmological and cosmological belief systems”. Conversely, Big data is more than communication, powered by the data sciences and associated technologies. For instance, in understanding an individual (for medical or housing needs), big data will include all unstructured and structured forms [4] in addition to the individual’s medical history and other demographic details. To understand industry for operational optimization, as noted in [5] big data “is turning mobility, medical, automobile, and pharmaceutical billions of gigantic data into actionable insights to help make informed business decisions, including all significant industries. Big Data is providing every person 320 times more information provided by the third century store house of knowledge, the Library of Alexandria [2] Blockchain is providing the shared, secured holding and transparency of big data in never before accelerated ways as in video-1 [6]. Nevertheless, a “multifaceted team with complementary skills are needed to realize the full value of big data” [7].

Conversely, the construction industry seems indifferent in harnessing its big data. A few reasons are:

- Lack of effective leadership [8].
- The lack of understanding of the impact and purpose of data sciences in broader society [9].
- Data sciences perceived narrowness, and quick testing and scrutinizing rather than engaging and inspiring has been a discouraging factor among women. Uber, the public cab transport transformer, and the construction Building Information Modeling (BIM) entered the market about the same period in 2009. Conversely, BIM regardless of the potentials beyond design and 3D modeling as buttressed in [10], it has not impacted the construction industry as much as Uber has done to transportation.

Many things have changed, but the architects’ fingers, eyes, and creative intellect are yet valuable means to ends in architecture. The sense organs capture, process, analyse, memorise as part of “database of the mind.” The same is share and enjoy or rejected as pattern, images, sounds, and alike. Depending on the creative database, architects can deliver static non-interactive alphanumeric multisensory models before the emergence of computer 3-D graphics and its rapid advancements. Conversely, the imagination, hands, and simple tools like pencil pen, rule, Set Square, and paper, for another 30 years ahead (as in [11]), the architect, will continue express and communicates aided by standard architectural graphic symbols and elements with understanding of design principles. Discussing graphics, Obina Wodike, an architect and Graphic lecturer with Port Harcourt Polytechnic, noted graphics is not new to human civilization. Wodike buttressed his point tracing graphics to the Biblical times, Egyptian Heliographic, and cited Thomson (1993). Thomson connected graphics and the era when historians, sociologists, linguists, and visual communication students produced art for commercial purposes, including mass consumption or graphic design, with 1986 marking the formation of Graphic Design Education. The importance of “origin” as a continuous influencer of the future progress validating the continuous influence of the seemingly primitive tools -architects finger, pencil, practices, and more- was further buttressed in [12]. Stating, “the origin and practice in unmasking assumptions within current forms and practice” [12] while in [13]

described graphic navigation to imply the manipulation of graphic devices, including organization, hierarchy, line weights, colors, and more on a “surface” which range from a book to a highly complex computer screen. Organizations must embrace learning culture and there must be effective strategies to leverage on emerging opportunities.

2. Literature review

2.1 Brief description

- Graphics: The Cambridge Dictionary gave for Graphic to mean “very clear and powerful” and “having to do with drawings and images” [14]. It is communication by means of standard elements and symbols with creative understanding and design philosophy [13].
- Data: information, especially facts or numbers, collected to be examined and considered and used to help decision-making, or information in an electronic form that can be stored and used by computer (ibid) [13].
- Data Sciences: “interdisciplinary field that uses scientific methods, processes, algorithm and systems to extract knowledge and insights from noisy, structured, and unstructured data, and apply the knowledge and actionable insights from data across a broad range of application domains” [15] data science is different from information science and communication. As concept the term include “statistics, data analysis, informatics, and their related methods in order to understand and analyses actual phenomena with data” [15].
- Data scientist one who create programming codes and combines it with statistical knowledge to create insights from data [15].
- Small Data: For centuries and up till now, small data has been and is useful. We recall experiment, production quality control, social sciences all using small sample sizes to represent the larger population in their investigations [16]. The data sample size can range from 30 to a value determined by Fisher formula [17]. Hardly over a million, relative to big data with sample size in billions and increasing. IBM Watson went through millions of file samples of a patient within few minutes to determine the unique Leukemia that have baffled doctors using relatively negligible data sample over days [18].
- Big Data: Extremely large data set that that may be analyzed computationally and impossible with traditional method to reveal patters trends and association, especially relating to human behavior and interaction; supported in [19] by products, usually useless and unstructured, but insightful and useful when cleaned, labeled, structured, and stored appropriately for secure and safe retrievals.
- Creators economy: An Web 3.0 which will be in sharp contrast with Web 2.0 and web 1.0. In web 3.0 the content creators are owners of what they create (see [20]) Totally different from the current work place and web 2.0 where one works for JP Morgan, Shell, Exxon, Google, Facebook to help create the mega profits, but have no strategic say in the affairs of the firms. They are paid salary- minute of profit- or noting for their creation; “content “created as it is with Google and

Facebook. One man or few decide what the majority do; what to produce, where to, how to, and who gets what, and how the profit is shared.

- Data Scientist From SAS, a “leader in business analytics software and services” has been a leading global business analytic and intelligence software developer since 1976. The 2021 personality survey of data scientists report in [21] identified several personalities of the data scientist. Four relevant to the chapter are: “Deliverers,” “Drivers,” “Voices,” and “Ground Breakers.” In another publication, in Towards Data Science website, Andrew Lombardi (2022) discussed “7 Data Science Projects You Should do to make your resume stand out” (see [22]): Regression project, Classification project, Clustering project, Sentiment analysis project, Recommender system project, Natural Language Processing (NLP) project, Artificial neural network project. The various traits in [21, 22] of data scientist fit the architect discussed elsewhere in [9].

2.2 Transformations and big data

Like hurricane, big data inspired technologies transformations will ultimately blow across the construction industry and only the prepared, agile, and adaptive will survive it. For example:

- IBM Watson machine identified a rare form of Leukemia, including treatments after analyzing millions of data of 60-year patient; that baffled doctors [18].
- In the UK, a Nigerian developed algorithm that identify glaucoma more accurately and swiftly than doctors [23].
- In India, the pharmaceutical industry is joining China to use AI to reduce cost, improve quality and minimize waste [24].
- In Natural Language Processing (NLP) have near perfect human models like WuDao 2.0 and GPT-3 [25].
- In [26] GE Additive Manufacturing (AM) is revolutionizing manufacturing or “mass production of components.” The hand tool-free AM process depends directly on CAD data. It is also called “indirect manufacturing”. MIT Additive Printing, also called 3D Printing, is a process of building an object one thin layer at a time, but with each 3D print head delivering as thermoplastic material deposit multiple layer of the build material. The order of 12000 engines with 19 fuel nozzles per engine for Boeing 737 and the Air Bus 320neo will be achieved by 3D printing (see [26]).
- In animation and simulation, “the divide between the real world and the digital world is getting thinner as shown in **video** [27].

Nevertheless, much of these shall be changed with Quantum computing replacing traditional super computer, as quantum teleporting, and virtual world (virtual reality- VR, virtual augmentation -VA) is fully developed (see [28, 29]). Supporting the view in video-3, Professor Michio Kaku, a physicist discussed the era of “brainet” when “computer chip will cost as little as penny”. A concept beyond fiction, the “brainet” project will mark the era when, like the internet, human brains will be sending signals directly and networking

with other brains [30]. In [31] hint the revolutionary changes Johnson (1984) said will occur in computer-aided architectural design process. An instance, “architects will have to learn to think in the computer’s terms.” Also, in [31] reported uploading or downloading from the human memory is not theoretical but practicable.

3. Architects and architecture

3.1 The architect

The architect is well trained to design buildings and processes of achieving them (see engineer’s view of the architect in [32]). Architecture ranks among topmost toughest courses in the world with students averaging 22.2 hours of study time weekly; 5.28 hours sleep per night compared to seven hours expert recommended [33]. Often called “master builder,” a phrase traced to the original meaning of the word in Greek and Roman renditions. In “English speaking world” it was traced to 1563 and in 1898 (see [34]) A significant product of the architect is architecture, including landscaping which seen in [35] to include building transformed into a living art and expression; not a style. Architecture defines the limit of the city while in [36] “urban planners influence the entire communities with decisions about how areas are developed and even where building can be placed.”

Additionally, leadership in of the building and construction industry may have been ascribed to the architect, but with new solutions from digital construction, computing and simulation, it is being challenged. Indeed, entry of more players from non-traditional construction cores, is therefore challenging the architect’s leadership. Greater burden is on the architect and related institutions if the cap must fit. New thoughts in [37] are demanding a sectional leadership such as architecture management, construction management, engineering management. Also, with concept like integrated project Development (IPD) and “profit distribution of IPD” based on “degree of participation.” Axiomatic to state, “a finished building represents the abilities of more than one individual” [37].

In another study, evidence supports a significant level of ignorance and indifference in the construction industry (see Appendix 1) [9]. All the same, the study demonstrated architect’s leadership among peers in the construction industry with a significant lead of 80 percent in participation. This is despite the equal treatment across selected clusters- architecture, engineering, management, and others [9]. Additionally, the National Building Code of Nigeria, Neufert Architects’ Data and 3D [38], ArchiCAD, AutoCAD. Apple Pencil(with iPad Pro) recently ranked among world-top 25 inventions [39], and in [40] Germany’s most beautiful hydroelectric plant, all have significant big data input of the architects. All these point to the intersection of architecture and data science. Progressing, the chapter will develop and cover the implications of poor data for cities and city users after critical reviews of over fifty purposed sampled scholarly and appropriate articles. Personal experiences and opinions of industry leaders shall be helpful.

3.2 Ignorance and dismissive attitude

The figures below show the survey carried out in 2021 that gave graphic portraits of both ignorance and dismissive attitude of the architect as a professional creating data and significantly with data sciences skills [9]. See appendix 1.

3.3 3D computers graphics and architecture symbiotic relationship

The design process is initially done with a pencil, a ruler, a scale rule, and paper. Then, the process takes a longer time, and relatively inaccurate and significantly limited. Yet they are marvelous works of the likes of Frank Lloyd Wright, and alike. Conversely, limitations were significantly broken with new construction materials, and computer aided design (CAD) gave birth to a greater freedom evidenced in architectural expression clustered under Deconstructivism [41, 42]. Libeskind, Zaha Hadid are few Deconstructivists, see **Figure 1**. The use of modern technologies extends throughout the entire design with distorted surfaces, odd leanings, and fractured wall surfaces. Indeed, possible due to speed, fluidity, and accuracy delivered by CAD which significantly relieved architects of time required for complex forms; for more quality family life or creative endeavors. Also, architectural studios are looking very different compared to a decade ago [42]. In Nigeria, the studios are sluggishly adapting, see **Figure 2**.

Indeed, things have changed with the introduction of CAD and significant architectural practice uses CAD: few are ArchiCAD, Revit, BIM, Chief Architect,



Figure 1.
A fit for Deconstructivism by Zaha Hayed. Credit UNSPLASH.



Figure 2.
Architecture studio: sleepless nights. Credit: Allison.

Lumen360, and Sketchup. These tools make easy the organization of data to be more meaningful visually. Thus, in use more commonly among young people who are quick to practice even as students, heavily patronized by clients seeking for cheap labor and thus, compounding the problem of quackery in Nigeria.

More, 5G, 7D are merging to further reshape the design terrains and how architects work. In [43] the symbiotic partnership (man-computer) will enable “men will set the goals, formulate the hypothesis, determine the criteria, and perform the evaluations. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific thinking.” Design process is not linear, but cyclic for user experience designer because efforts are continually made satisfy the users leaving assumption behind and uncover alternative solutions” [44]. The CAD tools have made the iterative processes easy because design for real people not machines and robots imply understanding complex processes [41, 44]. Further, it empowers the client to make more informed contribution to the design process. From the lens of digital humanities and national development, 3D Computer Graphics is, for example, contributed to the restored sense of pride and patriotism among Chinese young people [45]. The regeneration of the Summer Palace from ruin has turned the once idle ruins into tourist site. With 3D computer graphics the beauty and splendor of the Summer Palace has been fully animated. The ruin site thronged with Chinese young people restored, reliving the past, appreciating the true stories of Summer Palace [45].

All above, 3D computer graphic is important, and noteworthy is the important role played by architects in identifying standardizing, creating symbols, and elements for extracted from ethnographic studies by architects in use by 3D computer graphic community. The standard elements, symbols, minimum dimensions, and other research driven data stored and published in the 680-page Neufert Architects Data authored by an architect, Ernst Neufert indeed testify to interdependent and mutually benefit from each other’s progress (see [38]). More benefits are on the horizon, with Metaverse and creator economy is one the fastest growing sector; in terms of income generation, job creation, and export earnings [20]. View supported in [46] as Internet of value ((IoV), Web3.0, discussed the “risky necessity” “datafication,” “dematerialization,” “platformisation,” in addition to social and resource value awareness” (see [44, 46]) architects as potentially key benefactor will have increasing role to play.

3.4 Architect, as data scientist

Architectural production includes: cities, homes, furniture, and more. In addition, it takes a minimum range of 5-6 year to be qualified to pursue full professional or chartered membership in Nigeria. Thus, architecture is a rigorous and highly educated profession [33] and in [47] architecture as toughest major in America from 2017 survey of global students’ survey by students. An architectural study is one with high incidence of sleep deprivation among students, **Figure 2**. While architects rely on quantitative and qualitative analysis of data to recommend and make decisions, architectures consume about 55% global electricity and contribute about 38% of total global energy related Carbon IV Oxide (CO₂) waste into the environment [48]. As by-product of architecture, big data is elucidated below focusing on waste paper generated in office activities and how big data can be captured for recycling.

The consulting office is involved in design through tender processes to construction, including post-construction activities. The activities are usually accompanied the shredded waste papers which remain useless not until the following action is carried out:

- The waste papers associated with the project are weighed;
- Findings (associated data) standardized, labeled (like design, stage, tender stage, construction stage)
- Related to the project's scale and scope (e.g. per total floor area and project type- shopping mall, residential, and more- which data itself).
- Finally, extraction of meaningful data and information

For instance, assuming the office used and trashed a ton of A4 papers from design to completion of a 1500 square meter floor areas shopping mall. Then, a useful data/information is "1 metric tons of paper wasted per 1500square meter floor area shopping mall; also, 0.67 kilogram of paper per square meter floor area." Another data or information has environmental implications. For example, if producing A4 paper consumes 2-13 litre of clean water (as in [49]) and 52 Kilojoules of electricity in 2015 (as in [50]). Then, the hidden environmental cost of 1 metric ton of A4 paper equals: 0.4–2.6 millions liters of clean water and 10.4 million Kilojoules of electricity to produce 200000 A4 papers as trash). Further, (see Appendix 1) complex data table can be developed by substituting, one at a time, paper with electricity, gasoline, diesel, water, ink, timber off cuts, and more. Comprehensive and AI-Blockchain integrated smart table can predict, recommend, and support decisions, including climate change mitigation strategies. For example, in [51] was business case for Blockchain Carbon trading.

Methodology:

The architect's systematic process is with a loop of thinking, making (build detailed and engaging models), breaking (open to criticism) and repeating (gathering feedback) [52]. Like all sciences, architecture has laws, principles, and theories guiding actions including the manipulations of *numeric and categorial data, structured and unstructured data*. For example:

- Principles include: balance, affordance, feedback, mapping
- Theories: form follow function; architectural design as a social process.
- Unstructured data like surveyor site plan dimensions, client's demographic details (client age, income, and family size), site's vegetation, topographic detail (slope), and ethnographic data like cultural symbols characters. Including narratives are analyzed, clean, labeled, structured, and stored securely for easy retrieval and use.
- Structured *data are clustered* into compatibility, noise area, private areas, and semi- private areas (i.e. data modeled overriding some significance issues).
- Synthesis using real data: models including bubble diagrams, zoning, 3D computer model, physical model, figure. Update data base which indicates the use of "*real data:*" including the use of streaming data to analyze traffic around project site using *modern technologies* like Google Earth, Drones.

Supporting the claim of the science and statistic skills demanded of the architects is in [53, 54]. The use SPSS, graph and reports, of *z-score, t-score, normal distribution*

curve to generalize findings by architects is common. Architects perform *regression analysis* to determine relationship between architectural productions and users' demographics. Indeed, scholars disagree architecture is more complex than machines because humans are not machines. These are useful for decision making [54, 55]: as consultant, public policy maker. For example,

- Household income and house typographic relationship; it is important in housing studies and housing projects.
- Also, regression analysis is used to determine household income, age, or occupation relationship with transit choices (car owner, mass transit, and pedestrian behavior); important for discerning group behavior and infrastructure use patterns; informed sustainable transit infrastructures spatiality in neighborhoods.
- Regression analysis can also reveal motorist most probable behavior when relative to different stress levels such as in traffic, argument, extortions, and noise. It is important in giving insights and determining standards for walkway design, strength and proximity to road, including safety in spaces-places.

Finally, the architect is *open to criticism, creative, team player, analytical, numerate*, with products aimed at making *impact in society*. The data gathered and generated from the above are appropriately managed and stored in the cloud (Google, IBM provide cloud storage services), Dropbox, and alike for easy access and use, including updating data outside the office. Each circle yields more data and progressively better the Design; called iterations. The point is, the architects collect the data, analyze it, label and classify it, and store it safely. He or she also retrieve and use the same for future project or training manual. All these involve using modern tools. They are consistent requirements of a data scientist [56].

3.5 The city

- Smart city

A term that has been the tonic with the political, built-up space, but most commonly the Smart city is understood to mean only a sophisticated computer driven city or even a "laboratory" in [57]. Conversely, other scholars think smart city is not all about a computer city, but that "the value lies in how this technology is used rather how much of it is used" [58]. In support, the chapter point at the intersection of using computer to identify appropriate data and use of such data appropriately. For instance, **Figure 3** indicates smartness rather than poverty; knowing what is sustainable, available, and using it rather than using what is sophisticated, yet on loan, and not sustainable. In other word, to deliver responsiveness in demand, justice, sense of belonging and wellbeing among city users in addition to availability of internet is smartness. In cities, it implies shared risk, wealth, collective decision making were the individual differences of the majority are significantly respected, rather than being over ruled by a few. In [58] data availability, integrity, confidentiality, accountability and operation laws were identified as canonical. Indeed, these requirements are significantly possible by use of AI-Blockchain technologies which is inspiring the big data sciences. As in [5] so, cities' safety and security can be preserved from detrimental



Figure 3
Ijaw stilt house: smart and simple.

behaviors by data analytics of appropriate big data (extracts of terrorists, cells, deviants). City's infrastructures can be more responsive and preserved by citizens when infrastructures associated decisions, policy and laws are democratic in origin [59].

Poor data can impact cities negatively as earlier demonstrated. With disadvantageous data, subjectivation of the city: (a) cities abating crimes, (b) assume wrong identity, (c) anti-citizenship. The fact, AI-Blockchain can also learn the wrong stuff, if errors are not immediately corrected. In that sense, no matter the level of computer sophistications such cities are not "smart". Increasingly as symbols of exploitation, and battlefields of the winner take it all. Yet worsen by financialization and capitalism. Indeed, worst is the thinking of cities as "laboratory" which may justify why extremist as leaders can imagine turning cities into "radioactive ash" [60].

- Leadership Failure and Impact.

Considering architects' big data capacity, so why the disillusionment? Poor motivation. In a conversation the authors had with scholars of the Port Harcourt Polytechnic O. Wodike, G. Irighmah, C. Chendu, F. Dimabo blamed client's unwillingness to financially commit adequately for architectural services as reason for lack "focused research" required for "every project is unique." Thus, the attendant weak "architectural language" development, and repetitive narrative in cities. Besides, clients do not exclude the government while the "digital transformation is no longer optional" [61]. Therefore, poor data in addition to fragmented data culture in Nigeria's construction industry has enabled the impunity and bad image of the sector. In [62] Executive Director of Project in the Niger Delta Development Commission (NDDC) created to provide infrastructural gap in the Niger Delta region, described winning NNDC contract as a winning lottery to emphasize the impunity in the sector. Politicians have hijacked the data management weakness and unrestricted entry.

Today, politicians and public officials seamlessly inflate building and construction projects with a 2021 survey reported 56,000 abandoned projects valued about N12trillion, scattered across Nigerian cities as a result [63]. The construction sector's porosity, simulating a zero knowledge-based sector, has enable misfits into the sector's strategic leadership. Unlike with the health (Federal Ministry of Health), and justice sectors (Federal Ministry of Justice) that allow only doctors and lawyers as ministers and commissioners to head the ministries. In Nigeria, the Ministry of Housing and

Works, Ministry of Transport, and Niger Delta with huge infrastructural budget have lawyers as ministers with so much power. Expectedly, the misfit may account for the huge “debt implication”, “lambasting,” politicizing human right (e.g. right to descent shelter), and corruption [64–66] with impunity. A misfit issue becomes important, with a disadvantageous data management system yet securing infrastructure financing loans from the likes of China [67]. Thus, the demanding leadership and accountability from the construction industry leaders as in **Video** [68].

More details of poor performance:

The Ministry of Transport construction of a USD 1.9 billion standard gauge railway from Kano to the Niger Republic is causing uproar in the Senate, including the citizens [66]. Relative to the dreadful roads plaguing the industrial and commercial hubs, including West Africa largest market Onitsha (South east of Nigeria), the Kano-Niger Republic railway is economically disadvantageous; indeed a symbol of marginalization and insecurity as illustrated in **Figure 3** [66]. In Guardian November 10, 2021, the Nigerian Institute of Surveyor “Call For Subsidence Monitoring & Deformation Study of High Rise Structures” following incessant building and overpass collapses in Nigeria [63].

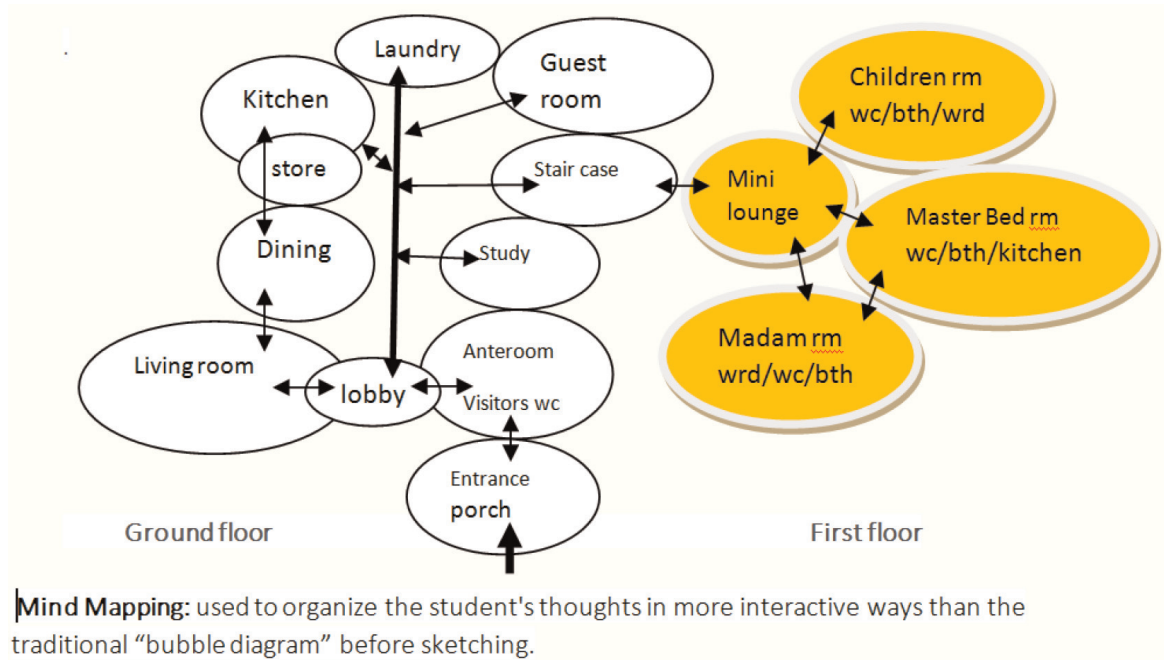
3.6 Possible information and telecommunication technologies for students

As matter of emphasis, it is necessary to dedicate a subsection dealing with possible IT technologies. Architects must constantly seek ways to improve their communication tools and channels to clients and all stakeholders. Thus, this subsection will offer in specific and significant detail the possible data technologies for both students and architects; now and into the future. The list of possible IT technologies cannot be exhausted as more are emerging and others evolving fast too. Below paragraph are few in use and to be use by Architecture students and architects:

Excel, Google form, Mind Mapping tools, Google Earth, others for common graphics editors are: Photoshop, Illustrator, Paint Shop Pro, CorelDRAW, cloud storage. In addition, the Apple Photos plug-in from Macphun, Adobe Lightroom, Digital Image Suite, Canva, and related programs. For designs and animation, 3D data works are Revit, ArchiCAD, BIM, Sketchup, and Mind Mapping software (e.g. Microsoft Mesiere, Yed, see **Figure 4**). While the aforementioned are already in use, the future increasing immersion and free-hand experiences have Microsoft HoloLens 2, SketchUpViewer, demonstrated in Vieo-6. Blockchain, NLP, 7D, 6G, and Digital Twins (DT) as IT technologies the architects will depend in everyday service delivery. A few technologies are discussed next (**Figure 5**).

- *Excel:*

In [69] is “a software program created by Microsoft that uses spreadsheets to organize numbers and data with formulas and functions,” according to Corporate Finance Institute (CFI). In [70] Excel was described “as a way to create nice looking tables of data – things like building programs or drawing lists.” Also, it has mathematical formulas with capacity to analyzing and computing data. ArchiDaily, in the same [70] listed twelve useful Excel formulas for architects few are: SUM, IF, SUMIF, COUNTCOUNTIF, COUNTBLANK, AVERAGE, and more. SUM will enable the performance of mathematical operations on data (i.e. parametric data). “IF” will enable architecture student perform conditional analysis, e.g. IF income is income higher than N300000 monthly group data as “middle income.” SUMIF will enable addition of specific group of data if specific condition if fulfilled, e.g. SUM the number clients,



Mind Mapping: used to organize the student's thoughts in more interactive ways than the traditional "bubble diagram" before sketching.

Figure 4. Bubble diagram achieved by 3D computer graphics with arrows indicating human circulation. Credit: Anita Bala.



Anita, a student, is using ArchiCAD software in computer to generate 3D interactive model of residential homes. A finished Lumen rendered 3D model approved by client is shown next. In future, Microsoft HoloLens 2, selling for USD3000 package will enable Anita, her client, and other multiple stakeholders, irrespective of the individual's locations, to enter the buildings in 1:1 scale. The mix-reality is that: (a) the design is automatically updated for any change made. (b) they can be in the same or different space, moving items to desired positions, handling the same equipment, tools, and appliances while experiencing the spaces and fixtures (kitchen work-top, sockets, wc, bath, columns, lamps, windows, etc).(c) The spaces and places can be altered together like in real world. Credit Anita

Figure 5. 3D graphics and Data use is serving as an essential component of computer-assisted learning system. Mix-reality, a future .But current in market at USD45000 with Microsoft HoloLens 2 which is mix- reality headset will be increasingly use for interaction.

IF income is above N300000monthly. The COUNT function counts specified element in cells, like none parametric data- "Female", "Married" and as such. In addition, Excel makes easy the non-pleasurable aspects in real estate. For instance, the

management of land related complex and multiple sales demands involve keeping track of different measurable areas, associated varied facilities, areas for outright and installment purchases, and lease areas.

Kilkelly further acknowledged, Excel offered, “a lean and mean Excel spreadsheet accurately calculated the leasable area. Using the formulas I had built, we could quickly play out scenarios for our client” [70]. The point is, Excel is suitable for: Data input, Data management, Accounting, Financial analysis and analytics, Charting and graphing, Programming, Time management, and Task management (as in [69]).

- Tablet and Digital Art

Other than desktop, Laptop, powerful tablets have emerged to take make digital arts easy and handy. Apple Pencil, Gamon PD1560 15.6, Wacom Cintiq 22, Xp-Pen Artist Display 22R Pro, HuionKamvas Pro-Pro 22, while in [71] listed top ten “architecture apps (that) have completely altered the working habits of architects” to include: (a) DroneDeploy “developed to care to the growing need for aerial site intelligent software,” (b) “ArchiSnapper is a field reporting App that allows users to efficiently draft a report during site visits- users can take photo, draft and comment and the app generates seamlessly the report,”[71] others are Shapr3D(IOS), and RoomScan Pro. The 3D modeling process produces a digital object of value that can be sold, hired for fee, transferred as valuable gift. One of such object as None Fungible Token (NFT) like rear art can be sold for thousands to millions of dollars. In [72], for instance, the “Artist Beeple’s Crossroad fetched \$6.6 million on Nifty.” Few architects are now specializing in building NFTs: owning virtual estates, including cartoon characters, and football stadium, like in the real world.

- Blockchain

Looking at HoloLens 2 and SketchUpViewer demonstration, blockchain value emerges as it can permanently keep track of all changes, clients approvals, and serve as basis for undertaking contract. Thus eliminating copyright violation issue, and providing evidence for contract violation. In future, a combination Microsoft HoloLens 2, SketchUpViewer, digital twin (DT) technologies, and additive manufacturing or printing all on Blockchain would make it impossible to violate construction in terms of design and specifications. A very common trend in Nigeria: roads built without drainage, kerb removed, and asphalt thickness highly compromised.

- Photoshop, Lightroom, and Adobe Illustrator.

Architectural profession involve the use of photography which good marketing tools and skill. Students are taught photography as core course. It is important in content creation for books, magazines, gallery, and graphical objects enhancement. A picture “is a thousand word” declared wisdom; even so, the quality matters. Adobe Photoshop is one such powerful tool for high quality photo editing. The Lightroom as an editor and organizer is judged much better than most photo editing alternatives tools, including photoshop for easy and light manipulations. For example, with over 100 possible different filters settings Lightroom can improve a given poor quality image to great photograph for different themes: landscape, food, city view at night day, construction sites, presentations, and more. Nevertheless, alternatives to

photoshop are many. Adobe Illustrator, according to the Graphic Design Institute's publication also facilitates creating stunning art.

3.7 Possible information technologies: the future of architecture

Looking at the future, some technologies are already in the market including payment systems. Before considering HoloLens 2, that chapter will present a case that may support the invalidation of fear by architects over losing jobs to computers; the case of Web 3.0 and None Fungible Tokens (NFTs).

- None Fungible Token (NFT):

Which are digital objects of unique kind- two cannot exit. Paola Tasca, the Executive Director, UCL Centre for Blockchain Technologies in [73] recommended "tokenise business model," "tokenised economy" "tokenization of everything" [74]. Architecture students' photos can be digitized. Then, using algorithm converted into NFTs. Original outstanding architecture sketches, hand drawn inclusive, can all be tokenized. There increasing importance is not in doubt with the emerging Web3.0. Indeed, 3D objects are vital in character animation and special effects processes because they can be animated. Described as digital artwork, and "unique cryptographic token" (NFT), Sharma quoted JPMorgan analysts: "the monthly sales of digital tokens (NFT) 'hovers' at around \$2 billion"[72]. In [73] recommended "tokenise business model," "tokenised economy" "tokenization of everything" [74]. "The collapse of Moore's Law" [75, 76], in addition, educational systems and business enterprises are adopting computer graphics for data visualization, graphical data processing, interactive learning, immersive learning, virtual and augmented reality, presentations" [77].

- Microsoft HoloLens-2.

Introduced in 2019, the Microsoft HoloLens-2 is a pair of mixed-reality smartglasses developed and manufactured by Microsoft, **Figure 6**. It unveils the future of the free-



Figure 6. Microsoft HoloLens-2 introduced in Spain at the Mobile world congress in February 24, 2019 with USD3500 pre-order value. While picture speaks 1000 words, a walkthrough video speaks a thousand pictures. Credit: Anita to AJP.

hand computer. It has Bluetooth, camera, CPU, sound, and holographic lenses. The tool enables students to pull out the 3D graphics design and virtual tools from the computer into the real world or project site. With free hands -not mouse, or pen – any objects can be manipulated like in the real world. Architects, engineers, and clients can with their hands measure headroom, touch, move things to desired positions- life size or reduced scale of things. In more realistic ways, the Hololens-2 saves architects (AEC professionals) the stress of many explanations of ideas by providing the same capabilities of the real world into the virtual world (mix-reality). Microsoft demonstrated possibilities of Holocene-2 is in [78] video-6, in [79] **video** and in [68] **video 3**. Indeed, the immersion will enable reduced amend reoccurrences, step up the tempo of design, and manage customers in new ways. Further, students can identify risk earlier and accurately from design through to construction.

- Digital Twin (DT).

Yet another interesting and possible IT technology for architectural uses is DT; which enables architects, students, and schools to collaborate like never before in real time, with real world experiences. In [80] DT will enable sharing the power of super computers hosted in cloud as algorithm; used for complex computation and visual simulations. For instance, building performance in earthquake, flood, and high genetic impact: such as accident or terrorist attacks. Also, in additive printing with powerful sensors, DT can enable changes in CAD drawings to be automatically updated and reflected physically at construction site. Today, such is not possible as changes in CAD drawing may take days and weeks to be implemented at construction site.

Ordinarily, a significant number of tertiary institutions of architecture and engineering in Nigeria can only dream of such super computer hardware, but with DT the narrative may be different. DT of such hardware computer is affordable yet without compromising performance quality relative to that of the corresponding hardware (physical twin). Amazing opportunities of instinctual interactions, collaboration of students and lecturers across national borders can best be imagined [81]. For example, imagine MIT, Harvard and Port Harcourt Polytechnic sharing the same equipment, faculty members in real time without need for travel. Internet of Things (IoT), Industrial internet of (IIoT), and Internet of Value (IoV) powered by powerful sensors are fore runner of DT technologies opportunities.

- SketchUpViewer.

SketchUp is architectural software like ArchiCAD, with many use savvy students. Collaboration with Microsoft to release SketchUpViewer that is compatible Holocene-2 is game changer: see video 6. So, students can draw with the computer, but also can pull-out the designs into the real world before construction- mix reality. The point is, 3D data interaction are getting better giving students and architects more free time for more creative none stereotype activities. Also, greening the process by eliminating work travel need, waste, and enabling one-to-one interactions of human-to-human, human-to-machine, including the virtual-to-reality [81].

- Educationally:

Interactive learning software, multimedia software, online courses and many other applications have received much attention. A view supported in [77] stating, “It

touches many facets of everyday activities: online or offline digital content”. Others like in [82] stressed play is essential to learning: “Literacy and numeracy development”. The chapter recommended the use of 3D computer graphic strategy and tactics used to engage players to be used for development of instructions for architecture students; a potentially significant and educational application area. Indeed, 3D Computer Graphics and Data use is serving as an essential component of computer-assisted learning system [82]. The statistics associated with the use of the 3D data technologies are impressive. For instance, in [83] “83 % Decrease in training time. Northeastern University has reduced a 3-hour lesson plan into less than 30-minute. 50 % Better student scores Case Western students in the HoloLens lab scored 50% better on retention and required 40% less class time”. Indeed, 3D data technologies can “improve learning result and revolutionize curriculum with hands on lesson plans that convey complex concepts in 3D. With HoloLens2, students can learn-by-doing from anywhere with holographic instructions and assessments”[84].

3.8 Architectural institutions and educators

Considering the fast pace of development, highlighted challenges have been discussed. A case for architects, engineers and construction (AEC) professionals having well integrated and shared data management structure has been established. A database for comparison and control projects cost inflation in public projects. Architects’ duty and obligations include building liveable communities. Thus, the chapter is also interest in pollutions in neighborhoods and communities. Therefore, architectural educators should be passionate in data sciences with a goal of establishing a Construction Blockchain (see [69, 81, 85]).

It demands more openness and agility. It demands improvement of career options in architecture to attract young people interested in creative discipline (e.g. architecture) and trending high-tech jobs with good pay and prestige. While calculus, mathematics, statistics, algebra are core of data sciences in [70, 85, 86], it is very encouraging that coding and programming language like Python do not require mathematics, or even an engineering degree, but critical thinking, little play, and design principles. The authors are architect yet good in Microsoft Excel, coding, and python. Furthermore, with Additive Manufacturing and printing as the future of construction and manufacturing, including Microsoft Hololen, 7D AR and powerful sensors, it is imperative for educators and institutions to build capacities aligned to working with CAD transformative experiences and methods (see **video** [86]). Progressive and impactful institutions must embrace strategies and tactics consistent with the learning organization as supported in [87].

Building compelling strategies and tactics can include incentive (e.g. scholarships), explore and exploit full potential of data sciences skills by sensitisation. For example, making high school Data Sciences Credit pass (General Certificate Education, or West Africa School Certificate) as Physics alternate course requirement for admission into architecture in polytechnics and universities. Next, is to move people into result-oriented actions by positive influence. However, in [88] influence can be animated by making real changes across relationships. Scholars agree, influence is magnetic and can pull people into the institution’s orbit with the power to make real global changes across relationships. In [89], the wisdom to overcome barriers was revealed: colleges and universities should invest in digital transformation for more accessibility, flexibility, and affordability. They must overcome tendency of being just owners of hardware equipment or DT by becoming enabler of processes delivering:

- Distinguished skill for their students,
- Advance working performance,
- Further their mission.

In [90] was the insightful demand on AEC professionals' educators. That "Construction industry: more needs to be done." For example, the importance or reliability of psychometric is yet questionable, [91] so, the use of drawing boards. Yet both are compulsory with Psychometric test pass being mandatory for graduation in Nigerian polytechnics. However, such policy is not strategic to the AEC professional development and learning experiences. For instance, many young vibrant students are discouraged seeing Psychometric course as more like an ambush and exploitations. Moreover, time is scarce for required courses. In significant number of schools in the Niger Delta, there is lack of competent staff with centralisation as a problem. For example, in some cases, much as 50 percent of students psychometric test results are delayed yet mandatory for graduation. Students have suffered additional session and associated extra fees.

Institutions should build citizenship and raise the knowledge base of the construction industry, purposefully. Construction Blockchain can provide a platform for team growth, accountability, and trust. While studios should be more conducive, collaboration is required between architectural faculty and data sciences. In [92] is the call to "upsized your strategic practices, implement new marketing, including finding new ways to build the students and faculties strategies (e.g. careers and curriculum options, lowering entry barriers for women, image improvement). As investors and decisions are increasingly influenced by big data, educators must increasingly embrace big data-driven decision making and develop competence in these areas, in addition to gradually downplaying the traditional methods. Blockchain and metaverse are good direction to prepare architects to lunch into the virtual world. The architect's creativity and expression through various media is not in doubt, **Figure 7**. Web 3.0, IoT, IoV are rather consoling and basis for confidence building among architectural educators and curriculum developers; rather than the fear of becoming obsolete. They represent opportunities and benefits from ownership of NFTs in a "tokenize economy" [93]. Architects can be significant contributors and virtual estate owners by embracing Web3.0, AI, Blockchain, and



Figure 7. *Analytical presentation and communication skills: Architecture student presentations and graphic communication through various media: Project design night Club.*

animations technologies. Currently, “fintech firms are using Bitcoin blockchain and mobile technologies to create the internet of value” [94].

3.9 Conclusion and recommendation

The chapter has demonstrated similarity between the architecture and data scientists in terms of personality traits, educational skills requirements, and use of data. Architecture and its productions are scientific derivations involving multiple professionals with enormous as big data as by product. 3D computer graphics maintain symbiotic relationship with architect and architecture was explained. Further, the impact of disadvantageous data on the construction industry and the city were discussed. The fear of machines taking over the job of the architect was invalidated, because there are new opportunities in the creative economy. Indeed, there is limit as what computer can do. On career and image, Data science is a compatible as career option for young architects seeking trending high-tech and high in demand yet creative profession. Collaboration is canonical and such will add unique value to the data scientists’ community. Data science can help enforce transparency, accountability and create a new wealth economy for all. Big data creation and use in the construction industry and Blockchain are critical to the desired transformation; particularly for Nigeria. The implications of policy, design, and education were also highlighted. Finally, the uncertainty demands the adoption with strategy for the organic development of the data sciences and technologies as appropriate. In Particular, Blockchain in risk free area to build capacity.

Recommendation:

- The educator must share an interest in the underlying technologies industry 4.0, web 3.0.
- Educators must understand what different levels of workers want to use the technologies in accomplishing
- Building the strategic responsiveness space distinct capability or core competence to protect the knowledge-based construction industry leadership from being open to all.
- Complete control and liability of public relevant ministry on the institute and regulatory bodies which hitherto create barriers to both imitation and mobility
- Promote synergistic cooperation among the industry professionals towards building a shared and distributed pool of big data.
- The organic development of the data sciences and related technologies like AI and Blockchain.

Finally, the imperative also Blockchain adoptions in risk free areas, as follows: (a) The legislators must demonstrate interest and political support by creating the enabling laws to give Blockchain driving big data sciences the required legal backing in Nigeria. (b) The law enforcement agencies must demonstrate interest and learn about the technologies to collaborate with the self-governing system.

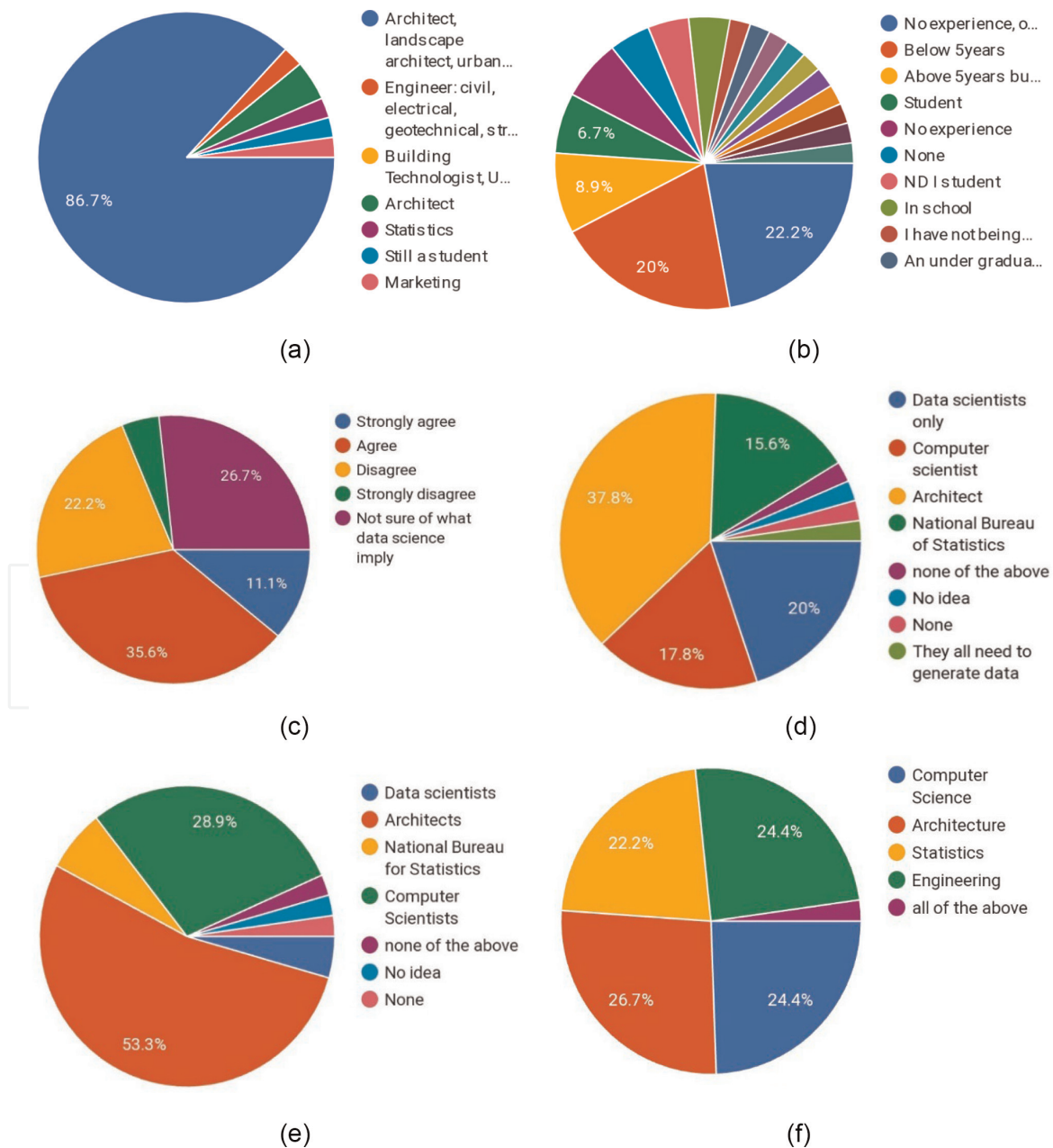
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Conflict of interest

There is no conflict of interest, whatsoever.

Appendix 1: Survey response: evaluating the awareness and participation in data use in the construction industry. Survey by Anita Bala 2021



Appendix 2: Specific consumption item per item rate for 1500 floor area

Shopping Mall Project								Design & tender stage/1, 500 sqm
ITEM	Gasoline	Diesel	Water	Ink	Timber off cuts	Electricity	Steel off cuts	Time
Water	X	X		X	X	X	X	Date
Electricity,	X	X	X	X	X		X	
Gasoline,		X	X	X	X	X	X	
Diesel,	X		X	X	X	X	X	
Water,	X	X		X	X	X	X	
Ink,	X	X	X		X	X	X	
Timber off cuts,	X	X	X	X		X	X	
Steel off cuts,	X	X	X	X	X	X		
Others								
Construction stage/1500SQM								
								Time
Water								Date
Electricity								
Gasoline								
Diesel								
Water								
Ink								
Timber off cuts								
Steel off cuts								
Others								
Post construction stage/1500SQM								
								Time
Water								Date
Electricity								
Gasoline								
Diesel								
Water								
Ink								
Timber off cuts								
Steel off cuts								

Shopping Mall Project								Design & tender stage/1, 500 sqm
ITEM	Gasoline	Diesel	Water	Ink	Timber off cuts	Electricity	Steel off cuts	Time
Others								
Maintenance to scrap value stage								
								Time
Water								Date
Electricity								
Gasoline								
Diesel								
Water								
Ink								
Timber off cuts								
Steel off cuts								
Others								

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