Technological Innovations (Virtual and Augmented Reality) in Housing for Sustainable Economic and Social Development in a Post Covid-19 Nigeria

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ABSTRACT

The COVID-19 pandemic is bringing about changes, and alongside these, we can alter the way we design our housing using technological innovations in architecture. The need for healthy and comfortable housing is essential to sustainable economic and social development in a post Covid-19 Nigeria. The present study investigates technological innovations in housing for sustainable economic and social development in a post Covid-19 Nigeria. The study adopted a case study design while simple random techniques was employed to select fifty participants within Ibadan North Local Government. For data collection, structured questionnaire and an oral interview were used for each variable examined. The questionnaire covers technology innovations, sustainable economic and social development. Two research questions were generated and answered accordingly. Data collected was analyzed using frequency count and simple percentage at a 0.05 level of significance. It was found that virtual reality has so much potential for architects. According to 70% of the participants, virtual and augmented reality should be used by architects because of their effectiveness in building and because it gives users the opportunity to explore a virtual representation of a room, floor, or building. According to the findings, 30% of the participants recommended BIM, VR, and mixed reality as the most powerful technology innovations in housing that could improve the economic and social development of the users and citizens. In conclusion, future researchers will investigate BIM and VR as technology innovations in housing. The outcome of the findings shows that architects and designers should recommend virtual and augmented reality when designing buildings. If it is used effectively, it will improve their skills.

KEYWORDS: Virtual Reality, Augmented Reality, Sustainable Economic, Social Development, Covid-19

INTRODUCTION

The Corona Virus is a deadly virus that has affected countries all over the world. The COVID-19 global pandemic started affecting countries in Africa and Latin America in 2020.

With the largest population in Sub-Saharan Africa and long-standing travel and trade links within Africa and to the rest of the world, it seemed inevitable that the pandemic would eventually reach Nigeria. In late February 2020, Nigeria recorded the subcontinent's first confirmed case, after which it began to spread throughout Lagos, Ogun State, and the Federal Capital Authority (FCT) area of Abuja (Morris, 2020). The arrival of the pandemic set off a chain of policy actions, including public health and education campaigns, fiscal and monetary measures, restrictions on large sections of the economy, and compensating measures in the form of social protection for poor and vulnerable people (Onyekwena and Amara Mma, 2020).

December 2019, marked the beginning of a novel disease outbreak, later called COVID-19 by the World Health Organization (WHO) (2020). Epidemiological links trace the virus's origins to animal stock in Wuhan. Taking into account that some previous disease outbreaks have also been zoonotic (originating from animals), such as SARS (Severe Acute Respiratory Syndrome) in 2003 and MERS (Middle East Respiratory Syndrome) in 2012, researchers claim that the number of novel zoonotic diseases is expected to rise in the future (Nghiem, 2020). For instance, markets that sell meat and products from wild animals are still not prohibited and thus continue to exist globally. Filho (2020) reported that COVID-19's economic impacts are unexamined and only going to unfold during the global economic downswing, which is estimated to be more challenging than the financial crisis of 2007–2009. According to the United Nations Trade and Development Agency (UNCTAD) (2020), the consequences of COVID-19 are going to cost the global economy in 2020 around one trillion USD, considering that the length of the pandemic is ambiguous. A global economic collapse is expected to have harsh consequences, including food shortages and hunger.

A sustainable economy is a development that meets the needs of the present generation without encroaching on the strength of future generations to satisfy its own needs (Morris, 2020). Sustainability is referred to as the concept of using wisely the available natural resources, avoiding depletion of such resources. This implies that builders, architects, designers, community planners, and other stakeholders strive to create buildings and communities that will not deplete natural resources. The goal is to meet today's needs using renewable resources so that the needs of future generations will be provided for. Sustainable economic practices aim to reduce greenhouse gas emissions, slow global warming, protect natural resources, and create communities that allow people to reach their full potential.

A sustainable economy has been defined by several authors as it expands its horizons over the years. However, the most common element of this definition is the ability to provide for the present without compromising the standard of living for the future; the sociocultural needs of people are fundamental. The social well-being of people has to be balanced by the conservation of environmental resources for the benefit of future generations (Drosten,2020). It could be inferred that there should be a balance between environmental conservation and social needs while implementing sustainable development. Drosten (2020) noted that sustainable economic means total regard for the integrity of nature as well as the needs and privileges of present and future generations. This means development which has its origin in socio-cultural activities should be rejected. However, it has been observed that the ethos of sustainable development has been defined in isolation, each with its distinctive views; little effort has been made as regards a holistic conception.

In the context of micro or small businesses, sustainable economic refers to the focal variables such as employment, profit, and sales (Venkataraman 2002).Bjerke (2007) states that firm success is achieved when there is a substantial increase in sales, revenues, or employees. Bigstenand Gebreeyesus (2007) perceived a firm to be progressive if it increased in economic size in terms of employees. Scholars have been more interested in using employees as an indicator of economic sustainability rather than other indicators. They argued that relying on other economic indicators such as income, profit, and sales makes it difficult to compute due to incomplete records of microenterprises. However, change in employment is also seen as a traditional indicator because the number of workers in a firm depends on its sales and profit (Parker and Torres 2004).

Social development is the promotion of a sustainable society that is worthy of human dignity by empowering marginalized groups, women and men, to undertake their own development, to improve their social and economic position, and to acquire their rightful place in society. Social development encompasses a commitment to individual well-being and volunteerism and the opportunity for citizens to determine their own needs and to influence decisions that affect them. "Social development" incorporates public concerns in developing social policy and economic initiatives. Until relatively recently, social development was conceived in terms of a set of desirable results: higher incomes, longer life expectancy, lower infant mortality, and more education. Recently, emphasis has shifted from the results to the enabling conditions, strategies, and public policies for achieving those results: peace, democracy, good governance, social freedoms, equal access, laws, institutions, markets, infrastructure, education, and technology (Bilance, 2007).

Social development is defined in the broadest social terms as an upward directional movement of society from lesser to greater levels of energy, efficiency, quality, productivity, complexity, comprehension, creativity, choice, mastery, enjoyment, and accomplishment. The development of individuals and societies results in increasing freedom of choice and an increasing capacity to fulfill their choices through their own capacity and initiative. Growth and development usually go together, but they are different phenomena subject to different laws. Growth involves an expansion of existing types and forms of activities. Development involves qualitative enhancement. Social development is driven by the subconscious aspirations of society for advancement or progress. Society (and individuals) will seek progressive fulfillment of a prioritized hierarchy of needs—security of borders, law and order, self-sufficiency in food and shelter, organization for peace and prosperity, expression of excess energy in entertainment, leisure and enjoyment, knowledge, and artistic creativity (http://www.icpd.org/).

Technological innovation in housing involves "the introduction of something new, or a new idea, method, or device" to design and build houses. Sustainable economies must take into account the effectiveness of technology. Technological innovation, as part of technological change, allows organizations to test new ideas at speeds and prices that were never before time-consuming (Zheng, 2017). Goi (2017) anticipated a decade ago that changes in consumption patterns could drive the creation of new technologies necessary for sustainability and their adoption and diffusion at the desired pace. Success in bringing about these changes will require substantial reorganization of the economy and society and changes in lifestyles. Economic and financial incentives for the creation and adoption of new technologies will be needed, which may include innovative policy reforms. " Megahed and Ghoneim (2017) highlighted some significant changes that are expected to happen in future architectural approaches, promoting self-sufficient strategies and refocusing on green space and low-rise buildings with better indoor air quality. The autonomous design of a building is especially crucial during pandemic conditions when the transportation of food and other goods is limited.

Augmented and virtual reality are technology innovations in housing that will be measured in this paper. Augmented and virtual reality have attracted the attention of architects, civil engineers, and construction companies globally because of their suitability to the architectural discipline. Augmented Reality (AR) and Virtual Reality (VR) are technologies of utmost importance for the Architecture, Engineering, and Construction (AEC) sectors as the built environment is intrinsically associated with three-dimensional (3D) space and AEC professionals rely heavily on imagery for communication. Since the 1990s, Virtual Reality and Augmented Reality, to a lesser degree, have been used by built-environment professionals to support the visualization of design, construction, and city operations since around the 1990s (Davila, 2019).

Augmented Reality is a technology that overlays information and computer-generated imagery on the real environment to enhance or augment the contextual perception of the user's surroundings. Augmentations are visualized using a mobile device, a tablet, or a head-mounted display (HMD). On the other hand, Virtual Reality is a technology that creates virtual environments entirely generated by a computer, replacing the user's perception of the surrounding environment with a virtual environment using HMDs, glasses, and multi-display setups (Li, 2018).

Augmented and virtual reality are considered among the top 10 Gartner strategic technology trends for 2019. The main Augmented and Virtual Reality applications are in the gaming and entertainment sectors, but marketing, tourism, sports, and education have experimented with Augmented and Virtual Reality as well. Companies from a wide range of sectors are using augmented and virtual reality for training and productivity improvements. For example, UPS, a parcel delivery company, is using Virtual Reality for driver safety training, while Boeing, an aerospace company, reported up to 40% productivity improvements in electrical wiring installation tasks when using Augmented Reality HMDs. However, augmented and virtual reality technologies are not yet robust and reliable enough to comply with real-life industrial requirements. Technical limitations are one of the main factors that limit adoption in the dynamic and rough environments typical of the construction sector (Nee, 2017).

Other factors are also at play, according to researchers. Yung and Khoo-Lattimore (2009) noted that lack of awareness of the technology, poor usability, the large time commitment for implementation, and the unwillingness to accept a virtual substitute are issues that need to be addressed. Virtual Reality (VR) was coined in 1989 by Jaron Lanier of VPL research to distinguish between the immersive digital worlds that he was trying to create and traditional computer simulations (Pimentel, 1995). Virtual Reality involves exploring a 3D environment solely through the monitor of a computer. Examples include games like Myst, VRML architectural walk-through simulations, etc. Ever since Ivan Sutherland developed (with support from ARPA) the first surprisingly advanced virtual reality system in the late sixties (Negroponte, 1993), there have been high expectations for the implications of this discovery for architects. For example, in 1968, Coons stated in his New York Times interview, "In a few years from now, you (a group of architects) will be able to walk into a room and move your hand and have a plane or surface appear before you in light." You will be able to build a building in light so that you can walk around it and change it "(Herzberg, 1968).

Van Dam (2000), a notable pioneer of computer graphics, observes that virtual reality would offer a natural interface for architects to navigate through, make spatial judgments in, and manipulate three-dimensional physical environments. Therefore, there is a good reason to be optimistic about its applicability. Glegg and Levac (2005) assert that regardless of the Augmented and Virtual Reality level of technical maturity, there is a need to study the actual effectiveness of Augmented and Virtual Reality for particular construction tasks and for the targeted development of implementation research.

Virtual Reality has been extensively tested for stakeholder engagement in real estate, as it is the ideal medium to immerse stakeholders in a virtual environment, helping them to understand what the end-product will look like and how it will feel (Delgado, 2019). Kini and Sunil (2018) presented a virtual reality system to visualize different types of sustainable construction techniques in rural communities. Most of the recent research has been focused on providing multi-user capabilities. For instance, Duet (2001) presented a multiuser Virtual Reality platform that enabled several parties (e.g., clients, architects, engineers, and general contractors) to interact in a unified Virtual Reality environment, improving the stakeholders' engagement and communication.

Sandor and Klinker (2011) presented an Augmented Reality system called ARCHIE that supports architects in working collaboratively on a virtual model placed on a table and presenting the design intent to stakeholders. Nee (2000) described how Augmented Reality could be used to support collaborative design in which various users interact with a single virtual model instead of using physical mock-ups. Lin (1999) presented an Augmented Reality system that displays the results of computer fluid dynamics simulations of indoor thermal environments on mobile devices. Roach and Demirkiran (2002) presented a Virtual Reality-enabled 3D modeling software that facilitates the creation of 3D models. The authors compared their VR-enabled software with other VR-enabled 3D modeling software (i.e., Google Blocks and Make VR Pro) and with traditional 3D modeling software (i.e., Blender, FreeCAD, and SolidWorks). The authors reported that virtual reality-enabled modeling software is easier to learn, more intuitive to use, and allows faster modeling than traditional 3D modeling software.

Nguyen (1999) presented a Virtual Reality system for city planning and object modeling that included special communication protocols and gesture recognition techniques. Motamedi (2003) showed an approach to testing the effectiveness of signage in Japanese subway stations using Virtual Reality environments. Dong (2010) presented an Augmented Reality system for collaborative design review and planning of operations in civil engineering applications. Schubert (2005) presented an Augmented Reality-based decision-support system for design review of urban design problems. The presented system combines physical models and hand-drawn sketches with virtual 3D models on a multi-touch table. The AR augmentations are enabled through tablets and mobile phones. Berg and Vance (2009) evaluated the effects of using Virtual Reality for design reviews by conducting a study with manufacturing engineers to carry out design reviews in a projection-based Virtual Reality environment. The system enabled the participants to view and interact with the geometry at real scale. The authors reported that the participants gained a better understanding of the spatial relationships between product components as well as the interactions required to assemble the product.

Dunston (2001) presented a virtual reality system for design review of hospital patient rooms. The authors indicate that VR-enabled design reviews improve interaction and have a greater influence on design decision-making. Liu and Kang (2004) used virtual reality to explore the correlations between urban environments and visual and audio comfort in streets by varying the street width to building height ratio. Echevarria Sanchez (2001) also developed a Virtual Reality system that enables one to assess how the visual aspect can reduce noise discomfort. Mutis and Ambekar (2006) investigated the existing Augmented Reality challenges to visualizing virtual objects on construction sites, and Chu (2008) investigated how Augmented Reality can be used to improve information retrieval from BIM models, thus reducing time in construction planning tasks.

Golparvar-Fard (2009) presented an Augmented Reality system that automates progress monitoring and provides a colour-coded overlay to easily identify sections of the construction site that are ahead, on, or behind schedule. More recently, Zhou (2003) presented an Augmented Reality approach to support the inspection of segment displacement during tunneling construction. The approach overlays a quality control baseline model onto the real segment and measures the differences. Virtual Reality enables us to carry out progress monitoring remotely, especially for dangerous sites. For instance, Robbins (2010) presented a Virtual Reality system that helped track maintenance operations of fusion reactors. More recently, Pour Rahimian (2009) presented a system that enables progress monitoring of buildings in a virtual environment using BIM data and real images from construction sites. In view of the above review, this paper investigated the impact of technological innovations (augmented and virtual reality) on sustainable economic and social development in post-COVID-19 Nigeria.

Statement of the Problem

Previous studies have reviewed and classified research output related to augmented and virtual reality in the built environment. However, up-to-date study and discussion are necessary. There is no granular study that investigated technology innovations using augmented and virtual reality in housing on sustainable economic and social development in post-Covid19 Nigeria. In particular, there is no local study in the literature that investigates (i) how Augmented and Virtual Reality technologies are used in the architectural field; and (ii) the potential benefits to architects. The present study presented in this paper seeks to fill this gap.

Objectives of the Study

The objectives of this study was to investigate Augmented and Virtual Reality in housing on sustainable economic and social development. The specific objectives are:

1. To define how Augmented and Virtual Reality use-cases for the architects in the study area.
2. To provide percentage of the Augmented and Virtual Reality usage among architects.

Research Questions

1. Is Augmented and visual reality technology innovation in housing been effectively used among architects before?
2. What are the percentage of Augmented and Virtual reality usage among architects?

Methods

This study adopts a descriptive case study design. The population of this study consists of trained architects in Ibadan North-East Local Government, Oyo State, Nigeria. A questionnaire was developed to measure virtual and augmented reality on sustainable economic and social development among architects. A 5-point Likert scale was used in the questionnaires to codify the responses, which, despite its limitations, is a very effective method for response codification. The questionnaire was pilot-tested by six experts (4 from industry and two from academia) to ensure the clarity of the questions and the structure and logic of the questionnaire. Convenience and stratified sampling methods were used to select participants from architects and technology development companies who designed augmented and virtual reality. Fifty completed questionnaires were received out of 55 approached participants, representing a 91% response rate. An expertise level factor was developed to obtain an indication of the relevant experience of the respondents. This factor is the average of the following attributes captured on the 5-point Likert scale in the questionnaire: Frequency count and simple percentage were used to analyze the data at a 0.5 level of significance.

Results

Research Question: Is Augmented and virtual reality technology innovations in housing been effectively used among architects in the study area?

Table 1:

Usage of AR&VR	Frequency (F)	Percentage (%)
AR	35	70
VR	15	30
Total	50	100

Source: Field Survey, 2021

Table 1: It was found that augmented and virtual reality has so much potential for architects. According to 70% of the participants agreed that virtual and augmented reality has been effectively used by architects because of their effectiveness in building and it gives users the opportunity to explore a virtual representation of a room, floor and building. While 30% participants disagreed that augmented and virtual reality has not been used effectively in the study area.

Research Question: Is Augmented and Virtual reality a powerful technology among architects?

Table 2:

Percentage	Frequency (F)	Percentage (%)
AR	15	30
VR	35	70
Total	50	100

Source: Field Survey, 2021

Table 2: According to the findings, 30% of the participants recommended BIM, VR and mixed reality as most powerful technology innovations in housing that could improve economic and social development of the users and citizens. While 70% of the participants disagreed that Virtual and Augmented reality is not a powerful technology innovation among architects. The outcome of the findings shown that architects and designers should use virtual, BIM and mixed reality when designing building.

Discussion

The outcome of the study showed that augmented and virtual reality have so much potential for the architects in the study area. This is in support of the study by Dunston (2001) on the Virtual Reality system for design review of hospital patient rooms. It was found that VR-enabled design reviews improve interaction and have a greater influence on design decision-making. Liu and Kang (2004) used virtual reality to explore the correlations between urban environments and visual and audio comfort in streets by varying the street width to building height ratio.

According to the findings of the study on table 2, 30% of the participants recommended BIM, VR, and mixed reality as the most powerful technology innovations in housing that could improve the economic and social development of the users and citizens. While 70% of the participants disagreed that virtual and augmented reality are not powerful technology innovations among architects.

Conclusion

Virtual and Augmented Reality technology in houses has been found effective in designing buildings. According to the findings of the study, virtual and augmented reality are effective technology innovations in housing. BIM, mixed, virtual, and augmented reality should be used by future researchers to determine their impact on sustainable economic and social development. In this paper, we conducted an investigation to find out if virtual and augmented reality could lead to sustainable economic and social development. The following were critically reviewed during the study to build the literature of the study: several magazine articles, conference papers, journal articles, scholarly essays, and books on Virtual and Augmented Reality. In analyzing the usage of virtual and augmented reality in architecture, we sought the opinions of architects through instruments in the study area, and recommendations were made based on the findings of the study on how to improve the usage of virtual and augmented reality.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Virtual and Augmented Reality should be introduced to architects in the study area so as to improve the usage.
2. Seminars for architects in the study area should be organized to educate them on the importance of augmented and virtual reality in design.
3. Future studies should be conducted in all local governments in Oyo State so as to make augmented and virtual reality known among architects.

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