

# Application of Innovative Technologies in Computer Science Education during Covid-19 School Closure in Enugu

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**Abstract**—The study examines the application of innovative technologies in Computer Science education during the Coronavirus school closure in Enugu, Nigeria. A total of One hundred and fifty (150) structured questionnaires were administered online to participants that consisted of Computer science students and educators from four (4) different tertiary institutions in Enugu State. This is in addition to secondary data sources generated from journals and the Internet. The sample was selected using the Stratified random sampling technique. Thereafter, the collected data were analyzed using simple percentage, frequency, mean and standard deviation. While the hypotheses were tested using a T-test. The results show that technologies such as Smartphones, Laptops, Desktop computers, E-readers, Personal Digital Assistants (PDAs), Projectors, Smartboards, Videoconferencing tools e.g. Zoom and Google Meet, and wearable technologies were largely available and used by most of the respondents during the COVID-19 school closure. Also, the findings show that majority of the participants admitted using the various mentioned technologies for; virtual academic meetings, access to the internet and online educational resources, lesson/assignment preparations, participation in e-learning/online classes, conduct/taking of e-examinations and assessments, and communications with students/teachers and colleagues. Furthermore, the majority of the respondents admitted that “They felt very confident and comfortable using the various technologies for teaching and learning during the COVID-19 school closure. However, most of the respondents expressed concerns about; constant power failure, internet connection issues, financial or cost issues, and lack of institutional support which were found to have impeded the use of technology for Computer Science education during the COVID-19 school closure. The work conclude that relevant authorities should invest more in education technology and other necessary infrastructures that support the integration of innovations and technologies that enhance the teaching and learning of modern-day realities in schools.

**Keywords:** Innovative technologies, Edutech, Zoom App, Smartphones, COVID-19, Computer science, E-learning.

## I. INTRODUCTION

### A. Background

The Coronavirus Disease 2019 (COVID-19) outbreak posed serious concerns to the global education systems. Global responses to the Coronavirus pandemic varied from country to country, but most countries endorsed the closure of school strategy as a means to contain the spread of COVID-19. This led to the unscheduled closure of schools in more than 100 countries worldwide, including in Nigeria and Enugu State to be précised [1]. The school closures due to COVID-19 leftover one billion learners out of school [1]. The Coronavirus pandemic affected educational systems worldwide, leading to the widespread closures of schools [2]. For instance, in Spain, about 11 million students were affected by school closures for Coronavirus leading to the suspension of job contracts for people who work at school cafeterias and in special education [3]. In Saudi Arabia, Middle East Monitor cited in [1], reported that schools and universities across the kingdom were ordered to close down for Coronavirus by the Ministry of Education, but the government, however, directed that technology should be employed to ensure that the educational process continues in an effective and quality manner. In Nigeria, the federal government ordered a total closedown of all schools. The decision was largely applauded, and the National University Commission (NUC), a regulatory body for all universities in Nigeria also gave a follow-up directive to all universities in the country to shut down.

Following the global closure of schools, the UNESCO Director-General, AudreyAzoulayals cited by VOA News [4], warned that “the global scale and speed of the educational disruption due to Coronavirus is unparalleled

and, if prolonged, could threaten the right to education". The unplanned school closures caused severe problems for students, educators, parents, and society at large. The COVID-19 pandemic created large educational disruptions and global health concerns that proved very difficult to manage by global health systems. It was more worrisome to know that reports from various continents, including, America, Africa, Asia, and Europe indicated a daily rise in the number of new cases and mortality due to COVID-19. As at the time of this study, there were no reliable treatments for Coronavirus, but a series of researches were in the pipeline across the world towards finding a clinical vaccine for the contagion.

The unplanned closure of schools for COVID-19 came with obvious implications on computer Science education even though; the decision to close schools appeared to be right considering the need to contain the Coronavirus pandemic. The fortuitous closure of schools worldwide revalidated the need for the adoption and deployment of cutting-edge technologies in education [1]. The outbreak of COVID-19 increased the global demand for online education. Technology has the potential to facilitate education from any location including home [5]. Thus, as the world struggles to contain COVID-19 or any future outbreaks, the use of educational technology platforms would become the new reality for educational institutions, educators, and learners. Technology is integral to student-teacher connection and communication especially in moments of isolation, quarantines, and lockdowns as a result of health crises and other emergencies. Technology is an essential tool to offer educational, psychological, spiritual, and medical advice or supports to parents, educators, and students during and after pandemics. The use of the technology-aided report of cases, testing, and social distancing was critical to the mitigation of the spread of COVID-19. In some climes, robots and drones were also used to deliver goods to reduce human interactions. Staying at home all day could be very challenging for students especially the digital millennials who are very mobile and inquisitive. Therefore, with the aid of technology, learners and educators can be productively and educationally engaged to reduce the boredoms that could push them to become Covidiot during lockdowns for pandemics [6]. Educational institutions that have inculcated the use of emerging technologies in their systems before the outbreak of COVID-19 had a comparative advantage over those who were yet to embrace technology in their operations. Teachers were required to teach remotely and students needed adjustments to the new teaching and learning techniques. The transition to online education posed a challenge to learners in countries where there were no

relevant infrastructures and facilities that facilitate online education.

Today, there is an increased pressure on educational institutions to respond to a technology-driven society and the broad use of technological tools i.e., ICT, mobile technology, and multimedia technology, etc. The role of technology in teaching is very significant because the use of technological tools improves the quality of education. Technology can improve the teaching and learning process through different ways, for instance: with greater enthusiasm by learners, enriched communication skills, assessable to learners of all levels and capabilities, excellent research tools, good assessment tools, better preparation of students for education [7].

According to Alves et al [8], technology provides a wide spectrum to learn and possesses an enormous power to alter traditional pedagogical environments. The use of technology in education does not only modify the social behaviors of students but also teaches them in several ways to interact in a social environment by instilling different values in them. Robin [9] stated that the impact of ICT in educational setups has been proven to bring about a remarkable change in the intellectual growth of students because of its effectiveness. Hussain et al [10] opined that ICT can potentially equip students for the challenges of the 21st century. Students can build up the competencies required to survive in the globalized world with the proper knowledge and understanding of various emerging technologies [11]. The shift in deploying new technological and pedagogical approaches in tertiary education is both exciting and daunting [12]. According to Bakar & Mohamed [13], the incorporation of technology in education represents the use of computer-based methods for teaching that incorporate into everyday classroom educational procedures. The use of technology offers a powerful and practical teaching-learning environment. Ghavifekr and Rosdy [14] stated that the objective of integration of technology in education is to enhance the quality, cost-efficiency, and availability of the distribution of knowledge to learners. The use of technological innovation tools in education and learning will lead to efficient studying and students will be able to learn better within the technology-based atmosphere.

Computer Science is a domain that always has grand expectations when it comes to producing positive outcomes and hence it faces immense pressure to adapt and evolve regularly. In the Computer science program, it is a teacher's responsibility to motivate students to identify different resources, research centers, and databases for infotainment applications. In lesson planning, teachers use a wide range of technologies to facilitate teaching and learning. Melhuish et al [15] stated that to keep up with the rapid developments (e.g., development of cloud-based computing supports, M-learning), the citizens of information-age societies are expected to possess certain qualities, including critical thinking, problem-solving ability, collaborating with others, communicative ability, ability to make use of different technological tools, the courage to strike novel ideas, and the determination to give rise to diversity in different learning situations.

Hussain et al [10] stated that to reach diversity in learning styles, the integration of technology into the classrooms proves very beneficial. The use of advanced technology changes the traditional way of passive learning and provides a chance for students to interact with classmates by encouraging collaboration [11]. With the help of technological tools, the classrooms can be restructured and redesigned to develop an environment that stimulates the development of higher-order thinking skills [16]. Since the outbreak of COVID-19, the demand for transition to online education has increased signaling that technology would play a more important role in the future of Education. Considering the various benefits associated with technology use, there is a need to examine the application of innovative technologies on Computer Science education during the COVID-19 school closure to create more awareness about the growing bond between technology and education.

### *B. Problem Statement*

The unplanned school closure due to coronavirus brought many adverse consequences on global education systems. Many educational institutions shutdown their activities and were unable to conduct any academic activities. This is particularly the case for many public educational institutions in Nigeria that lacked the infrastructures needed to sustain their activities during the compulsory school closures due to the COVID-19 pandemic. However, the use of various technological devices, applications, and platforms such as videoconferencing tools, mobile phones, and laptops provided opportunities for some of the educational institutions to continue their activities remotely during the COVID-19 school closure. Whereas there are growing studies on Coronavirus pandemic and technology in any aspect of education, there seems to be a gap in the literature regarding the application of innovative technologies in Computer Science education during the recent Coronavirus school closure, particularly in Enugu, Nigeria. Consequently, the current study attempted to breach that gap as it examined the impact of innovative technologies in Computer Science education during the COVID-19 school closure in Enugu State. This is intending to highlight the various potentials of innovative technologies in Computer science pedagogy, especially during emergencies.

## II. LITERATURE REVIEW

Emerging technologies play a vast role in the educational process [5]. The application of emerging technologies in education is changing learners' experiences both inside and beyond the classrooms. Diane and Steven [17] stated that there is an evolving relationship between education and technology, and the evolving pedagogies have also taken advantage of newly designed or emerging technologies. According to former U.S. Secretary of Education, John King, one of the most important aspects of technology in

education is its ability to level the field of opportunity for students. Also, the U.S Department of Education in her 2017 National Education Technology Plan Update stated that technology can be a powerful tool for transforming learning, and advancing relationships between educators and students, and adapting learning experiences to meet the needs of all learners. Diane and Steven [17] further stated that ubiquitous computing is being used for education and training to provide "augmented reality" interfaces, which are characterized by the use of handheld computers to infuse the virtual world onto the real one, resulting in deeply immersive simulations. Information and Communication Technology (ICT) such as Artificial Intelligence and robotics, are being employed by educational institutions to automate their processes.

The Covid-19 pandemic caused large-scale institutional and behavioral 'shock effects' in various areas of human activity including education. The impact on teachers and students was unprecedented. For instance, there were over 1,500,000,000 students worldwide from primary to tertiary level that was unable to attend school due to the COVID-19 pandemic [18]. To keep education running, educational institutions have had to quickly adapt to the situation. This has resulted in an unprecedented push to online learning [19]. Due to massive and unexpected school closures, affected countries and communities have been forced to seek quick fixes in different digital learning platforms [20]. These rapid moves from classroom to online teaching have set aside the more profound questions related to national educational policies and theoretical grounds and premises. Current conditions of formal educational systems can be described using Strong's [21] model of epidemic psychology consisting of three consecutive and overlapping epidemics: those of fear, explanation, and action. Strong uses 'epidemic' as a metaphor representing collective psychological reactions to an epidemiological crisis. The first aspect involves an epidemic of fear and opens up a question: How can the educational systems and individual learners cope with the exceptional situation?

The second aspect is an epidemic of explanation and moralization: 'People may be unable to decide whether a new disease or a new outbreak is trivial or whether it is something enormously important. They swing backward and forwards from one state of mind to another [21]. At the same time, different actors in administrative positions provide their accounts of how to make sense of the situation and ensure the continuation of teaching and learning. Politicians are, of course, at the front line of educational policy-making, simultaneously setting restrictions and measures based on health experts' assessments and constructing their official and authoritative narratives.

Social media allow experts and novices to share their rational and irrational views with little in the way of moderation. Lockdowns affect students in multiple ways, reinforcing inequalities and putting them under social and psychological stress. Parents and custodians are affected too, and many of them come to realize, perhaps for the first time, the social purpose of the educational system and its power to structure everyday life [19]. The third aspect is an epidemic of action. It demonstrates how educational institutions and teachers across the world's educational systems transfer their work from classrooms and lecture halls to digital platforms almost overnight. This quick transition has also revealed gaps and shortcomings in how online learning has or has not been adopted in educational institutions. Efforts at covering these gaps have created an influx of various kinds of support such as drop-in sessions, free webinars, and blog posts emergency policy documents (e.g. [22] and even lessons learned from earlier school lockdowns, perhaps more importantly, the situation has become a new market opportunity for commercial digital learning platforms providers.

Some forms of emergency online learning are being criticized for failing to adhere to sound pedagogical principles, best practices, and earlier research [23]. On social media, prominent experts have questioned the reasons driving some individuals, organizations, and companies so eagerly towards providing guidance, pondering whether their motivation has been driven by market reasons [24]. Others have noted the potential negative outcomes if educational technology quick fixes are implemented without balancing their consequences [25]. Quickly jumping on board with learning platforms and online learning has also raised concerns about privacy and surveillance and the impact on students' lives and human dignity [26]. In the moment of crisis, educational organizations should think carefully about their choices regarding online learning and education technology. These choices can potentially echo in the future as new relations of power and control, new forms of student inequity and inequality, and other unpredictable effects [25]. To mitigate possible negative impacts, educational organizations should leverage past knowledge of online learning as something that can be more varied than just a way to deliver information. Otherwise, they are in danger of falling into the trap of classic Bourdeausian 'misrecognition', that is, into interpreting digital learning as a self-evident and all-encompassing solution to the more profound problems of current mass education and institutionalized teaching and learning.

Online learning can take many different forms, including those pedagogically more innovative and engaging than commonly used processes of knowledge delivery and assessment. It can be informed and shaped by different education-philosophical and pedagogical underpinnings [19]. Thus, online learning should not be seen as 'one thing' or pedagogy in its own right. Online learning is often understood as synonymous with content-driven self-study,

where the advantages are limited to (a relative) independence of time and space. However, a digital learning environment that consists solely of textual files and lecture capture videos shared through a learning management system is very different from a digital learning environment that utilizes a situated online learning design such as the authentic learning framework [27], which centralizes collaborative knowledge construction and complex, authentic learning. Furthermore, engaging teachers and students in the development, implementation, and use of education technology can affect how successfully technology can support meaningful teaching and learning [28-29].

### III. METHODOLOGY

#### A. Descriptive Survey

The study adopted a descriptive survey research design and the primary instrument used for data collection was structured A total of One Hundred and Fifty (150) structured questionnaires were administered online to participants that consisted of Computer science students and educators from four (4) different tertiary institutions in Enugu State. The questionnaire was designed in a four-point Linkert scale: Strongly Agree (SA)-1, Agree (A)-2, Strongly Disagree (SD)-3, and Disagree (D)-4, and required the participants to indicate their level of agreement or disagreement to the items. This is in addition to secondary data that were generated from journals and the internet for review of the literature. The sample was selected using a stratified random sampling technique and the content validity of the research instrument was checked by two experts in research methodology at Ebonyi State University, Nigeria. Thereafter, the collected data were analyzed using simple percentage, frequency, mean and standard deviation. While the hypotheses were tested using a T-test.

### IV. RESULTS

Table 1 shows the distribution of the respondents by gender. It can be inferred from the table that 50.7% of the respondents were female, while 49.3% were male. This implies that the majority of the respondents were females.

Table1: Distribution of the Respondents by Gender

Gender				
	Frequency	Percent	Valid Percent	Cumulative Percent
Male	74	49.3	49.3	49.3
Female	76	50.7	50.7	100.0
Total	150	100.0	100.0	

Table 2 shows the educational qualifications of the respondents. As can be seen from the table, 40.7% of the respondents were undergraduates, 39.3% were postgraduates, while 20% had other classes of qualifications. This implies that the majority of the respondents were undergraduates.

Table 2: Educational Qualification of the Respondents.

Educational level				
	Frequency	Percent	Valid Percent	Cumulative Percent
Undergraduate	61	40.7	40.7	40.7
Postgraduate	59	39.3	39.3	80
Others	30	20	20	100.0
Total	150	100.0	100.0	

. Table 3 shows the designations of the respondents. As can be seen from the table, 73.3% of the respondents were students, while the remaining 26.7% were educators. This implies that the majority of the respondents were students.

Table 3: Designations of the Respondents.

Designation				
	Frequency	Percent	Valid Percent	Cumulative Percent
Students	110	73.3	73.3	73.3
Educators	40	26.7	26.7	100.0
Total	150	100.0	100.0	

*Research Questions (RQTN):*

**RQTN1:** What are the available technologies used by Computer Science Educators and Students during the COVID-19 School Closure in Enugu State?

Respondents were asked to indicate their scale of agreements or disagreements to the available technologies used by them for academic activities during the COVID-19 school closure? Their responses to shown in Table 4.

Table 4 shows that 93.3% of the respondents agreed that laptops were available and used by them for teaching and learning Computer Science during the COVID-19 school closure in Enugu State, while 6.7% disagreed. This table is further explained in figure 1. This implies that laptops were widely used by the respondents.

Table 4: Responses on the availability and usage of Laptop

Laptops				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	90	60.0	60.0	93.3
Disagree	10	6.7	6.7	100.0
Total	150	100.0	100.0	

Table 5 shows that 93.3% of respondents agreed that they accessed and used Videoconferencing tools for teaching and learning Computer Science during the COVID-19 school closure, while 6.7% disagreed. This table is further explained in figure 2. This implies that the use of videoconferencing tools was widespread among the respondents.

Table 5: Responses on the availability and usage of videoconferencing tools.

Videoconferencing tools				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	90	60.0	60.0	93.3
Disagree	10	6.7	6.7	100.0
Total	150	100.0	100.0	

Table 6 shows that 80% of the respondents said that projectors were available and used by them for teaching and learning Computer Science during the COVID-19 school closure, while 20% disagreed. This table is further explained in fig 3. This implies that the use of projectors was widespread among the respondents.

Table 6: Responses on the availability and usage of Projectors

Projectors				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	70	46.7	46.7	80.0
Disagree	30	20.0	20.0	100.0
Total	150	100.0	100.0	

As seen in Table 7, only 33.3% of the respondents agreed that Augmented Reality Devices were available and used by them for teaching and learning of Computer Science during the COVID-19 school closure, while 66.7% disagreed. This implies that the majority of the respondents did not have access to Augmented Reality Devices and did not use them for teaching and learning Computer Science during the COVID-19 school closure.

Table 7: Responses on the availability and usage of Augmented Reality Devices

Augmented Reality Devices				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	20	13.3	13.3	13.3
Strongly Agree	30	20	20	33.3
Disagree	100	66.7	66.7	100.0
Total	150	100.0	100.0	

As seen in Table 8 above, 86.6% of the respondents stated that Desktop Computers were available and used by them for teaching and learning of Computer Science during the COVID-19 school closure, while 13.3% disagreed. This implies that the majority of the respondents used desktop computers for teaching and learning Computer Science during the COVID-19 school closure.

Table 8: Responses on the availability and usage of Desktop Computers

Desktop Computers				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	80	53.3	53.3	86.7
Disagreed	20	13.3	13.3	100.0
Total	150	100.0	100.0	

Table 9 shows that 53.3% of the respondents agreed that E-readers were available and used by them during the COVID-19 school closure, while 46.7% disagreed. This implies that the majority of the respondents used e-readers during the COVID-19 school closure

Table 9: Responses on the availability and usage of E-readers

E-reader				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	30	20.0	20.0	20.0
Strongly Agree	50	33.3	33.3	53.3
Disagreed	70	46.7	46.7	100.0
Total	150	100.0	100.0	

Table 10 shows that 73.3% of the respondents agreed that PDAs were available and used them during the COVID-19 school closure, while 26.7% disagreed. This implies that the majority of the respondents used PDAs during the COVID-19 school closure.

Table 10: Responses on the availability and usage of PDAs

Personal Digital Assistance (PDAs)				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	50	33.3	33.3	33.3
Strongly Agree	60	40.0	40.0	73.3
Strongly Disagreed	40	26.7	26.7	100.0
Total	150	100.0	100.0	

Table 11 showed that 93.3% of the respondents agreed that smartphones were available and used by them for academic activities during the COVID-19 school closure, in contrast to only 6.7% of them who disagreed. This table is further explained in figure 8. This implies that the majority of the respondents found the use of Smartphones very useful for educational purposes during the COVID-19 school closure.

Table 11: Responses on the availability and usage of Smartphone

Smartphones				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	30	20.0	20.0	20.0
Strongly Agree	110	73.3	73.3	93.3
Disagreed	10	6.7	6.7	100.0
Total	150	100.0	100.0	

As seen in Table 12, 73.4% of the respondents agreed that smartboards were available and used by them for academic activities during the COVID-19 school closure, in contrast to only 26.6% of them who disagreed. This table is further explained in figure 9. This implies that the majority of the respondents found the use of smartboards very useful for educational purposes during the COVID-19 school closure.

Table 12: Responses on the availability and usage of Smartboards

Smart Boards				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	40	26.7	26.7	26.7
Strongly Agree	70	46.7	46.7	73.4
Disagreed	40	26.6	26.6	100.0
Total	150	100.0	100.0	

Table 13 showed that 93.3% of the respondents agreed that Wearable technologies like smartwatches were available and used by them for academic activities during the COVID-19 school closure, in contrast to only 6.7% of them who disagreed. This table is further explained in figure 10. This implies that the majority of the respondents found the use of Wearable technologies very useful for educational purposes during the COVID-19 school closure.

Table 13: Responses on the availability and usage of Smartboards

Wearable Technologies				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	60	40.0	40.0	40.0
Strongly Agree	80	53.3	53.3	93.3
Disagreed	10	6.7	6.7	100.0
Total	150	100.0	100.0	

**RQTN2:** To What Extent do Computer Science Educators and Students use the Available Technologies for Academic Purposes during the COVID-19 School Closure?

Respondents were asked to indicate their scale of agreements or disagreements of the extent of usage of available technologies for academic purposes during the COVID-19 school closure? Their responses to are shown in Table 14.

Table 14: Responses on the usage of Videoconferencing tools for academic purposes.

I often use Videoconferencing tools (e.g ZOOM AND Google meet) for virtual academic meetings and classes.				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	90	60.0	60.0	93.3
Disagree	10	6.7	6.7	100.0
Total	150	100.0	100.0	

As seen in table 15, 93.3% of the respondents agreed that they used Videoconferencing tools for virtual academic meetings and classes during the COVID-19 school closure, in contrast to only 6.7% of them who disagreed.

Table 15: Responses on the usage of laptops for academic purposes.

<b>I often use my Laptop to prepare lesson notes or assignments and to send and receive academic e-mails</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	90	60.0	60.0	93.3
Disagree	10	6.7	6.7	100.0
Total	150	100.0	100.0	

From table 15, 93.3% of the respondents agreed that laptops were very useful to them for the preparation of lesson notes, assignments and for sending and receiving academic e-mails during the COVID-19 school closure, while 6.7% disagreed.

Table 16 shows that 80% of the respondents agreed that projectors were very useful for their academic presentations during the COVID-19 school closure, while 20% disagreed.

Table 16: Responses on the usage of Projectors for academic purposes.

<b>I often use Projectors for class presentations and group discussions</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	70	46.7	46.7	80.0
Disagree	30	20.0	20.0	100.0
Total	150	100.0	100.0	

As seen in Table 17 above, 86.6% of the respondents agreed that the use of Desktop Computers aided their access to the internet and conduct or participation in e-exams and e-assessments during the COVID-19 school closure, while 13.3% disagreed.

Table 17: Responses on the extent of usage of Desktop Computers

<b>The use of Desktop Computers aid my access to the internet and conduct/participation in e-exams and e-assessments.</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	50	33.3	33.3	33.3
Strongly Agree	80	53.3	53.3	86.7
Disagreed	20	13.3	13.3	100.0
Total	150	100.0	100.0	

Table 18 shows that 53.3% of the respondents agreed that the use of e-reader enhanced their reading of digital books and other online educational materials during the COVID-19 school closure, while 46.7% disagreed.

Table 18: Responses on the extent of usage of E-readers.

<b>The use of e-reader enhanced my reading of digital books and other online educational materials</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	30	20.0	20.0	20.0
Strongly Agreed	50	33.3	33.3	53.3
Disagreed	70	46.7	46.7	100.0
Total	150	100.0	100.0	

Table 19 shows that 73.3% of the respondents agreed that

they used their PDAs to upload or download educational materials online during the COVID-19 school closure, while 26.7% disagreed.

Table 19: Responses on the extent of usage of PDAs for academic purposes.

<b>I often use my PDAs to Upload or Download Educational Materials Online</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	50	33.3	33.3	33.3
Strongly Agreed	60	40.0	40.0	73.3
Strongly Disagreed	40	26.7	26.7	100.0
Total	150	100.0	100.0	

Table 20 shows that 93.3% of the respondents admitted that the use of their Smartphones aided their communications with their teachers, students, and colleagues and engagements in e-learning activities during the COVID-19 school closure, in contrast to only 6.7% of them who disagreed.

Table 20: Responses on the extent of usage of smartphones.

<b>The use of my Smartphone aided my communications with my teachers, students and colleagues and engagements in e-learning activities.</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	30	20.0	20.0	20.0
Strongly Agreed	110	73.3	73.3	93.3
Disagreed	10	6.7	6.7	100.0
Total	150	100.0	100.0	

Table 21 shows that 73.4% of the respondents agreed that they used smartboards to enhance their experiences and access to an online resource during group discussions during the COVID-19 school closure, in contrast to only 26.6% of them who disagreed.

Table 21: Responses on the extent of usage of Smartboards

<b>I often use smart boards to enhance my experience and access to online resource during group discussions</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	40	26.7	26.7	26.7
Strongly Agreed	70	46.7	46.7	73.4
Disagreed	40	26.6	26.6	100.0
Total	150	100.0	100.0	

Table 22 shows that 93.3% of the respondents agreed that they used Wearable technologies like smart watches to record digital lectures and to attend online classes during the COVID-19 school closure, in contrast to only 6.7% of them who disagreed.

Table 22: Responses on the extent of usage of wearable technologies.

<b>I often use my Wearable Technologies such as smart watches to record digital lectures and to attend online classes</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Agreed	60	40.0	40.0	40.0
Strongly Agreed	80	53.3	53.3	93.3
Disagreed	10	6.7	6.7	100.0
Total	150	100.0	100.0	

These findings imply that the respondents found the use of various technologies very useful in their academic activities during the Coronavirus school closure. This means that technology played a major role in enhancing continuity in the education sector, particularly as it relates to Computer Science education during the recent Coronavirus pandemic school closure.

This is consistent with the earlier position of Onyema *et al* [1], which showed that many educators and students relied on technology to ensure continued learning online during the Coronavirus pandemic. These findings also support that of Sahu [30], which revealed that many educational institutions employed the use of various technologies during the COVID-19 school closure to mitigate the effects of the unplanned school closure on staff and students.

**RQTN3:** How do students react towards the use of technologies for Computer Science education during the COVID-19 school closure.

Table 23: Responses of student respondents on their attitudes towards the use of technologies for Computer Science education during the COVID-19 school closure.

S/N	Items	SA	A	SD	D
1	I enjoy using my Smartphone for self-directed learning and for communications with my teachers and colleagues	40%	50%	8%	2%
2	I feel very confident learning or receiving lectures with my laptop	65%	23%	8%	4%
3	The use of projectors and smartboards increase my learning experiences and academic presentations.	52%	30%	17%	1%
4	The use of e-readers encourages me to read educational or digital books online	30%	40%	24%	6%
5	I find it easy accessing the internet with my desktop computers.	53%	38%	07	2%
6	I feel comfortable using my videoconferencing tools like Zoom and Google meet to attend classes online	55%	30%	9%	6%

When asked about their attitude towards the use of technologies for computer science education during the COVID-19 school closure, 90% of the respondents said they enjoyed using their Smartphones for self-directed learning and communications with their teachers and colleagues, while 10% of them disagreed. 88% of the respondents said they felt very confident learning or receiving lectures with their laptops, in contrast to (12%) who do not think so. 82% of the respondents agreed that the use of projectors and smartboards increases their learning experiences and academic presentations, while 18% of them disagreed. 70% of the respondents believed that the use of e-readers encourages them to read educational or digital books online, while 30% of them did not think so. 91% of the respondents said they find it easy to access the internet with their desktop computers, but 15% of them disagreed. 85% of the respondents said they felt very comfortable using their videoconferencing tools like Zoom and Google meet to

attend classes online, in contrast to (15%) who do not think so. This implies that the majority of the students accept the use of technology for Computer Science education. Their reactions were very positive which is an indication that they find the use of educational technologies very interesting and helpful during the COVID-19 school closure. This finding is consistent with that of Onyema *et al* [1] which shows that technology was largely used by educators and students during the Coronavirus school closure to ensure continued education. This study also agrees with the finding of Sahu [30], which showed that many teachers and students have been excited by the use of technology in education and the move to online education during the Coronavirus school closure. This study affirms that students are enthusiastic about using various technologies to support their learning, and educators are also challenged by the new wave of technology use in education and the need to update their skills in line with the trend.

**RQTN4:** What are the barriers that inhibited the use of technology for Computer Science education during the COVID-19 school closure in Enugu State?

Table 24: Responses of student respondents on the Barriers that Inhibited the Use of Technology for Computer Science Education during the COVID-19 School Closure in Enugu State

S/N	Items	SA	A	SD	D
1	Constant power failure hampered my use of technologies for educational activities during the COVID-19 School Closure.	55%	30%	6%	9%
2	Poor or bad network connections impede my use of technologies for educational activities during the COVID-19 School Closure.	70%	28%	0	2%
3	Lack of institutional support inhibited my use of technologies for educational activities during the COVID-19 School Closure.	50%	40%	7%	3%
4	Affordability/Data cost issues hindered my use of technologies for educational activities during the COVID-19 School Closure.	45%	35%	8%	12%
5	Technical issues restricted my use of technologies for educational activities during the COVID-19 School Closure.	40%	38%	15%	7%

As seen from Table 24, 85% of the respondents believed that constant power failure hampered their use of technologies for educational activities during the COVID-19 School Closure, in contrast to (15 %) who do not think so. 98% of the respondents responded that poor or bad network connections limited their use of technologies for educational activities during the COVID-19 School Closure. While 2% of them disagreed. Also, 90% of the respondents responded that lack of institutional support inhibited their use of technologies for educational activities during the COVID-19 School Closure, while 10% of them disagreed. Similarly, 80% of the respondents believed that affordability/Data cost

issues hindered their use of technologies for educational activities during the COVID-19 School Closure, while 20% do not think so. Finally, 78% of the respondents agreed that technical issues restricted their use of technologies for educational activities during the COVID-19 School Closure, in contrast to 22% who do not think so.

The implication of these is that the use of technologies for Computer Science education during the COVID-19 school closure was hampered by several factors as seen in table 25 above.

It also means that if these issues or concerns are addressed, Computer Science students and educators would be in a better position to maximize the potential benefits of educational technologies. Hence, there is a need for authorities to provide the necessary infrastructures to enable educators and students to harness the enormous potentials of technology in education. The study supports the finding of an earlier study by Onyema [5], which found that bad networks, school policies, and electricity problems limit the use of technologies for teaching and learning. This finding is also consistent with that of Anene et al [31]; Onyema et al, [6] and Olutola and Olatoye [32], all of which showed that the use of technologies in the Nigerian education system is limited by poor technical infrastructure, financial restrictions, lack of computer literacy, Internet connectivity problems, and constant power failure.

**B. Testing Of Hypotheses**

**Hypothesis One:** The use of technology has no significant effect on the teaching and learning of Computer Science during the COVID-19 school closure in Enugu State.

Table 25: Hypothesis one testing

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
I often use Videoconferencing tools (e.g ZOOM AND Google meet) for virtual academic meetings and classes	150	1.6667	.59828	.04885
I often use my Laptop to prepare lesson notes or assignments and to send and receive academic e-mails	150	1.7267	.56636	.04624
The use of my Smartphone aided my communications with my teachers, students and colleagues and engagements in e-learning activities.	150	1.8667	.72043	.05882
The use of Desktop Computers aid my access to the internet and conduct/participation in e-exams and e-assessments.	150	1.7333	.57541	.04698
I often use my PDAs to Upload or Download Educational Materials Online	150	1.8000	.54342	.04437
The use of e-reader enhanced my reading of digital books and other online educational materials	150	1.8667	.50056	.04087

Table 26: One-Sample test

One-Sample Test						
	Test Value = 150					
					95% Confidence Interval of the Difference	
					Lower	Upper
I often use Videoconferencing tools (e.g ZOOM AND Google meet) for virtual academic meetings and classes	-3036.534	149	.000	-148.33333	-148.4299	-148.2368
I often use my Laptop to prepare lesson notes or assignments and to send and receive academic e-mails	-3206.403	149	.000	-148.27333	-148.3647	-148.1820
The use of my Smartphone aided my communications with my teachers, students and colleagues and engagements in e-learning activities.	-2518.304	149	.000	-148.13333	-148.2496	-148.0171
The use of Desktop Computers aid my access to the internet and conduct/participation in e-exams and e-assessments.	-3155.819	149	.000	-148.26667	-148.3595	-148.1738
I often use my PDAs to Upload or Download Educational Materials Online	-3340.109	149	.000	-148.20000	-148.2877	-148.1123
The use of e-reader enhanced my reading of digital books and other online educational materials	-3624.459	149	.000	-148.13333	-148.2141	-148.0526

From Hypothesis 1,  $p = 0.00$  meaning the test is significant, i.e  $p < 0.05$  and  $t(149)$ . This indicates that technology usage has a significant effect on the teaching and learning of Computer Science during the Coronavirus school closure.

Hypothesis Two: The attitudes of students towards the use of technology has no significant effect on their extent of usage of technology for academic purpose during the COVID-19 school closure.

Table 27: One-Sample Statistics

One-Sample Statistics				
	N	Mean	Std. Dev.	Std. Error Mean
I enjoy using my Smartphone for self-directed learning and for communications with my teachers and colleagues.	150	1.6667	.59828	.04885
The use of e-readers encourages me to read educational or digital books online.	150	2.6667	.59828	.04885
I feel very confident learning or receiving lectures with my laptop.	150	1.7933	.64814	.05292
I find it easy accessing the internet with my desktop computers.	150	1.7333	.57541	.04698
I feel comfortable using my videoconferencing tools like Zoom and Google meet to attend classes online.	150	2.5333	.72043	.05882

Table 28: One-Sample test

One-Sample Test						
	Test Value = 150					
					95% Confidence Interval of the Diff.	
					Lower	Upper
I enjoy using my Smartphone for self-directed learning and for communications with my teachers and colleagues.	-3036.534	149	.000	-148.33333	-148.4299	-148.2368
The use of e-readers encourages me to read educational or digital books online.	-3016.063	149	.000	-147.33333	-147.4299	-147.2368
I feel very confident learning or receiving lectures with my laptop.	-2800.544	149	.000	-148.20667	-148.3112	-148.1021
I find it easy accessing the internet with my desktop computers.	-3155.819	149	.000	-148.26667	-148.3595	-148.1738
I feel comfortable using my videoconferencing tools like Zoom and Google meet to attend classes online.	-2506.971	149	.000	-147.46667	-147.5829	-147.3504

From Hypothesis 2,  $p= 0.00$  meaning the test is significant, i.e  $p< 0.05$  and  $t(149)$ . This means that the attitudes of students towards the use of technology have a significant effect on their extent of usage of technology for academic purposes during the COVID-19 school closure.

### V. DISCUSSION OF FINDINGS

The findings of this study show that there was a widespread availability and usage of various innovative technologies among students and educators who participated in this study. As seen in table 5, 6, 7, 9, 10, 11, 12, 13, 14, the Majority of the respondents admitted the availability and usage of various technologies such as desktop computers, laptop computers, smartphones, e-readers, projectors, Personal Digital Assistants (PDAs), Wearable technologies, and videoconferencing tools such as Zoom and Google meet for academic purposes during the Coronavirus school closure in Enugu State. However, only a few of them admitted the availability and usage of Augmented Reality devices as seen in table 8. Only 33.3% of the respondents agreed on the availability and usage of Augmented Reality devices, which indicates the need for more investments in emerging education technologies, considering the growing need for use of innovative technologies in education. On the extent of usage of the innovative technologies, the findings show that the majority of the respondents find the use of technologies very useful and helpful during the school closure. No wonder, most of them admitted the use of these technologies for various academic purposes during the school closure. Some of the areas of usage of the aforementioned technologies as admitted by the respondents include; virtual academic meetings, access to the internet and online educational resources, lesson/assignment preparations, participation in e-learning/online classes, conduct/taking of e-examinations and assessments, and communications with students/teachers and colleagues. On students' attitudes towards the use of innovative technologies in Computer Science education during the

COVID-19 school closure, our findings show that majority of the respondents admitted that “They felt very confident and comfortable using the various technologies for teaching and learning during the COVID-19 school closure. Most of them said they enjoyed using their Smartphones and laptops for self-directed learning and for communications with their teachers and colleagues, and also find it easier accessing the internet and attending online academic discussions using videoconferencing tools like the Zoom and Google meet. When asked about the barriers that inhibit their usage of innovative technologies for academic activities, most of the respondents expressed concerns about; constant power failure, internet connection issues, financial or cost issues, technical issues, and lack of institutional supports which they said often impeded their use of technology for Computer Science education during the COVID-19 school closure. Our findings validate the growing influence of innovative technologies in education, particularly the important roles played by technology to enhance Computer Science education and that of other areas of human endeavors during the recent Coronavirus pandemic lockdown. The study highlights the need for more investments in education technology by stakeholders, and the need for students and educators to prepare themselves for the transition to online education which has become the new reality in global education systems.

### VI. CONCLUSION

The study establishes the significant application and impact of innovative technologies in Computer science education during the Coronavirus school closure. Our findings affirm that the use of innovative technologies facilitated the activities of Computer science educators and students during the COVID-19 school closure and quick transition to remote teaching and learning. The COVID-19 outbreak continues to disrupt school and education, not just because it demands an evolution in online learning, but because it demands a revolution to close the dangerous gap of digital inequity in learning. COVID-19 has rapidly rewritten all our realities, demanding that we learn as much and as fast as we can, and technology would remain a key part of the new teaching and learning realities even during the post-COVID-19 pandemic. Thus, the study raises awareness about the need for education authorities to do more in providing the needed technological infrastructures and other enabling facilities that would assist in implementing technology-based education at all levels of education.

### FUTURE WORK

There is a need for more research on the impact of innovative technologies on the teaching and learning of various practical-based courses in Computer Science education like Computer programming, Computer graphics, and other science courses during the Coronavirus school closure.

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