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Investigating the Impact of Fourth-Generation (4G) Mobile Technologies on Student Academic Performance

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Abstract
The fourth generation (4G) wireless communications and technologies has improved our way of life in many areas, such as health, communications, and education. This study sought to explore the impact of fourth-generation mobile technologies in education; more specifically, its impact on university students' academic performance. The study used the quantitative research method using a closed-ended questionnaire to determine the impact of fourth-generation technologies on students' academic performance in a higher education institution (HEI). The study measured and understood the students' performance through the research questions and specifically the question part 3 (question 4) which concentrated on the impact of 4G mobile technology on students' academic performance. It was found that 4G mobile technologies improve students' mobility, Internet quality, faster Internet connection, and online resources than going to the library. It also improves communication with other students and sharing of academic materials which directly impact students' academic performance and many more.

Keywords: Academic performance, 4G, 4G mobile technologies, LTE, Fourth-generation (4G), Students

1.0 INTRODUCTION

Fourth-Generation (4G) mobile technologies have become a crucial tool in learning as much as in any other part of our lives. On any university campus, it has become common that one would find students using an array of internet-enabled mobile/wireless devices [1]. Whether it be laptops, smartphones, tablets, or other devices that leverage the power of 4G mobile communications, networks have become an essential part of how students interact and access information in their day-to-day academic lives. Naturally, students employ such prevalent technologies to create a more engaging and personalized educational experience for themselves [2].

Khan, Qadeer, Ansari and Waheed [3] describe 4G as an all-encompassing and integrated network that provides an internet protocol (IP), voice-over-internet protocol (VoIP), data, streaming, and multimedia. These tools are accessible to users in real-time and on-demand in facilitating communication and Internet connectivity. Before the introduction of 4G mobile technologies, it was possible to perform functions like voice over internet protocol (VoIP) and data access through mobile devices, but 4G offers the ability to combine these technologies into an integrated and unified system. The 4G environment includes several tools and users, namely students, instructors, and devices such as mobile phones, smartphones, laptop computers, tablets, desktop computers, and handheld gaming systems. These participants are all dependent on the 4G network or infrastructure for the ability to communicate and access data.

Students are the leaders in integrating and adopting mobile technologies into institutions of higher education. In 2012, 67% of students who used smartphones, cell phones, and tablets credited these mobile devices as key to their academic success and used these devices in their academic work [4]. These devices are all 4G-enabled. However, a limit is known on the impact of 4G technologies on student academic performance within South African higher education institutions (HEIs).

Then, this aims to determine how fourth-generation technologies affect students' academic performance and how they have transformed how students interact with technology in their daily lives. Part 3 (question 4) of the research questions solely presented what the study measured in understanding the impact of 4G on student academic performance.

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2.0 PAST LITERATURE

2.1 The Use of Fourth-generation Wireless Technologies in Academia

The advent of smart wireless technologies and various mobile devices is increasingly popular and reasonably priced, mobile technologies drastically enhance education and introduce digital resources to learners. Students frequently use mobile technologies in their academic and personal lives [2]. According to a survey conducted by the Educause Centre for Applied Research, 67% of students in institutions of higher education are the leaders in the integration of mobile information technologies such as smartphones, tablets, laptops, and cell phones. The same students consider these technologies crucial to their academic success [4]. Wi-Fi technologies have introduced a welcomed adoption of mobile learning or m-learning by universities. Coinciding with more affordable, powerful, and usable mobile devices, there has been a notable switch towards portable computing in learning/education [5].

Wireless computing devices facilitate learning opportunities for students. Despite the location, learners can interact with instructors, and colleagues and even access educational content [6, 7, 8]. Contact sessions or classrooms that abide by a timetable are no longer as important in creating connections, discussions, and content in university education. Traditionally, the learning process would be based on times and dates. With the advent of mobile technologies, formal education and how it operates is misaligned with how students live and consume content on these devices. Universities are forced to keep up with the changes of a more mobile society [9]. According to Gierdowski and Galanek [10], a noteworthy variance in the percentage of students who have access to these technologies, with smartphones (95%) and laptops (91%) still being the preferred combination of tools. These two devices have been identified as the most important tools for a student's academic success although there are other prevailing technologies in virtual reality and 3D printing.

Mobile computing devices enhancing the power of fourth-generation communication networks have become a common sight on the campuses of universities and colleges. These technologies present a fresh opportunity for students in terms of flexibility and social media as an "instructional strategy" [11]. Furthermore, students can successfully integrate and share new knowledge through the ability to attain, identify, process, and assess knowledge through the use of mobile technologies in their academic work [12]. By using mobile technologies and their related social media platforms, these relationships and interactions are made more available and free web-based tools that enable users to communicate and upgrade their learning experience [13].

2.2 Advantages and disadvantages of fourth-generation technologies for students

The use of mobile technologies will inherently bring forth several benefits and challenges, especially to what is a traditional formal setting like a classroom. Mobile technologies and devices were not widely accessible for some time due to the fact they were not affordable for everyone and were too advanced at that period in time [14]. It is important to identify these benefits and challenges to understand 4G mobile technologies' impact on students' academics. The following table outlines the advantages and disadvantages of fourth-generation technologies for students [15]:

2.2.1 Advantages

a. 4G technologies can be employed in classrooms.
b. Mobile technologies and internet access create better access to academic information and resources.
c. Mobile devices and social networking can be used to enhance interactivity in large classrooms.
d. Mobile devices have become a replacement for traditional tools such as dictionaries.
e. Mobile devices allow immediate feedback between instructors and peers using online student response systems (OSRS).

2.2.2 Disadvantages

a. Mobile technologies are still seen as a distraction in classrooms.
b. Students use these technologies for texting, browsing the Internet, and messaging, which means students are not paying attention [16].
c. The 4G mobile technologies and other digital devices will always be susceptible to technical problems or network failure, which might leave affected students behind.
d. The ease of access to information opens the opportunity for cheating by students.

2.3 Fourth-generation mobile technologies impact student's academic

As new technology has advanced, the definition of mobile learning has gradually taken form. In its extremes, mobile learning, also known as, m-learning could include e-books, CDs, radios, and computers, the researcher will only consider technologies such as smartphones, laptops, and other devices that are driven by 4G [17]. A definition of mobile learning given by McConatha, Praul and Lynch [18] describes m-learning as the use of mobile devices for teaching and learning. The description includes laptops, smartphones, and other mobile technologies. Experts in mobile learning are always looking to maximize mobile

technology tool usage in universities while not compromising the educational mission. M-learning encompasses the mobility of technology, students, lecturers, and learning and teaching [19]. A broadly acknowledged and normally utilized meaning of mobile learning is a discovery that is wireless and omnipresent so that the possibility of wearable computing is very much connected to m-learning. The essential assignment of cutting-edge types of instruction is to give adaptable training that could guarantee portability to the students. Mobile learning is commonly characterized as e-learning through mobile technologies [20].

Institutions of higher learning are becoming aggressive integrators of technologies, especially Wi-Fi. The upturn in the popularity and use of laptops and other mobile technologies due to their affordability, power, and usability has sparked a new wave of what can be described as portable computing [5, 21]. Universities have become "fertile ground" for wireless / or mobile networks. The pervasive nature of the Internet throughout the world now allows very comprehensive web-supported electronic learning or e-learning tools called learning management systems (LMS). These tools allow educational content to be disseminated online to students [22].

2.4 The Use of Fourth-generation Wireless Technologies in Academia

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According to Gierdowski and Galanek [10], a noteworthy variance in the percentage of students who have access to these technologies, with smartphones (95%) and laptops (91%) still being the preferred combination of tools. These two devices have been identified as the most important tools for a student's academic success although there are other prevailing technologies in virtual reality and 3D printing. Mobile computing devices enhancing the power of fourth-generation communication networks have become a common sight on the campuses of universities and colleges. These technologies present a fresh opportunity for students in terms of flexibility and social media as an "instructional strategy" [11]. Furthermore, students can successfully integrate and share new knowledge through the ability to attain, identify, process, and assess knowledge through the use of mobile technologies in their academic work [12]. By using mobile technologies and their related social media platforms, these relationships and interactions are made more available, as well as, free web-based tools that enable users to communicate and upgrade their learning experience [13].

3.0 PROBLEM STATEMENT AND JUSTIFICATION

Universities are viewed as the authorities in "procuring, providing and controlling" technologies that are used in learning. Technologies that are changing how students not only create but also save, share and receive content. This could be a realization of a dream for educators, but it also presents a fresh obstacle for institutions, being "a loss of control and quality, consistency, uniformity and stability" [9, 10]. The advent of mobile internet technologies, such as 3G and all the preceding technologies, introduced mobile learning (m-learning) and electronic learning (e-learning). Online courses in institutions of higher learning along with online resources aligned with those courses became the norm in e-learning. The concern with those immobile technologies was that they remained on campus and that they were only available on campus [22].

3G technology provided services that allowed broadband internet access, media downloads, and uploads, to name a few. It could also leverage Wi-Fi networks, but speed was heavily dependent on the number of users on the network; one can immediately see how this would not be completely beneficial to high-density users such as university campuses [23]. The above-mentioned technologies are said to have improved learning experiences for students in terms of faster speeds, bandwidth, and

reliability in sharing and receiving teaching resources [11]. However, advancements in fourth-generation mobile technologies have resulted in wider network coverage and improved reception, making mobile technologies a viable option in education [24]. 4G technology provides improved broadband Internet connectivity to facilitate higher Internet access and enable students to learn across disciplines. High internet performance also means that users spend more time and hours on their smartphones browsing the internet and social media platforms. However, little or none is known of the impact of 4G technologies on students' academic performance.

The NWU, Mafikeng Campus currently has an extensive Wi-Fi network/hotspot all over the campus. Furthermore, numerous computer labs exist for students to use for academic purposes. The problem that arises is that these technologies are currently in use by students in the university, but there is no indication as to how effective 4G technologies have been in improving academic performance, if at all. Ultimately, this study investigates and measures the impact of fourth-generation technologies on students' academic performance and how the university can improve its technologies to benefit the students better. The study measured students' performance solely through its research question, specifically part 3 of the research (question 4) on the impact of 4G technology on students' academic performance.

4.0 RESEARCH AIMS/OBJECTIVES AND QUESTIONS

The core aim of this study is to analyze the impact of fourth-generation (4G) mobile technologies on the academic success of students.

4.1 Research Objectives

a. To determine the extent to which fourth-generation mobile technologies impact students' academic performance in a higher education institution.
b. To identify what students are using fourth-generation mobile technologies for.
c. To understand the benefits of fourth-generation mobile technologies for students.
d. To examine the impact of fourth-generation mobile technologies on student academic performance.

4.2 Research Questions

a. To what extent do fourth-generation mobile technologies impact students' academic performance in a higher education institution?
b. What are students using 4G mobile technologies for?
c. What are the benefits of fourth-generation technologies for students?
d. What is the impact of fourth-generation mobile technologies on student academic performance?

5.0 RESEARCH METHOD

The research method is generally defined as a way of systematically finding clarification to a research problem. It may also be termed the discipline of learning how a study is performed systematically [25]. Quantitative research is rooted in the measurement of amounts and numerical quantities. It is concerned with the collection of numerical data; this data is further examined by way of quantitative analysis [25] to ascertain answers or conclusions. This study used a quantitative method to explore if the 4G technologies have any impact on students' academic performance, through the closed-ended questions.

The sample size is a measurement of the unique samples observed or measured in a survey or experiment. Correctly determining a sample size is crucial to a study, if the sample size is too large it may require large amounts of resources and time. Similarly, if the sample size is insignificant, it may provide undependable data [26]. To determine the sample size of this study, Krejcie and Morgan's [27] table for determining sample size was used, the following formula was used and is shown below:

$$s = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)} \quad (1)$$

s = sample size
X^2 = The chi-square value for the degree of freedom.
N = The Population Size
P = The population proportion, which is assumed to be 50.
d = The degree of confidence.

From the sample population 12 489 students registered at the institution [28]. The chosen sample size is 370, which was determined using the "Krejcie and Morgan table for determining sample size". Sampling is a process that involves selecting a subset of a population referred to as a sample. The random sampling method was applied for the collection of data from the students.

A hypothesis must be adept at being proven or disproven. According to Payne and Payne [29], a hypothesis is a logical assumption about a connection between any number of social phenomena, expressed in a way that can be tested, verified, and gives direction to most commonly, quantitative research. When developing a hypothesis, it is important to consider the differences between the two types of hypotheses. A null hypothesis (H0) must be consistent with the specific hypothesis (disapprove); whereas, for an

alternative hypothesis (H1), it seeks to prove, unlike the null hypothesis that disproves.

For this study, the hypothesis is as follows:

a. **Null hypothesis (H0):** Fourth-generation mobile systems have no impact on students' academic performance.
b. **Alternative hypothesis (HA):** Fourth-generation mobile systems have an impact on students' academic performance at the HEI.
c. **Criteria for decision:** The respondents to the study's questionnaire expressed their beliefs or perceptions on the impact of fourth-generation mobile technologies on their academic performance. The conclusion for whether fourth-generation mobile technologies do impact students' academic performance was based on the majority of respondents.

The closed-ended questions were collected through the questionnaire techniques among the university student population. The population and sample were university students on one campus of a higher education institution (HEI) in South Africa. Data collection was conducted through the use of questionnaires administered to the sample population. Due to COVID-19 restrictions, an online survey strategy was used to collect data from the participants (students). Random sampling was used to get data from a sample of students and invitations to participate in the survey were sent and only those willing to attempt participated on their own time. The collected data analysis was extracted using statistical tools, Statistical Package for the Social Sciences (SPSS) and Microsoft Excel in understanding the impact of 4G mobile technologies on the academic performance of students.

6.0 DATA ANALYSIS

This section outlines the findings of the study and gives analysis and interpretations of the findings. The findings were acquired through the distribution of questionnaires and the results thereof are presented using tables and figures. Questions were asked of the participants and data were analyzed through statistical frequencies. The questions in the questionnaire were guided by the research objectives. The questionnaire survey was conducted at the HEI in South Africa. The participants were registered students of the institution. The study intends to analyze the impact of 4G mobile technologies on students' academic performance. This section begins with a descriptive explanation of the population sample and the participants' biographical information. This study had an intended sample size of 370 students for data collection. Questionnaires were distributed to first, second, third, and fourth year and postgraduate students. From the 370 questionnaires sample size expected, only 202 participated which represented 55% of respondent. The researchers made different attempts to encourage students to participate but no further response was received.

6.1 Data analysis and research objectives

The main objective of this study was to determine the impact of fourth-generation mobile technologies on student academics at the HEI in South Africa. The data were analyzed using SPSS version 26. The following section presents the data sets collected from students. The results were obtained through the use of statistical descriptions.

6.1.1 Section A: Demographic information

The findings from the age of participants illustrate that from the total of 202 respondents to the questionnaire, a total of 184 participants were between the ages of 17 and 31, which constitutes 88 percent of the respondents. Twelve (5.7%) respondents were between the ages of 32 and 41, 2 (1%) of the participants were aged 42 to 52, and 4 (1.9%) were 52 years and above. The findings clearly show that the largest portion of participants in the questionnaire is between the ages of 17 and 31. The gender frequency illustrates that from the total of 202 respondents to the questionnaire, 126 participants (60.3%) are male and the remaining 75 participants (35.9%) are female. One student opted not to state their gender on the questionnaire. No preference was given to any gender and the sample is a representation of those who were willing to participate in the research. The figure shows that the majority of the participants in the questionnaire are male students.

According to the age distribution, 186 participants were black students, which constitutes 89% of the total respondents. Four respondents (1.9) in the questionnaire were white students. Nine students (4.3%) were colored students, while only 2 students (1%) were Indian. One student failed to state their race in the questionnaire. No preference was given to any race, and the sample is a representation of those who were willing to participate in the research. The findings show that the majority of the participants in the questionnaire are black students. A total of 167 respondents (79.9%) were undergraduate students, who were either in the first, second, third, or final year of their studies. The remaining 34 students (16.3%) were postgraduate students. Again, 1 participant failed to state their level of study. No preference was given to any level of study and the sample is a representation of those who were willing to participate in the research. The finding shows that the majority of the participants in the questionnaire are undergraduate students.

6.2 Section B: Fourth generation (4G) wireless technologies

6.2.1 Use of 4G-enabled devices

The objective of this question was to determine how many participants were using or aware that they were using fourth-generation mobile technologies. In a survey conducted by the Educause Centre for Applied Research, 67% percent of students in institutions of higher education are the leaders in the integration of mobile Information technologies such as smartphones, tablets, laptops, and cell phones. The same students consider these technologies crucial to their academic success [4]. According to Gierdowski and Galanek [10], there is a significant difference in the percentage of students who have access to these technologies, with smartphones (95%) and laptops (91%) still being the preferred combination of tools. This study found that 179 participants (85.6%) own and/or are using fourth-generation mobile technologies in their everyday lives. While 23 participants (11%) say, they are not using or do not use fourth-generation mobile technologies in their academic lives. The findings show that the majority of the participants own or use 4G-enabled devices.

6.2.2 The uses for 4G mobile technologies

The objective of this question was to determine what participants use fourth-generation mobile technologies for from the given options. Participants were allowed to select more than one option. The finding illustrates that from the total of 383 multiple responses to the questionnaire, 138 participants (36%) chose social media, four participants (1%) chose gaming, and 107 respondents (27.9%) said they used their devices to browse the Internet. A total number of respondents (28.5%) said they use fourth-generation mobile technologies for their academic work, while 25 participants (6.5%) said they also use their devices to stream media content on the Internet. The findings clearly show that respondents use their devices for social media purposes than academic learning. Furthermore, a question was asked to determine the types of 4G devices participants predominantly used, if at all, from the given options. Again, Participants were allowed to select more than one option. The question recorded a total of 419 responses, 137 respondents (32.7%) used a laptop, 36 respondents (8.6%) used a tablet, 172 respondents (41.1%) used a smartphone, 72 participants (17.2%) used desktop computers, while 2 respondents (0.5%) used none of these devices. The finding shows that the majority of respondents use smartphones as their preferred form of technology.

The objective of the above Table 1 is to illustrate the types of 4G devices respondents predominantly use, if at all, from the given options. Participants were permitted to choose more than one option. The frequency Table 1 illustrates that from the total of 373 responses to the questionnaire, 107 participants (28.7%) said they find the ability to make voice and video calls beneficial. Mobile computing devices enhancing the power of fourth-generation communication networks have become a common sight on the campuses of universities and colleges.

These technologies present a fresh opportunity for students in terms of mobility and social media as an "instructional strategy" [11]. One hundred and seventeen respondents (31.4%) said high-speed internet access is why they find 4G technologies beneficial, 46 respondents (12.3%) chose lower data costs, 49 respondents (13.1%) said the portability and mobility of 4G technologies are beneficial to them, 53 participants (14.2%) said the security and privacy of 4G devices are also why they find 4G devices advantageous. The majority of respondents find that high-speed Internet is why 4G technologies are most beneficial.

6.2.3 Interpretation of the research questions

This segment illustrates the results of the statistics acquired from students. This section consists of three parts of the questionnaire. Part 1 has 9 questions; Part 2 has 10 questions and Part 3 has a total of 9 questions. The goal of this section is to the use of 4G Technologies, the benefits of 4G wireless technologies, and 4G mobile technologies' "impact on e-learning".

Table 1: Fourth-generation wireless technologies

Fourth-generation technology				
		Responses		**Percent of**
		N	**Percent**	**Cases**
Fourth-generation Technology Features	Voice & Video Call	107	28.7%	**55.4%**
	High Speed Internet	117	31.4%	**60.6%**
	Lower costs	46	12.3%	**23.8%**
	Mobility &Portability	49	13.1%	**25.4%**
	Security & Privacy	53	14.2%	**27.5%**
Total		373	100.0%	**193.3%**

Part 1: Use of fourth-generation technologies

Table 2 illustrates the results of the use of fourth-generation technologies by students. The results show that 50.5% of students prefer wireless Internet connections such as Wi-Fi over wired connections. 43.6% of students strongly agree that fourth-generation mobile technologies have improved the quality of their Internet connection. 47% of students find it easier to locate literature online than at the library. When asked if they prefer digital copies of literature, 42.6% of students agreed.

The results further show that 40.1% of students agreed that their academic performance improved when supplemented with 4G technologies and a fast internet connection. 32.7 % of respondents were unsure whether smart technologies would improve their learning experience in the classroom, while 30.7% of respondents agreed that they would improve their classroom experience. 50.5% of respondents strongly agree that social media has improved their communication with family, friends, and loved ones. 43.1% and 37.6% strongly agree and agree, respectively, that fourth-generation technologies have improved their continuous use of social media platforms. Only 25.7% of respondents rely on the Internet for news and weather updates.

Table 2: Use of 4G technology

Question/Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Majority of Response
I prefer using a wireless internet connection over a wired internet connection because it offers more mobility.	32.7%	50.5%	6.4%	3.5%	6.9%	50.5%
Fourth-generation wireless technologies have improved my Internet quality.	37.6%	43.6%	11.9%	3.5%	3.5%	43.6%
I find it easier to find academic literature online than in the library.	47%	29.7%	8.9%	9.4%	5%	47%
I prefer to use digital resources than physical copies of academic resources.	24.8%	42.6%	14.9%	14.4%	3.5%	42.6%
I find that learning that is supplemented by new technologies and a fast internet connection improves my academic performance	18.8%	40.1%	21.8%	15.8%	2.5%	40.1%
Fourth-generation technologies such as tablets; video conferencing technologies can be integrated into classrooms to improve academic performance.	20.8%	30.7%	32.7%	12.4%	3%	32.7%
4G technologies have improved communications with family members, friends, and loved ones.	50.5%	29.2%	11.9%	4%	4.5%	50.5%
4G wireless technologies have improved my continuous usage of social media applications	43.1%	37.6%	9.9%	5.4%	4%	43.1%
I rely on the Internet for the news, and weather more than any other medium, e.g. TV, radio, or newspapers.	25.7%	22.3%	19.3%	24.3%	7.9%	25.7%

Part 2: Benefits of 4G mobile technologies

The results for the benefits of fourth generation show that 54.8% of respondents find that fourth-generation mobile technologies have improved their academic performance. A further 53% of participants agree that fourth-generation mobile technologies have improved communication between students and lecturers. 42.1% and 40.1% of participants believed that 4G mobile technologies had improved their access to academic resources.

45.5% Agreed, and 40.1% strongly agreed that fourth-generation mobile technologies help share academic resources with fellow students. 34.7% agreed that 4G wireless technologies had improved that experience in class. 41.6% of the respondents said that they prefer wireless technologies. 41.6% of the respondents agreed that access to the Internet is improved because of 4G mobile technologies. 42.1% of respondents had seen an increase in internet speeds in their fourth-generation mobile technologies. 42.2% agreed that there was a significant increase in 4G internet speeds compared to 3G. 33.7% of participants disagreed that 4G mobile technologies had cheapened the cost of internet access. 38.6% of the respondents agreed that fourth-generation mobile technologies had improved their overall productivity when doing academic work.

Table 3: Benefits of 4G mobile technologies

Question/Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Majority of Response
The use of fourth-generation wireless technologies has improved your academic performance.	15..8%	58.4%	10.9%	10.9%	4%	**58.4%**
The use of fourth-generation wireless technologies has improved communication among your fellow students and the instructors (lecturers).	29.2%	53%	10.4%	4.5%	3%	**53%**
The use of 4G wireless technologies helps you gain better access to academic resources?	42.1%	40.1%	7.9%	6.9%	3%	**42.1%**
Using fourth-generation wireless technologies helps you share resources with fellow students?	40.1%	45.5%	7.9%	3%	2%	**45.5%**
The use of fourth-generation wireless technologies has enhanced your overall experience in classes?	22.8%	34.7%	30.2%	9.4%	2.5%	**34.7%**
I prefer a wireless/mobile internet connection to a wired connection such as LAN.	26.2%	41.6%	22.3%	7.4%	2.5%	**41.6**
Access to the Internet is much easier because of fourth-generation wireless technologies.	34.2%	42.1%	18.3%	2.5%	1.5%	**42.1%**
I find that 4G gives me faster access to the Internet compared to technologies such as 3G.	32.2%	42.2%	16.3%	5%	4%	**42.2%**
Fourth-generation wireless technologies have made it cheaper to access the Internet.	10.4%	19.3%	22.3%	33.7%	14.4%	**33.7%**
4G wireless technologies have improved my productivity, I find it easier to complete my academic work.	15.8%	38.6%	24.3%	16.8%	4.5%	**38.6%**

Part 3: 4G impact on students' academic performance

The objective of this section was to analyze the impact of fourth-generation mobile technologies on e-learning. 54.5% of participants agreed that they used online courses or videos to supplement what they learned in class. 42.1% of participants agreed that they used online resources to complete their assignments. 39.15 and 34.7% of participants agree that video-recorded lectures would benefit their academic performance.

56.4% of participants agreed that Fourth-generation had improved online collaboration among fellow students. The results further show that 33.2% of respondents disagreed that learning alone using online academic material was beneficial. While 43.6% of respondents used fourth-generation mobile technologies to learn about content outside of their university work, the majority of respondents (27.7%) preferred contact lectures.

Table 4: 4G impact on students' academic performance

Question/Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Majority of Response
I often use online courses to supplement what I've learned in class.	17.8%	54.5%	9.4%	14.9%	3.5%	**54.5%**
The majority of my assignments are completed using online sources.	42.1%	38.6%	3%	11.9%	4.5%	**42.1**
Recorded lecturers that I can later access online would improve my academic performance.	34.7%	39.1%	15.3%	6.9%	3.5%	**39.1%**
Classes with smart technologies improve my ability to learn and the quality of teaching.	21.8%	50.5%	16.8%	7.9%	2.5%	**50.5%**
I am more comfortable learning by myself using resources I found on the Internet.	21.3%	19.8%	15.8%	33.2%	8.9%	**33.2%**
Fourth-generation technologies have made learning and collaboration between fellow students easier.	24.8%	56.4%	13.9%	4.5%	0.5%	**56.4%**
I use 4G technologies to learn about topics or content that is outside my university work.	21.8%	43.6%	16.3%	15.8%	2.5%	**43.6%**
I feel e-learning is as effective in learning as face-to-face/contact sessions.	9.9%	19.3%	24.8%	27.7%	17.8%	**27.7%**

6.3 Reliability

The Cronbach Alpha Coefficient was employed to examine the reliability of the questionnaire and descriptive statistics scales. The Cronbach Alpha was determined using the number of variables/questions verified for reliability. The alpha resulted in 0.896, which is considered an acceptable alpha (Figure 1). Cronbach's alpha is used in statistical research to measure the internal consistency of the data acquired and results obtained in data analysis [30].

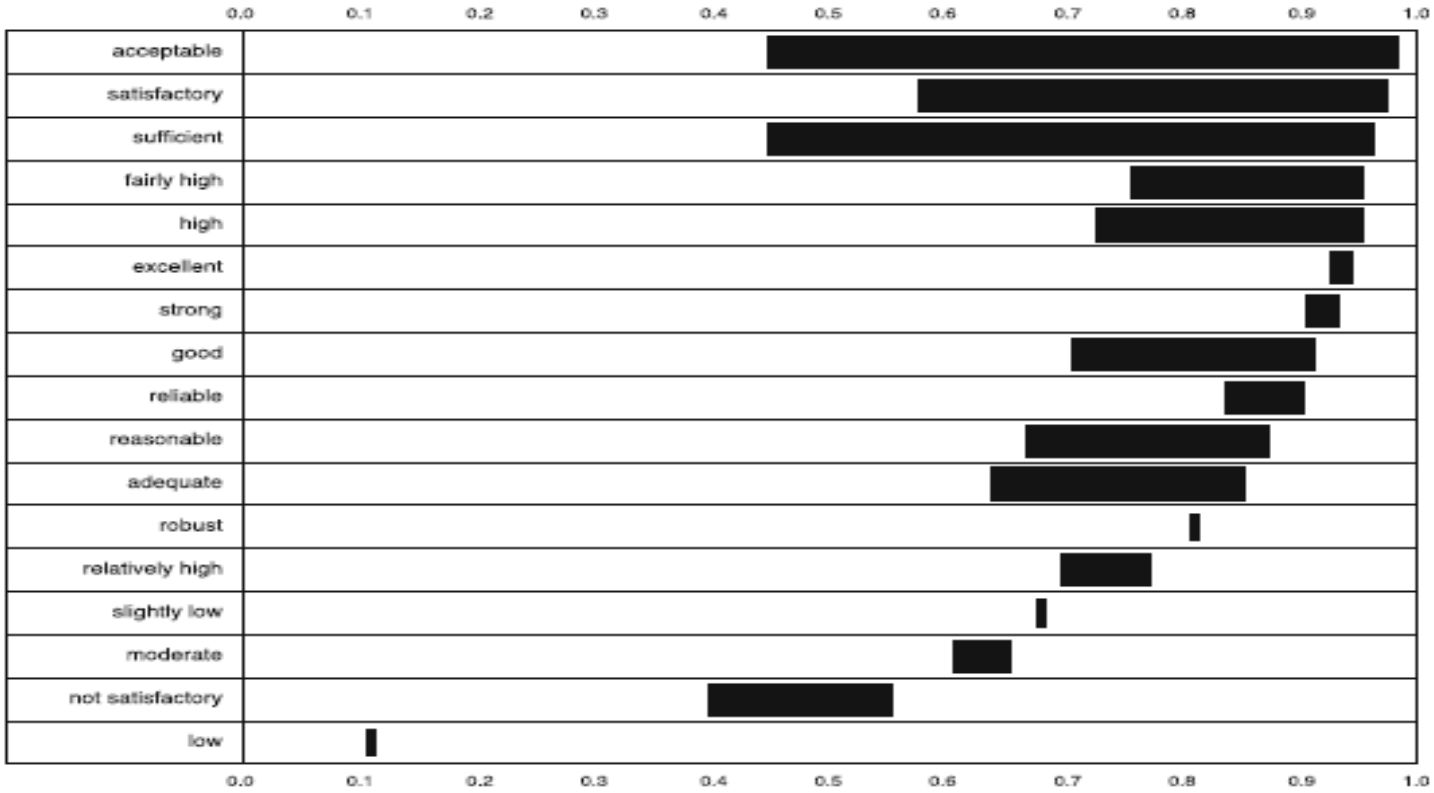

Figure 1: Descriptors for ranges of the Cronbach's alpha

6.4 Reliability checked for research data

Table 5: Reliability (use of 4G wireless technology)

Reliability (use of 4G wireless technology)	Mean	Std. deviation	N
I prefer using a wireless internet connection over a wired internet connection because it offers more mobility.	2.01	1.059	199
Fourth-generation wireless technologies have improved my Internet quality.	1.91	.970	199
I find it easier to find academic literature online than in the library.	1.94	1.166	199
I prefer to use digital resources than physical copies of academic resources.	2.30	1.101	199
I find that learning that is supplemented by new technologies and a fast internet connection improves my academic performance	2.56	2.343	199
Fourth-generation technologies such as tablets; video conferencing technologies can be integrated into classrooms to improve academic performance	2.46	1.048	199
4G technologies have improved communications with family members, friends, and loved ones	1.81	1.056	199
4G wireless technologies have improved my continuous usage of social media applications	1.89	1.053	199
I rely on the Internet for the news, and weather more than any other medium, for example, TV, radio, or newspapers.	2.66	1.312	199

The participants in the questionnaire scored high on whether they relied/used fourth-generation mobile technologies more than any other tools or services to receive news and weather updates. Two hundred and sixty-six with a mean of 1.312 and 2.56 with a standard deviation of 2.343 on responding that their learning that was supplemented by new technologies and a fast internet connection improved their academic performance.

The results further show that students were aware of fourth-generation mobile technologies and found these technologies useful in many different situations.

Table 6: Reliability (Benefits of 4G mobile technologies)

Reliability (benefits of 4G mobile technologies)	Mean	Std. Deviation	N
The use of fourth-generation wireless technologies has improved your academic performance.	2.27	.986	195
The use of fourth-generation wireless technologies has improved communication among your fellow students and the instructors (lecturer	1.96	.922	195
The use of 4G wireless technologies helps you gain better access to academic resources	1.87	1.022	195
Using fourth-generation wireless technologies helps you share resources with fellow students	1.78	.858	195
The use of fourth-generation wireless technologies has enhanced your overall experience in classes?	2.33	1.013	195
I prefer a wireless/mobile internet connection to a wired connection such as LAN.	2.14	.974	195
Access to the Internet is much easier because of fourth-generation wireless technologies.	1.92	.879	195
I find that 4G gives me faster access to the Internet compared to technologies such as 3G.	2.07	1.026	195
Fourth-generation wireless technologies have made it cheaper to access the Internet.	3.24	1.230	195
4G wireless technologies have improved my productivity, I find it easier to complete my academic work.	2.56	1.093	195

The respondents scored high on whether they believed that fourth-generation mobile technologies had not made Internet costs more affordable. 3.24 with a standard deviation of 1.230. Students also scored high 2.33 with a standard deviation of 1.013 when asked if they found fourth-generation mobile technologies improved their experience in the classroom.

The results show that students did not believe that fourth-generation mobile technologies had made internet costs cheaper. Students believed that fourth-generation mobile technologies had improved their classroom experience.

Table 7: Reliability (4G impact on student academic performance)

Reliability (4G impact on students' academic performance)	Mean	Std. Deviation	N
I often use online courses to supplement what I've learned in class.	2.32	1.041	202
The majority of my assignments are completed using online sources.	1.98	1.155	202
Recorded lecturers that I can later access online would improve my academic performance.	2.05	1.045	202
Classes with smart technologies improve my ability to learn and the quality of teaching.	2.18	.950	202
I am more comfortable learning by myself using resources I found on the Internet.	2.88	1.319	202
Fourth-generation technologies have made learning and collaboration between fellow students easier.	2.00	.782	202
I use 4G technologies to learn about topics or content that is outside my university work.	2.34	1.063	202
I feel e-learning is as effective in learning as face-to-face/contact sessions.	3.24	1.239	202

The respondents scored high when asked if they preferred learning through contact sessions compared to online lectures 3.24 with a standard deviation of 1.239. When asked if they preferred learning alone using online materials students scored 2.88 with a standard deviation of 1.319. Students scored high 2.32 with a standard deviation of 2.32 when asked if they supplemented what they learned in class through online courses.

The results show that students are comfortable using materials found through e-learning courses and websites but still prefer to learn through contact sessions.

Table 8: Statistical reliability

Statistics Reliability	Statements or Questions	Cronbach's Alpha
Part 3	9	.709
Part 4	10	.827
Part 5	8	.739

7.0 ANSWER TO THE RESEARCH QUESTIONS

This section aimed to determine if the main research questions were answered. The four research questions were summarised indicating the answers to the questions.

7.1 Have fourth-generation mobile technologies improved students' academic performance?

This question aimed to determine whether 4G mobile technologies could improve students' academic performance. 40.1% of the 202 respondents agreed that learning that was supplemented by new technologies and a fast Internet connection improved their academic performance. 32.7% of respondents were unsure whether fourth-generation technologies such as tablets; video conferencing technologies could be integrated into classrooms to improve their academic performance. Furthermore, 34.7% of the 202 respondents established that the use of fourth-generation wireless technologies had enhanced their overall experience in classes. 36.6% of respondents agreed that 4G wireless technologies had improved their productivity; they found it easier to finish their academic tasks. Based on the findings, students use fourth-generation mobile technologies in their everyday academics improves academic performance, but some are still unaware of the potential uses that 4G technologies could have in their academics.

7.2 What are students using 4G mobile technologies for?

This question aimed to investigate what the students are using 4G mobile technologies in their daily lives. The examination of the outcomes illustrates that 85.6% of the 202 respondents answered yes when asked if they had 4G-enabled technologies. From the following questions where students were asked what technologies they predominantly used, 137 out of the 202 respondents confirmed that they used laptops, and 172 answered that they predominantly used smartphones. Students used a combination of these technologies or either one individually.

Based on the results and findings, students' perception of fourth-generation mobile technologies is that they have access to these technologies and use them on a day-to-day basis. 47% of the 202 respondents answered that they preferred using fourth-generation mobile technologies to access academic materials online instead of in the library. 40.1% of students used fourth-generation mobile technologies to connect with fellow students and lecturers. 58.4% of the 202 respondents established that the usage of fourth-generation wireless technologies had improved their academic performance. 42.6% of respondents preferred using digital resources than physical copies of academic resources. Based on the results, the findings show that students use fourth-generation mobile technologies to find academic resources online. Students also use 4G mobile technologies to keep in touch with fellow students and lecturers.

7.3 What are the benefits of fourth-generation technologies for students' academic performance?

The purpose of this question was to examine what students found most beneficial about fourth-generation mobile technologies. When asked which 4G technology features they found most advantageous to them, 117 of the 373 responses (60.6% of responses) agreed that High-Speed Internet was the most beneficial feature of 4G mobile technologies. A further 107 responses (55.4%) agreed that the ability to make voice and video calls over the Internet was an advantageous feature. 42.1% of students agreed that fourth-generation mobile technologies were most beneficial in finding and gaining access to academic resources. Based on these findings, students preferred a good quality, high-speed Internet for features such as voice and video calls. Additionally, students use the high-speed Internet to access all the academic material they need.

7.4 What is the impact of fourth-generation mobile technologies on student academic performance?

The purpose of this question was to measure the impact of fourth mobile technologies on e-learning and how it affects their academic performance. 54.5% of respondents agreed when asked how they used online courses to supplement what they had learned in class. 42.1% of the respondents agreed that they completed their assignments using online sources. In addition, 39.1% of respondents said they would like to have recorded lecturers that they can later access online to improve their academic performance.

Furthermore, 33.2% of respondents disagreed when asked if they were more comfortable learning by themselves using resources found on the Internet. 43.6% of the respondents agreed that they used 4G technologies to learn about topics or content that is outside their university work. Although, 27.7% of respondents disagreed when asked if e-

learning was as effective in learning in contact sessions. Based on the findings, the results show that students use online courses and e-learning to supplement what they learn in class because of the 4G mobile technologies impacts. Students still appreciate contact sessions/lectures and collaborative learning with fellow students.

7.5 Testing Hypothesis

7.5.1 Null hypothesis (H0)

Fourth-generation mobile systems have no impact on students' academic performance.

7.5.2 Alternative hypothesis (HA)

Fourth-generation mobile systems have an impact on students' academic performance.

7.5.3 Testing the hypothesis

From a population sample of 370 students who indicated that they used fourth-generation mobile technologies, students find 4G technologies in accessing academic resources and collaborating and communicating with lecturers and other students. Students agreed that these benefits of fourth-generation mobile technologies improved their academic performance.

7.5.4 Hypothesis decision

To test both the null and alternative hypotheses, numerous questions in the questionnaire were tailored to speak to both hypotheses. Many of the respondents did not agree with the questions that addressed the null hypothesis when looking at the findings. When testing the alternative hypothesis, the majority of the respondents agreed with the questions aimed at addressing the alternative hypothesis. This means that most of the respondents accepted the alternative hypothesis (Fourth-generation mobile systems impact students' academic performance).

8.0 RECOMMENDATIONS

The findings illustrate that it is recommended that the university continue to expand on mobile/wireless technologies. The university should consider using other forms of technology such as video-recorded classes to supplement what is learned in class. The university should also consider adding more smart technologies in classes to improve students' classroom experience. It should be encouraged and recommended that the university use more electronic academic content and e-learning platforms to enhance the learning experience for students. The university should attempt to encourage students and lecturers to collaborate on the use of video and voice calls. Overall, the university should consider technologies such as streaming, which are currently unused in teaching and learning to collaborate between students and lecturers in the university and from other universities.

9.0 CONCLUSION

The university should encourage students to understand the impact of fourth-generation mobile technologies on their academic performance of students. Students should have access to 4G devices and academic resources. The finding indicates that a large majority of students agree that fourth-generation mobile technologies impact students' academic performance and over effect on students' well-being. Furthermore, students must understand what fourth-generation mobile technologies are. The study tried to understand whether these technologies had a progressive or undesirable impact on students' academic performance. This study includes a literature overview that outlines the definitions of 4G and fourth-generation mobile technologies. The study further describes the features of Fourth-generation mobile/wireless technologies and a comparison of the third-generation technologies and fourth-generation of technologies.

This study's findings describe the research findings through the analysis and interpretation of the data acquired using descriptive statistics. In the questionnaire, specific questions were probed with regard to the research questions. The analysis was done through descriptive frequencies, and the Cronbach alpha of coefficients was employed to verify that the questionnaire and its variables are reliable. The results showed that fourth-generation mobile technologies had an impact on students' mobility, increased Internet quality and faster Internet connection, and increased online resources than going to the library which supports and improves the academic performance of students. From the interpretations made, students use 4G mobile technologies to supplement their studies, whether to access academic resources, complete assignments, or share resources and communicate with fellow students and lecturers. Also, 4G mobile technologies provide good quality, high-speed Internet for students to engage in voice and video calls for their academic learning. Additionally, students use the high-speed Internet to access all the academic material they need.

In summary, the study showed that students have already adopted 4G mobile technologies, and they use these technologies in their academic lives in several ways. With the understanding and having answers to the research questions posed in this study, the findings indicate that 4G technologies have influenced the academic performance of students with regards to how they communicate with other students and lecturers. Students have also found it easier to access academic resources when in need of them. In summary, fourth-generation mobile technologies are affecting students' academic performance.

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