

# Application of Online Pedagogy to Enhance Undergraduates' Learning Outcomes in Chemistry

Okafor Ngozi\*

Department of Science and Technology Education, University of Lagos, Lagos, Nigeria

\*Corresponding Author: [nokafor@unilag.edu.ng](mailto:nokafor@unilag.edu.ng)

## ABSTRACT

The low Cumulative Grade Point Average of most chemistry undergraduates results in their low achievement and motivation which poses a threat to the production of future chemistry teachers. The diversity of this problem has resulted in several suggestions concerning the application of Google Meet strategy to determine its efficacy in ameliorating this problem in the Nigerian educational setting. Two null hypotheses guided the research. This study was an ex-post facto and quasi-experimental designs that involved 125 chemistry undergraduates. Three research instruments were used in data collection. Data were analyzed using mean and analysis of variance. Results showed that undergraduates exposed to Google Meet Pedagogy (GMP) had greater achievement than those exposed to Classroom Teacher Approach (CTA). However, undergraduates exposed to CTA had better motivation in chemistry than those exposed to GMP. The finding showed a significant influence of course types on undergraduates' achievement in chemistry. There was no significant influence of course types on undergraduates' motivation. The study concludes that undergraduates should be provided with adequate online facilities to be skillful and knowledgeable. It suggests that university lecturers should be sponsored for professional development on the application of online pedagogies to enhance undergraduates' achievement and motivation in chemistry.

**KEY WORDS:** Google meet; course type; motivation; achievement; classroom approach

## INTRODUCTION

Chemistry is a central science that contributes immensely to national development in diverse fields, such as food production, clothing, housing, transportation nursing, medicine, pharmacy, agriculture, engineering, geology, and among others. In Nigerian universities today, undergraduates taking chemistry are few in number and their performances are quite discouraging (Okafor, 2013b). To ensure that undergraduates improve their learning outcomes amidst the COVID-19 pandemic cankerworm ravaging the world, there may be the need to make online teaching and learning in Nigeria's tertiary institutions compulsory. If so, to prepare undergraduates for better achievement, they would need to be exposed to a virtual chemistry laboratory (Okafor et al., 2019).

The onset of COVID-19 pandemic in the early 2020's has exposed many inadequacies in Nigeria's education system ranging from inadequate access to the resources required for virtual learning to inadequate knowledge on the application of a few available resources. The pandemic has interrupted the conventional method of teaching shifting students to E-classrooms (Carey, 2020). Unfortunately, many Nigerian university lecturers adapting to online lesson delivery do not have adequate training nor do many of their learners have adequate access to digital learning resources (Carr, 2016). This has contributed to the decline in students' learning outcomes in chemistry at all levels of education (Okafor, 2021). Motivation

gives individuals the zeal to keep learning and adjusting to innovations (Okafor, 2021; 2016b).

Liguori and Winkler (2020) and Nistor and Nyer (2018) posited that only a shift to online teaching could help in tackling teaching and learning problem amidst the pandemic crisis. Purwanto and Tannady (2020) suggested the application of Google products such as (a) Google Hangouts, (b) Google Jam board and Drawings, and (c) Google Meet among others. Purwanto and Tannady (2020) posited that Google tools could be used as alternative to face-to-face classes. Undergraduates' low grade point average could be tackled if competent lecturers used Google tools effectively during online instructions. It was observed that most chemistry undergraduate had low Cumulative Grade Point Average (CGPA) which poses a threat to the production of future secondary school chemistry teachers. Several efforts had been made by Science Teachers Association of Nigeria in providing solutions to students' poor learning outcomes in chemistry (Okafor, 2020). Unfortunately, the problem still persists due to poor teaching pedagogies, lack of motivation, poor reasoning level, and learning styles (Okafor, 2021, 2020, 2016a; Okafor and Yewande, 2015). Poor students' achievement and motivation in chemistry are quite alarming and these require immediate attention to avoid production of inexperienced manpower in the teaching of chemistry and its related disciplines (Okafor, 2021, 2020). As a result, this paper investigated Google Meet Pedagogy (GMP) and Classroom

Teacher Approach (CTA) (lecture method) on undergraduates' achievement and motivation in chemistry.

### Transactional Distance Education Theory (TDET)

The theoretical framework used for this study was TDET developed by Moore (2007) which provides a framework of the pedagogy involved in online education. TDET theory was developed to define the field of distance education in terms of pedagogies (Moore, 2007). The framework of this theory is specific to teaching and learning which occur outside the traditional classroom setting, thereby addressing the time and space between teacher and learner. According to Moore and Kearsley, (2005), the cognitive separation, which exists between teachers and learners in distance education can be applied to online learning. Moore (2007) explained further that this cognitive separation as transactional distance, a potential space of misunderstanding between teacher inputs and those of the learners defined online learning. Moore (2007) also described the distance as a psychological separation influenced by three pedagogical components which include: structure, dialogue, and autonomy. Therefore, TDET is concerned with the pedagogy of online learning (Moore and Kearsley, 2005). TDET suggests that an online course must intentionally be planned and design to overcome gaps in teacher/student, student/student, and student/content interactions. Moore (2007) claimed that the theory was flexible and could be applied to all programs that have separation with distinctive characteristic, no matter the degree of structure, dialogue, and autonomy. GMP fits into TDET due to its efficacy outside the classroom settings.

### Problem

An established trend in higher education learning is the development and application of online learning to promote undergraduates' achievement (Okafor et al., 2019). Some of these developments include setting up of Learning Management System, MOODLE, and the use of application tools such as Google Meet, Zoom, and among others. These applications have helped to curb the spread of COVID-19 virus and improve undergraduates' performance in several institutions (Basilaia and Kavadze, 2020). The problem of undergraduates' achievement has been viewed from different angles due to its diversity. Lebatam and Mudau (2014) stated that students' poor learning outcomes in biology stemmed from outdated teaching approaches, and none are compliant with virtual learning. Okafor et al. (2019) suggested that studies on virtual lessons should be documented to ensure that instructors embrace them for improving learning outcomes in chemistry. Okafor et al. (2019), further, posited that to improve students' achievement in chemistry laboratory, they should be exposed to a virtual laboratory to acquire cognitive competence and science process skills. The low CGPA of most undergraduates in chemistry courses could be adduced to inappropriate innovative pedagogies, abstract nature of chemistry, and poor application of virtual tools for the 21<sup>st</sup> Century teaching and learning (Okafor et al., 2019).

Okafor (2013a) found that graduates of today could not solve common problems envisaged in their environments due to poor knowledge of online learning potential in education. Despite the excitement chemistry brings to students' lives, most of them still believed that the subject was boring, uninspiring, and may likely not contribute to their aspirations. Carr (2016) designed online conference teaching to motivate and inspire learners of diverse age groups and class levels. Herro et al. (2021) reported that acquisition of computational skills could enhance the time learners devote to learn, expose them to available data and information, provide immediate feedback, and assist less qualified teachers, and increase teachers' efficiency and effectiveness during teaching-learning process. The purpose of this study therefore was to investigate the effects of Google Meet, CTA, and the influence of course-types on undergraduates' achievement and motivation in chemistry at the University of Lagos. Two null hypotheses guided the study:

$H_{01}$ : There is no significant mean difference in pre-post-tests scores of GMP and CTA on undergraduates' achievement and motivation in chemistry.

$H_{02}$ : There is no significant influence of undergraduates' course types on achievement and motivation in chemistry.

## LITERATURE REVIEW

### Google Meet, Traditional Approach, and Course Type on Achievement and Motivation

In education, virtual learning has been used as a source of professional learning community for information dissemination (McConnell et al., 2013). GMP is an online video-communication service developed by Google for delivering lectures and training (St John, 2020). It is a shift from the traditional face-to-face classroom training (CTA) to ICT-based personalized, flexible, individualized, self-organized, and collaborative learning which focus on the community of learners, teachers, facilitators, and experts (St John, 2020). Google Meet involves teaching and assessment approaches that use technology to enhance learning experiences and research (St John, 2020). This innovative pedagogy offers potential values as opposed to the traditional teaching due to its flexibility and accessibility of information to numerous learners at the same time. International Association for K-12 Online Learning (INACOL) (2013) reported that online instruction is an approach to teaching and widely recognized by many seeking for information and knowledge. However, some researchers hold the view that motivation could influence students' learning outcomes positively or negatively irrespective of the approaches employed (Wang et al., 2008). Lebatam and Mudau (2014) explored the factors affecting performance of Biology students in Lesotho revealed that online learning was a significant factor on students' learning outcomes. Some studies have applauded students' satisfaction when taught with Google Meet and face-to-face blended approach (Buzzard et al., 2011). Bratina (2017) and Nistor and Nyer (2018) reported that blending online instruction and

CTA (lecture method) could enhance students' collaborative ability, achievement, and motivation. According to Okafor (2021), motivation propels learning and provides pathway for career in every endeavour. Okafor (2021), further, explained that students enjoy classroom interactions that connect them to their imaginative world. Okafor and Yewande (2015) posited that motivation predicts reasoning levels, interest, and self-esteem of the learners. Okafor et al. (2019) concluded that virtual learning contributes significantly to the performance of chemistry students during acid-base titrations. Okafor (2021) deployed role model attributes to capture the understanding and motivation of slow learners in chemistry and a positive result was obtained. McConnell et al. (2013) explained that virtual learning may have positive impact on teachers' perception of teaching styles, and students' motivation during teaching and learning.

## METHODOLOGY

This study was an ex-post facto and quasi-experimental design which involved an intact class in each of the two groups (experimental and control). There were pre-post-tests to ascertain the initial differences and controlling of selection biases which might threaten internal validity of the study. The experimental group was taught with GMP, while the control group was taught with CTA. The study was conducted at the University of Lagos involving selected undergraduates from the Department of Science and Technology Education (chemistry education unit), and the Department of Chemistry, where the researcher had access to chemistry undergraduates and materials required for the study. It involved all the 300-level undergraduates of chemistry education unit and pure chemistry. Among the 300-level undergraduates, only those with CGPA of 3.5 and above during the 2019/2020 second semester examinations were considered. These two departments were chosen due to their willingness to participate in the study. Gas laws were considered due to the misconception undergraduates' experience in the concepts. The 300-level chemistry education and pure chemistry undergraduates' second semester 2019/2020 academic session broadsheets were obtained from the Course Advisers of the respective departments to outline those with CGPA of 3.5 and above. A total of 125 had CGPA of 3.5 and above which include: Chemistry Education 63 (42 females and 21 males) and Pure Chemistry 62 (33 females and 29 males) with an average age of 20 years. Comparison of undergraduates' achievement and motivation in the study was based on the sample size for each of the departments. WhatsApp group chat was opened to accommodate the experimental group (GMP), whose surnames begin with alphabets A to O, while P to Z is the control group (CTA) as agreed unanimously by the participants. Overall, 70 were in the experimental group with 55 in the control group. Both groups had favorable disposition to participate in the study due to the incentives of free internet airtime and snacks provided for them.

## Instruments

Three research instruments were used in data collection which include: Google Meet and Classroom Teacher Lesson Manuals (GMCTLM), Chemistry Achievement Test (CAT), and Motivation in Chemistry Rating Scale (MCRS).

### GMCTLM

This comprised two different lesson plans written by the researcher on Google Meet pedagogical strategy (for experimental group) and CTA (for control group) in teaching gas laws. Each covered the topic, sub-topics, duration, behavioral objectives, instructional materials, content, assessment, summary, and assignment on gas laws concept in chemistry. Each covers steps and instructions which the teacher used to deliver the lesson using GMP with adequately prepared slides, videos, and pictures on the concept. For the experimental group, the teacher introduced the topic by asking the students questions on gas laws, displayed the content using screen share icon available on Google Meet while in the CTA for control group, the teacher introduced the concept of gas laws by dictating notes for them to copy during the physical classroom without instructional materials for interactions.

### CAT

CAT was comprised 20-items adapted from the West African Examination Council multiple choice objective question-type used in testing Senior Secondary School Chemistry Students from 2010 to 2020. Test items offered four options, see the following for example questions:

- (1) Which of the following statements is correct.
  - a. The average kinetic energy of a gas is directly proportional to its temperature
  - b. At constant temperature, the volume of a gas increases as the pressure increases
  - c. The pressure of a gas is inversely proportional to its volume
  - d. The temperature of a gas is directly proportional to its volume
- (2) Which of the following is an exception in the assumptions of the kinetic theory of gas?
  - a. Gases are composed of many elastic particles
  - b. The particle is of negligible size
  - c. The particles are in constant random motion
  - d. The particles collide with each other
- (3) When pressure cooker is half filled with water and heated to boiling point, then the pressure inside the cooker will:
  - a. Decrease, since only a fraction of the water molecules has changed to vapour
  - b. Remain constant because the total number of water molecules has not changed
  - c. Increase, because the water molecule can now reach every part of the sealed tube
  - d. Increase, because the water vapor molecule now strikes the walls of the tube more frequently due to their increased velocity
- (4) The density of a certain gas is  $1.98 \text{ gdm}^{-3}$  at Standard

- Temperature and Pressure (S.T.P). What is the molecular mass of the gas?
- 26.0 g
  - 31.0 g
  - 54.0 g
  - 44.0g (Molar Volume of gas at S.T.P = 22.4 dm<sup>3</sup>)
- (5) What volume of oxygen is produced from the decomposition of 2 moles of KClO<sub>3</sub> at S.T.P?
- 22.4 dm<sup>3</sup>
  - 33.6 dm<sup>3</sup>
  - 44.8 dm<sup>3</sup>
  - 67.2 dm<sup>3</sup>
- (6) What volume of gas is evolved at S.T.P is 2 g of calcium trioxocarbonate (IV) is added to a solution by hydrochloric acid?
- 112 cm<sup>3</sup>
  - 224 cm<sup>3</sup>
  - 448 cm<sup>3</sup>
  - 2240 cm<sup>3</sup>
- [Ca = 40, C = 12, O = 16, Cl = 35.5, H = 1,]  
[Molar Volume of a gas at S.T.P = 22.4 dm<sup>3</sup>]
- (7) If 30 cm<sup>3</sup> of oxygen diffuse through a porous pot in 7 s, how long will it take 60 cm<sup>3</sup> of chlorine to diffuse through the same pot if the vapor densities of oxygen and Chlorine is 16 and 36, respectively?
- 9.3 s
  - 14 s
  - 21 s
  - 28 s

Each correct answer on the CAT attracts one mark. A total of 20 marks was converted to 100%.

### MCRS

The MCRS was adopted from Okafor (2016a) which is comprised 20 items, in which each respondent would make a tick on a Four-point Likert-Scale of 4=Strongly Agree, 3=Agree, 2=Disagree, and 1=Strongly Disagree. See the following examples: (1) My teacher encourages me to get in touch whenever I fail to solve problem in chemistry involving calculations. (2) Whenever I ask question or answer questions correctly in chemistry, teacher grades me with five marks. (3) Active participation during chemistry lesson gladdens my heart due to the positive reinforcement attached to it. (4) I am motivated to connect previous ideas of concepts learnt to a new concept for meaningful understanding. (5) My grades will improve when taught chemistry with GMP. (6) CTA affords me the opportunity of copying notes for safe keep and others.

The GMCTLM, CAT, and MCRS instruments were validated by two professors who are experts in instruments development. They authenticated the contents to be valid for the research. The CAT and MCRS were administered to 75 chemistry education undergraduates of State University that did not participate in the study. Their responses were analyzed using Kuder-Richardson Formula 20 and Cronbach alpha which

gave reliability indices of 0.89 and 0.75 for CAT and MCRS, respectively, showing evidence of internal consistency.

These instruments were administered to the respondents and every response was dichotomously scored. Data collection lasted for 3 weeks during the 2020/2021 first semester academic session for both the experimental and control groups. A day was for administration of pre-test (CAT and MCRS) on the respondents, 2 weeks and 5 days of 4 periods in each week (12 periods) for teaching the experimental and control groups (GMP and CTA), respectively, while one day for administration of post-test (CAT and MCRS). The respondents in the experimental group who did not have data were asked to gather at the Faculty of Education, University of Lagos to utilize Campus Wi-Fi, while the control group were in the chemistry education unit laboratory. At the end, each of the respondents was offered free hand sanitizer as incentive. Data were analyzed using simple percentages, mean, and one-way analysis of variance (ANOVA) for inferential tests at 0.05 alpha level of significance.

### FINDINGS

The results of the null hypotheses and discussions of the findings are stated below.

H<sub>01</sub>: There is no significant effects of GMP and Classroom Teacher

Approach (CTA) on undergraduates' (a) Achievement and (b) Motivation in chemistry.

Table 1 shows the summary results of mean difference in the pre- and post-tests chemistry achievement of the undergraduates exposed to CTA (control group) and GMP (experimental group). The results showed that undergraduates exposed to GMP had greater achievement in Chemistry than those exposed to CTA with post-test-pre-test mean difference value of 3.4 and 2.2, respectively.

Table 2 shows an F-value of 6.61 and a significant value of 0.01 which implies a significant difference in the test mean scores of both the control and experimental groups. Since the significant value of 0.01 was <0.05 with calculated F-value of 6.61; hence, the null hypothesis was rejected.

Table 3 shows the summary results of mean difference in the pre- and post-tests motivation of undergraduates in chemistry when exposed to CTA (control group) and GMP (experimental group). The results showed that undergraduates exposed to CTA had better motivation in Chemistry than those exposed to GMP with post-test-pre-test mean difference value of 5.2 and 2.4, respectively.

Table 4 shows an F-value of 0.01 and a significant value of 0.94 which implied that there was no significant influence on undergraduates' motivation in chemistry with the mean score value of 0.94 for both the control group (CTA) and experimental group (GMP) was greater than 0.05 and the calculated F-value of 0.01. Hence, the null hypothesis was accepted.

**Table 1: Summary effects of GMP and CTA on chemistry undergraduates' achievement**

Strategy	Sample N	Pre-test			Post-test			Post-test–Pre-test
		Min	Max	Mean	Min	Max	Mean	Mean difference
CTA (Control Group)	55	4	14	9.3	8	19	11.5	2.2
GMP (Exptal Group)	70	5	14	9.5	8	20	12.9	3.4

Field Survey, 2021. GMP: Google Meet Pedagogy, CTA: Classroom Teacher Approach

**Table 2: Description of the ANOVA statistics on achievement in chemistry**

Achievement	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	46.49	1	46.49	6.61	0.01
Within Groups	865.14	123	7.03		
Total	911.63	124			

Field Survey, 2021. ANOVA: Analysis of Variance

**Table 3: Summary effects of GMP and CTA on chemistry undergraduates' motivation**

Strategy	Sample N	Pre-test			Post-test			Post-test–Pre-test
		Min	Max	Mean	Min	Max	Mean	Mean difference
CTA (Control Group)	55	90	116	106	95	120	111.2	5.2
GMP (Exptal Group)	70	94	124	108.4	95	126	111.3	2.4

Field Survey, 2021. GMP: Google Meet Pedagogy, CTA: Classroom Teacher Approach

**Table 4: Description of the ANOVA Statistics on Motivation in Chemistry**

Motivation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.31	1	0.31	0.01	0.94
Within Groups	6173.5	123	50.19		
Total	6173.8	124			

Field Survey, 2021. ANOVA: Analysis of Variance

**Table 5: Paired sample t-test on influence of undergraduates' course-types on achievement and motivation in chemistry**

Variable	Course type	N	Mean	Calculated-t	Tabulated-t	Df	Sig	Remark
Achievement	Chemistry education	63	12.71	2.03	1.66	123	0.045	Significant
	Pure Chemistry	62	11.77					
Motivation	Chemistry education	63	112.56	0.61	1.66	123	0.543	Not significant
	Pure chemistry	62	111.71					

Survey, 2021

$H_{02}$ : There is no significant influence of undergraduates' course types on Achievement and Motivation in chemistry.

Table 5 shows a calculated t-test value of 2.03 which was greater than the tabulated t-test value of 1.66. Furthermore, a significant value of 0.045 was  $<0.05$  with a degree of freedom of 123 for Chemistry Education and pure chemistry undergraduates on their achievement mean scores. This implied a significant influence of course type on chemistry undergraduates' achievement in chemistry. The motivation mean scores of both Chemistry Education and Pure chemistry undergraduates indicated a calculated t-test value of 0.61 which was less than the tabulated t-test value of 1.66. In addition, a significant value of 0.543 obtained was  $>0.05$  at a degree of freedom of 123. This implied no significant

influence of course type on chemistry undergraduates' motivation in chemistry.

## DISCUSSION AND CONCLUSION

### Effects of GMP and CTA on Chemistry Undergraduates' Achievement

The results showed that undergraduates exposed to GMP, which was the experimental group, had greater achievement than those exposed to CTA, the control group. This is in line with the study carried out by Okafor et al. (2019), who stated that virtual learning promotes academic achievement. The finding corroborates with Purwanto and Tannady (2020) work on the application of GMP that could improve students learning outcomes in diverse disciplines than teaching with

the alternatives face-to-face classes. The result also supports the finding of Lebatam and Mudau (2014) who suggested teachers compliant to online instructions to improve students' achievement in science subject. The application of Google Meet has assisted in curbing the spread of coronavirus pandemic in several institutions with improved academic performance of some undergraduates. GMP, therefore, should be used to replace the traditional Classroom Teacher face-to-face approach for better achievement of undergraduates at the University of Lagos. The significant effect of GMP on undergraduates' achievement is evidence that virtual learning interactions could improve students learning outcomes if the required tools are provided.

### Effects of GMP and CTA on Chemistry Undergraduates' Motivation

The finding showed that undergraduates exposed to CTA had better motivation in Chemistry than those exposed to GMP.

This negates the intention of Carr (2016) who designed online conference teaching to motivate and inspire learners of diverse age groups and class levels. The results are not in agreement with the work of St John (2020) who stated that innovative pedagogy offers potential values in motivating undergraduates than classroom-based learning. But the findings corroborate with the work of Wang et al. (2008) who envisaged that students' motivation could be influenced positively or negatively irrespective of the pedagogical approaches employed. This relates to the study conducted by McConnell et al. (2013) which explained that teachers' perception on some concepts being suitable for virtual learning while others being good for teacher face to face approach. The studies done by Bratina (2017) and Nistor and Nyer (2018) agreed with the finding of the study on blending online instruction and classroom teacher method since they promote students' collaborative ability, achievement, and motivation. This supports Okafor's (2021) assertion that motivation propels learning and provides pathway for career in every endeavor irrespective of the teaching approaches involved. More so, low motivation on most undergraduates exposed to GMP could be due to some factors such undergraduates' socioeconomic status, inconsistent power supply, poor internet connection, and among others.

### Influence of Undergraduates' Course types on Achievement and Motivation in Chemistry

The findings of the study showed a significant influence of course types on chemistry undergraduates' achievement in chemistry while there was no significant influence of course types on undergraduates' motivation in chemistry. The results have also shown that chemistry education undergraduates had better achievement and motivation than pure chemistry undergraduates. This entails that course types could determine students reasoning levels and achievement based on the modes of delivery (Okafor and Yewande 2015; Okafor, 2013a).

However, no significant influence of course type on undergraduates' motivation could be attributable to test anxiety,

negative perceptions, and inability to work independently. The result negates the statement of Okafor (2021) who obtained positive result on motivation and chemistry understanding when the role model attributes were applied on slow learners. Although, there was evidence from the results that undergraduates were motivated using CTA than GMP. The no significant influence of course types on undergraduates' motivation could be attributable to the degree of exposures, concept suitability, and passive acceptability of GMP and CTA by the chemistry education and pure chemistry undergraduates.

## CONCLUSION

Nigerian Universities have not fully provided enabling environments for virtual learning to thrive despite multimedia technologies and internet tools that are available and accessible to the learners. The beginning of the 21<sup>st</sup> Century and onset of COVID-19 have heralded these educational technologies to facilitate online pedagogies for improved learning outcomes. This study has given insight on the potential, utility, strength, and capacity of GMP on undergraduates' achievement and motivation in chemistry, though this requires efficient training of the instructors for quality lesson delivery. This online learning sparked by coronavirus pandemic is an educational paradigm shift to advancing the frontiers of knowledge and skills virtually. It is obvious that when undergraduates of chemistry are provided with adequate facilities for online teaching and learning especially with GMP, they would be skillful and knowledgeable with independent mind in tackling their low CGPA problem resulting from the abstract nature of some chemistry concepts. It is very important that the established policies and laws of the National Universities Commission involving the development and standardization of e-learning in Nigeria are duly monitored and implemented to ensure that graduates of Nigeria Universities can compete academically with other institutions globally. The higher performance of Education Chemistry undergraduates on achievement and motivation depicts their intellectual superiority over the pure chemistry undergraduates. These might result to highly skilled and efficient chemistry manpower in all secondary schools in Nigeria. In addition, to bridge the gap on undergraduates' poor achievement and low motivation, compulsory implementation of GMP and other online instructions should be enforced in all Nigerian universities to give windows of opportunities to some of them from low-income status to partake in the technological revolution. These would lend credence to undergraduates with low performance upgrading their CGPA for improved learning outcomes at the University of Lagos, Nigeria since their achievement and motivation in chemistry are major determinants of the future in attainment of individuals and nation's educational goals. Therefore, tertiary institutions should prepare lecturers and undergraduates with incentives on the use of effective and efficient online pedagogies like Google Meet in the teaching and learning to ensure that quality chemistry education is delivered for national development.

The following suggestions are hereby made:

- GMP should be made compulsory in the teaching of all undergraduates' courses that will cater for their diverse cognitive developmental problems during instructions as well as ensuring that no one is left behind in promoting learning outcomes in chemistry.
- Blending of CTA with other online pedagogies could be emphasized to ensure favorable motivation of undergraduates' especially on their CGPA before graduation.
- University Lecturers should be sponsored to attend conferences, seminars, and workshops that will enable them gain adequate knowledge, and skills on how to utilize Google Meet strategy and other online pedagogies in enhancing achievement and motivation in chemistry.
- Tertiary institutions should ensure that funds are provided adequately on resources required for online learning in various courses at the University of Lagos, Nigeria.
- Universities should provide standard generators and internet facilities in different Universities faculties to enhance undergraduates CGPA for excellent results before graduation.

## ETHICAL STATEMENT

The need to enhance undergraduates' achievement and motivation in chemistry through online teaching and learning at the University of Lagos cannot be compromised. This study was based on personal ethical principles. The author is thus responsible for any challenging criticism when published for public knowledge and citations.

## REFERENCES

- Basilaia, G., & Kvavadze, D. (2020). Transition to online education in schools during a SARS-CoV-2 coronavirus (COVID-19) pandemic in Georgia. *Pedagogical Research*, 5(4), 63-74.
- Bratina, T. (2017). Study content and motivation for using ICT in education. *New Trends and Issues Proceedings on Humanities and Social Sciences*, 4(6), 105-114.
- Buzzard, C., Crittenden, V., Crittenden, W., & McCarty, P. (2011). The use of digital technologies in the classroom: A teaching and learning perspective. *Journal of Marketing Education*, 33, 131-139.
- Carey, K. (2020). *Everybody Ready for the Big Migration to Online College? Actually No*. The New York Times. Available from: <https://www.nytimes.com/search?query=Is+everybody+ready+for+the+big+migration+to+online+college%3F+Actually+no>
- Carr, T. (2016). Designing online conferences to promote professional development in Africa. *International Journal of Education and Development using Information and Communication Technology*, 12(2), 80-104.
- Herro, D., Quigley, C., Plank, H., & Abimbade, O. (2021). Understanding students' social interactions during making activities designed to promote computational thinking. *The Journal of Educational Research*, 114(2), 183-195.
- International Association for K-12 Online Learning (IAK12OL). (2013). *Fast Facts about Online Learning*. Vienna, VA: International Association for K-12 Online Learning. Available from: <https://aurora-institute.org/resource/fast-facts-about-online-learning>
- Lebatam M.C., & Mudau, A.V. (2014). Exploring factors affecting performance in biology at selected high schools in Lesotho. *Mediterranean Journal of Social Science*, 5(8), 271-278.
- Liguori, E., & Winkler, C. (2020). From offline to online: challenges and opportunities for entrepreneurship education following the COVID-19 pandemic. *Entrepreneurship Education and Pedagogy*, 3(4), 346-351.
- McConnell, T.J., Parker, J.M., Eberhardt, J., Koehler, M.J., & Lundeborg, M. (2013). Virtual professional learning communities: Teachers' perceptions of virtual versus face-to-face professional development. *Journal of Science Education and Technology*, 22(3), 267-277.
- Moore, M. (2007). The theory of Transactional Distance. In: Moore, M., (Ed.), *Handbook of Distance Education*. New Jersey: Erlbaum. pp. 89-105.
- Moore, M., & Kearsley, G. (2005). *Distance Education: A Systems View*. Belmont, CA: Thomson Wadsworth.
- Nistor, C., & Nyer, P. (2018). A new framework for online business teaching. *Open Journal of Business and Management*, 6(3), 576-584.
- Okafor, N. (2013b). Gender influence on students' attitude in accessing chemistry education in Nigerian University. *Journal of Educational Review (JER)*, 6(1), 87-92.
- Okafor, N. (2020). Effects of kitchen-explanations analogy model and gender on secondary school students' achievement in chemistry in Isolo, Lagos State, Nigeria. *Journal of Science, Mathematics and Technology Education Research (JOSMATER)*, 2(1), 1-18.
- Okafor, N. (2021). Role model attributes as correlates of slow learners' motivation and understanding of chemistry concepts in Lagos State schools. *Kampala International University (KIU) Journal of Humanities*, 6(4), 79-90.
- Okafor, N.P. (2013a). Effectiveness of two modes of distance learning on Nigerian college teachers' meaningful understanding of chemistry concepts. *Practice Journal of Education and Practice*, 4(1), 36-42.
- Okafor, N.P. (2016a). Perceived influence of learning styles on chemistry achievement of secondary school girls in Nigeria. *Journal of Research and Contemporary issues in Human Kinetics and Health Education*, 3(1), 77-86.
- Okafor, N.P. (2016b). Teachers' gender, motivation and reinforcement as predictors of girls' completion of secondary school chemistry in Abia State. *International Education Journal (INTEJ)*, 10(1), 131-144.
- Okafor, N.P., & Yewande, R.O. (2015). Motivation and self-esteem: Exploring students' gender, reasoning Levels and interest in secondary school chemistry. *International Journal for Cross-Disciplinary Subjects in Education*, 5(3), 2583-2589.
- Okafor, N.P., Okunuga, R.O., & Ojo, T.O. (2019). Effect of virtual chemistry laboratory software (VCLS) on secondary school student achievement in acid-base titrations experiment. *Journal of the Nigerian Academy of Education (NAE)*, 16(2), 38-48.
- Purwanto, E., & Tannady, H. (2020). The factors affecting intention to use Google Meet amid online meeting platforms competition in Indonesia. *Technology Reports of Kansai University*, 62(6), 2829-2838.
- St John, A. (2020). *It's not just Zoom. Google Meet, Microsoft Teams, and Webex have Privacy Issues too*. *Consumer Reports* 3. Available from: <https://www.consumerreports.org/video-conferencing-services/video-conferencing-privacy-issues-google-microsoft-webex-a7383469308>
- Wang, Y.M., Lin, C.C., & Chen, Y.C. (2008). A study on learning motivation, values, learning obstacles and learning behavior. *National Huawei University of Science and Technology*, 27(1), 89-108.