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Research Article

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Effect of Blended Learning Models on Students' Academic Achievement and Retention in Science Education

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ABSTRACT

The norm for pedagogical situations in the 21st century in education is digitization. After the COVID-19 pandemic lockdown, the use of blended learning models (BLMs) at universities has become crucial. The use of teaching in the classroom, particularly in higher education, enhances student learning. In order to build effective teaching-learning, blended learning (BL) places learners in a new learning environment based on technology. The purpose of the current study is to figure out the viability of embracing a BL method in learning science course at the secondary school level. The current study project has been conducted using a quasi-experimental design. The University of Abuja's Center for Distance Learning and Continuous Education recruited 120 undergraduate students for this study. The blended learning model success test (BMAT) and blended learning model retention test (BMRT) were the instruments used for data gathering. The experimental groups' students were instructed using BL methods for eight weeks. The three tests, including the pre-test, post-test I, and post-test II, were given to six groups. Statistical package for social science version 26 was utilized to assess the hypotheses and provide response to the research questions with mean score, standard variation, and error, while the inferential statistics utilized related samples t-test at level of significant of 0.05. Results showed a significant difference between the mean pre- and post-test achievement and retention capacity of students who were receiving science instruction through BL. The study concluded that learners' achievement and retention in science are significantly improved by BLMs. It is recommended that BL approaches be utilized for teaching the sciences because they improve the learner's retention and academic performance.

Keywords: BMAT, BMRT, blended learning, models, achievement, retention, science education

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INTRODUCTION

Science and technology have always played a crucial role in increasing productivity and improving all facets and human labor. Blended learning (BL), a term derived from the words "blend" and "learning," is an educational model that combines various learning strategies. Blending things together is what the term means, and learning is the act of acquiring useful information. Because the author argued that BL is a suitable use of a combination of ideas, techniques, and technologies to establish optimum learning in a certain environment, Cronje (2020) proposed that a definition of BL must contain context, theory, method, and technology. Supporting technologies like learning management systems, virtual and remote laboratories, interactive quizzes, and remote invigilation, as well as enabling technologies like 4G/5G communication systems, big data and data analytics, artificial intelligence, sensors, and the Internet of things, and augmented and virtual reality, are crucial for an effective transition from traditional teaching to online or remote teaching and learning (Reine et al., 2021; Salta et al., 2022). Additionally, the incorporation of devices like computers, cellphones, tablets, and cloud-based resources into educational institutions has changed how instruction is delivered (Bati & Workneh, 2021; Dudar et al., 2021). Using blended learning models (BLMs) in the classrooms has various advantages for teachers, including more convenient teaching resource storage, greater communication, and freedom to roam around the classroom with the resource materials (Tuma, 2021). As a result, many people are adopting new technology to enhance their learning overall (Amankwah-Amoah, et al., 2021; Egielewa et al., 2022; Poquet & de Laat, 2021; Sahni, 2019). BL is not new but nowadays the technological advancement and computer usage in teaching learning process has expended the use of BL in our education system. BL approach uses the positive aspects of traditional teaching-learning. BL also considers the place of learning where the learning happens and directs to reconsider the traditional instructor-centered classroom. BL also directs to reflect on, retool, and then reformat what is a classroom. Instead of the limited traditional

classroom space, BL environment leverages online and out-of-class spaces that respond better to the ever changing and ever evolving with the needs of the students. BLMs also help a teacher to move outside of thinking of the lecture in only this very traditional, hour-long lecture format. The possibilities of BL environment encourage a more active classroom environment or online learning space that engage the students with the content material in an interesting, refined, and targeted way. Selvakumar et al. (2020) noted that the specific advantages of BL are to: provide flexibility in terms of scheduling a course, planning for space and more options to achieve the same learning outcome; provide verity of learning opportunities as per engage himself/herself and can actively participate; balance the face to face and online teaching-learning; and make effective use of the conventional and online teaching and learning

Blended Learning Models

By and large, learning implies blending of on the web and eye to eye educating educational experience, and that implies understudies, are as of now doing some type of mixed advancing as they are learning through up close and personal connection and furthermore riding applicable material on web to finish their ventures/tasks. As advanced and online entertainment mediations become increasingly more predominant in the existence of students. Mishra and Devi (2022) expressed that to execute the mixed learning, six models ought to be hypothesized, specifically: supplemental model, replacement model, emporium model, completely online model, buffet model, and linked workshop model.

Supplemental model

This is a mixed learning supplements of conventional course or educating growing experience by utilizing innovation based materials, items and talks or out-of-class exercises. By utilizing innovation based materials it changes over the latent learning climate of a class into dynamic learning climate and furthermore countless understudies can be benefited by embracing this model of mixed learning (Olatunde-Aiyedun, 2021). The fundamental qualities of Supplemental model are the quantity of class gatherings (eye to eye addresses) continues as before; the class gatherings (up close and personal) addresses are enhanced by the innovation based materials, items and talks or out-of-class exercises; the fundamental reason for involving supplements in up close and personal class gatherings is to make the understudies more drew in and dynamic in the class. The strategy expects understudies to audit the material containing intuitive exercises, reenactments, narratives, recordings and so on.

Appraisal can be directed by online tests toward the finish of every week. The understudies might be approached to endeavor the tests on various occasions until they fulfill with their own advancement. The understudies might be told that main the last score or the most noteworthy score will be viewed as in their formative appraisal. This cycle can be utilized preceding up close and personal connections; for example, out-of-class. Be that as it may, carrying out supplemental model of mixed learning the test is in regards to responsibility on understudies (Viditi, 2022).

Replacement model

This model replaces some homeroom time (eye to eye collaboration time) with on the web, intuitive exercises. In this manner this model decreases the quantity of class gatherings by supplanting some class gatherings with on the web, intuitive or clobber exercises and by making a few changes in nature of outstanding class gatherings. The fundamental attributes of replacement model are: it diminishes the genuine number of class gatherings for example up close and personal class time; it additionally thinks about which exercises can be performed better in web-based mode and can give improved outcome, which exercises can be directed separately and which can be led in bunch; the leftover class gatherings might be altered by changing the exercises into open air, lab, or online exercises so understudies can take part and connect with themselves whenever, anyplace. During these exercises, understudies might work exclusively or in bunch. This model plans understudies by perusing the reading material, finishing tasks, and utilizing web-based assets (Chowdhury, 2020).

Emporium model

This model replaces the entire class gatherings with a learning resource center model. This principal component of this learning resource center is use of intuitive program and customized help whenever required. This model depends on learning resource center model having intuitive programming and customized help. A space like the learning resource center offers heaps of network and offices–PCs, remote associations, simple admittance to all web-based course materials, adaptable furnishings, and so on. It gives the potential open doors to understudies to choose learning materials for example intelligent programming relying on their inclinations and requirements, and to deal with the materials rapidly (Mozelius & Hettiarachchi, 2017). The ramification of this model is that it requires more framework and costly gear to advance the better utilization of shared space for example learning resource center.

Fully online model

This is a shift or dispose of eye to eye classes to internet growth opportunities, web-based exercises, reproductions, intuitive programming, online appraisals alongside input and elective model human resource management. It might take on certain components of different models like components of supplemental, replacement, and emporium models including web-based exercises, recreations, intelligent programming, online appraisals along directed criticism, connections to extra assets and elective human resource management model. In this model educators are not liable for all cooperations, addressing each question exclusively, remark, or conversation (Ekpo & Aiyedun, 2020). Educators don't have to introduce content before understudies as Software presents the substance. All tasks evaluated up by the actual product thus the accomplishment of learning targets regarding every understudy can undoubtedly be investigated by the educators (Olatunde-Aiyedun et al., 2021).

Buffet model

The buffet model spotlights on customization of the learning climate for individual understudy in light of their experience, learning inclination, and scholarly/proficient objectives. This model offers understudies a progression of individualized ways to every understudy to accomplish similar learning results. This model redoes the learning climate for individual understudy according to their experience, learning inclination, and scholarly/proficient objectives. It requires a web-based appraisal to recognize the understudy's learning styles and study propensities. It incorporates a progression of learning open doors for understudies for example it incorporates addresses, individual disclosure by research center work (in-class and web-based), group/bunch revelation by lab work, individual and gathering audit

(both live and remote), concentrate on in little gatherings, recordings, therapeutic/essential/strategy preparing modules, oral and composed introductions, critical thinking in huge gathering, schoolwork tasks, and individual and gathering projects (Bryan & Volchenkova, 2016). It presents the total course as modules.

Linked workshop model

This model gives medicinal/formative guidance. The medicinal directions are given by connecting studios. These studios offer understudies supplemental scholastic help on time. This model holds the fundamental design of the course, for example the quantity of class gatherings continues as before. The healing/formative course is given by studios, not in class gatherings. The motivation behind leading these studios is to eliminate lacks in course ideas understanding and abilities (Ayob et al., 2020). Studios are led in little gatherings utilizing PC-based guidance. Programming modules are appointed to individual understudy according to their exhibition and test survey of symptomatic testing. Incredible understudies of the greater classes are prepared by the educator and afterward these understudies work with these connecting studios.

Objectives of the Study

The goal of the current study is to determine if using one of the six undergraduate-level BLMs significantly affects students' academic performance and retention. The study's specific goals are, as follows:

1. Analyze the variation in the mean achievement scores of students taught using BLMs; and (supplemental model, replacement model, emporium model, fully online model, buffet model, and linked workshop model).
2. Measure the variation in students taught using BLMs' average retention scores (supplemental model, replacement model, emporium model, fully online model, Buffet model, and linked workshop model).

Research Questions

The study's research questions and hypotheses were in line with the study's research goals:

1. How do students who take science classes using BLMs differ from one another in terms of mean achievement scores?
2. How varied are the mean retention scores of students who are being taught science using BLMs?

Hypotheses

For the investigation, the following null-hypotheses were examined:

1. **H_{01}:** The mean accomplishment scores of students who were taught using BLMs did not differ significantly from one another (BLMs).
2. **H_{02}:** There is no discernible difference in the average retention capacity of students taught using BLMs.

LITERATURE REVIEW

The effectiveness of the BLM over the conventional teaching and learning approach has been the subject of several studies. According to Khamis (2003), BL is a system that combines traditional instruction with e-learning in a variety of ways inside the classroom to support students at every level of their learning. Mendez and Gonzalez (2010) suggested incorporating a reactive component known as a fuzzy logic-based controller into an introductory control engineering course using BL approach. The methodology assessment's findings supported the blended method's effectiveness in terms of the learning level and performance of the engineering students. The ability of instructors to design and implement BL strategies was examined by Abumosa and Al-Sous (2010) used BL technique on the ability of teachers in designing and producing educational multimedia.

The findings show that the teachers were able to develop instructional multimedia, giving them more confidence when dealing with e-learning and developing their own BLM. Al-Shaer (2013) looked into how using BL could improve the teaching and learning of comprehension in an English as a foreign language (EFL) course blended education. The outcomes revealed a statistically significant change in the students' attitudes and enthusiasm for using computer-based activities and learning English. The effects of a BL paradigm on junior high school students' learning outcomes and attitudes toward mathematics are examined by Lin et al. (2017). The study's findings also suggested that classroom activities utilizing the BL approach have a considerably beneficial impact on students' views toward this type of instruction. The results showed that male students were more motivated in BL.

In a world where information communication technologies (ICTs) increasingly communicate with one another, Dziuban et al. (2018) addressed a number of outcomes, implications, and potential future paths for BL in higher education. There are sound if-then decision rules for deciding how students evaluate their educational experiences, according to research on students' perceptions of course excellence. Although BL predates present instructional technologies, it was found that although these technologies are approaching some features of human brain processes, their development will be inexorably linked. Kavitha and Jaisingh (2018) look at undergraduate and graduate students who take programming courses in a BL environment.

The findings showed that students who are proficient in using particular computer apps and programs benefit more from the BL method. The study's findings also shed light on how students prefer to learn in these collaborative, knowledge-sharing contexts. Students' perspectives about mixed learning and associated ideas like paperless and traditional classrooms were examined by Akbarov et al. (2018). According to the study, in an EFL setting, pupils favor integrated learning over regular classroom instruction. However, they preferred taking paper-and-pencil tests for English rather than online ones.

They disagreed on whether English coursework should be turned in personally or electronically. They had a similar level of confidence in analog and digital English teaching and learning resources. Within an EFL environment, students' attitudes toward infographics and paperless classrooms were moderately good. Alsalhi et al. (2019) looked into how BL affected ninth-grade students' science achievement and attitudes toward using it. It contrasts the outcomes of various science lesson plans with students' attitudes toward their application. The results showed that there were statistically significant differences between the experimental and control groups, favoring the experimental group, and that attitudes toward the use of BL were also more favorable among the experimental group. They had favorable attitudes toward students who had performance level academic performance in a science subject.

The impact of BL on students' memory of physics in federal colleges of education in Southeast, Nigeria, was examined by Chinwendu and Nnoduka (2020). According to the study, pupils who took part in it retained more of the material in physics thanks to BL. It was also shown that students' memory of the physics material was independent of their gender.

The summary of the examined literature reveals that only a small number of studies have investigated BL strategies for scientific teaching and learning in the Nigerian educational system. However, there hasn't been any research done on using the BL approach to teach science to undergraduate students in Nigeria. In order to fill the research gap, this study shall investigate the impact of BLMs on the achievement and retention ability of University of Abuja Center for Distance Learning and Continuing Education students taught science when exposed to the six BLMs.

MATERIALS AND METHODS

Research Design

The quantitative approach was used in the current study to compare the efficacy of several BL methods. Descriptive statistical procedures were used. To confirm the effectiveness of the BL technique in learning science, a control group design with pre- and post-tests was used in conjunction with a quasi-experimental study methodology. Academic accomplishment and retention in learning science are the dependent factors in this study, while BL strategies are the independent variables.

Sample Size and Sampling Technique

The University of Abuja chose 120 undergraduate students using the purposive sampling technique. The sample was chosen in order to produce a homogenous group based on the percentage of marks they received in their prior exam. Additionally, these 120 were divided into equal parts using simple random sampling technique into groups namely the experimental group I, II, III, IV, V, and VI and each group consisted of 20 students each.

Data Collection Procedure

The researcher chose the unit "climate change" to investigate the study questions.

Learning objectives are carefully developed after a detailed analysis of the lessons within the chosen units. When defining the learning objectives, the opinions and ideas of seasoned science education lecturers were carefully considered. The researcher then created several exercises, pertinent audio and video clips, and instructional strategies for each BLM. For the study, two instruments were created: the blended learning model success test (BMAT), which had 25 multiple-choice questions to measure academic achievement, and the blended learning model retention test (BMRT), which measured academic retention. The data was gathered using the planning, execution, and observation, reflection, and evaluation stages of a classroom-based research process.

Eight weeks were used to complete this research investigation. The six groups were given the pre-test at the start of the treatment. Following that, the group members answered to the post-test-I (BMAT). To assess how well the students were retained after a month of treatment, post-test-II (retention test) was given to the groups (BMRT).

Data Analysis

Quantitative analysis was done on the gathered data. Statistical package for social science (SPSS) version 26 was used to examine the participant's pre-test, post-test, and post-test II scores. At the 0.95 confidence interval, all of the hypotheses were tested. The researchers employed both inferential analysis (paired samples t-test) to compute for the results of both groups and to analyze differences between the pre- and post-tests and descriptive analysis (mean & standard deviation [SD]).

RESULTS

Answering Research Questions

Students' mean achievement using blended learning method

This section presents the mean, SD, standard error, and means the achievement gain of students taught basic science using BLM.

RQ1: What is the difference in the mean achievement scores of students taught science with BLM?

A total of 120 University of Abuja Center for Distance Learning students participated in the pre- and post-test. The descriptive statistics of the pre and post students' achievement taught science using BL method showed that; the mean pre-test score was (21.6±3.208) while the mean post-test score is (36.3±5.639). The result further revealed that; there was an improvement in the pre- and post-test score of the students because the mean achievement was 14.7, which implies that

Table 1. Descriptive statistics of mean achievement of students taught science using the six BMAT

Models	Test	n	Mean	Standard deviation	Standard error	Mean achievements
BLM 1	Pre-test1	20	34.15	4.682	1.047	11.3
	Post-test2	20	22.85	2.777	.621	
BLM 2	Pre-test1	20	36.90	5.447	1.218	16.1
	Post-test2	20	20.80	3.397	.760	
BLM 3	Pre-test1	20	36.00	5.506	1.231	14.7
	Post-test2	20	21.30	3.389	.758	
BLM 4	Pre-test1	20	38.90	5.251	1.174	17.5
	Post-test2	20	21.40	2.836	.634	
BLM 5	Pre-test1	20	38.10	5.370	1.201	17.5
	Post-test2	20	20.60	2.909	.651	
BLM6	Pre-test1	20	33.90	6.240	1.395	11.3
	Post-test2	20	22.60	3.560	.796	

Note. Source: Result from SPSS output

Table 2. Descriptive statistics of mean retention of students taught science using the six BMRT

Models	Test	n	Mean	Standard deviation	Standard error	Mean achievements
BLM 1	Pre-test1	20	33.55	4.084	.913	10.7
	Post-test2	20	22.85	2.777	.621	
BLM 2	Pre-test1	20	37.40	4.860	1.087	16.6
	Post-test2	20	20.80	3.397	.760	
BLM 3	Pre-test1	20	36.80	5.531	1.237	15.5
	Post-test2	20	21.30	3.389	.758	
BLM 4	Pre-test1	20	38.50	4.850	1.085	17.1
	Post-test2	20	21.40	2.836	.634	
BLM 5	Pre-test1	20	36.50	5.726	1.280	15.9
	Post-test2	20	20.60	2.909	.651	
BLM6	Pre-test1	20	35.00	4.702	1.051	12.4
	Post-test2	20	22.60	3.560	.796	

Note. Source: Result from SPSS output

Table 3. Paired samples t-test result of achievement in science between pre- & post-test scores of students taught using six BMAT

	Test	n	Mean	Standard deviation	t_{cal}	df	p-value	Decision
Hypothesis 1	Pre-test	20	34.15	4.682	8.372	19	0.000	H_0 is rejected
	Post-test	20	22.85	2.777				
Hypothesis 2	Pre-test	20	36.90	5.447	14.152	19	0.000	H_0 is rejected
	Post-test	20	20.80	3.397				
Hypothesis 3	Pre-test	20	36.00	5.506	8.842	19	0.000	H_0 is rejected
	Post-test	20	21.30	3.389				
Hypothesis 4	Pre-test	20	38.90	5.251	11.454	19	0.000	H_0 is rejected
	Post-test	20	21.40	2.836				
Hypothesis 5	Pre-test	20	38.10	5.370	15.211	19	0.000	H_0 is rejected
	Post-test	20	20.60	2.909				
Hypothesis 6	Pre-test	20	33.90	6.240	6.647	19	0.000	H_0 is rejected
	Post-test	20	22.60	3.560				

Note. Source: Result from SPSS output & Decision rule: Reject HD if p<0.05

BMAT has an effect on the learning and teaching of science among undergraduate students at University of Abuja (**Table 1**).

Students' mean retention using blended learning method

RQ2: What is the variation in the mean retention scores of students taught science with BLM?

A total of 120 distance learning students at University of Abuja, Nigeria students participated in the retention test. The summary statistics of the students' retention of science using BL method showed that; the mean pre-test retention score was (21.59±3.208) while the mean post-test retention score is (36.29±5.144). The result further revealed that; there was a 14.7 improvement in the retention score of the students. This result implies that BMRT has an effect on the retention ability in science among undergraduate students at University of Abuja (**Table 2**).

Hypotheses Testing

Hypothesis testing of student achievement in science using blended learning method

H_{01}: There is no significance difference between the mean achievement scores of students taught with BLMs.

Students at the University of Abuja who were studying science took BMAT, and their post-test scores differed statistically from their pre-test results (**Table 3**). The post-test score (mean=36.3, SD=5.664) was greater than the pre-test score (mean=21.6, SD=3.21), and at 119 degrees of freedom (df), p=0.000<0.05, $t_{calculated}$=23.66>$t_{critical}$=1.96.

As a result, the null hypothesis one **H_{01}** is disproved in favor of the alternative, which shows that the general mean scores of all university of Abuja students have significantly improved from their pre-test to post-test scores. This finding suggests that there is a substantial difference between the mean accomplishment scores of students receiving scientific instruction using a BL approach (BLM).

Hypothesis testing of student retention ability in science using blended learning model achievement test

H_{02}: There exists no significance of difference between the mean retention ability of learners taught with BLM.

Results on the paired samples t-test presented in **Table 4** indicate a statistically significant difference in retention ability, as the post-test-II score of students was significantly higher (mean=364.3, SD=5.14) than the mean post-test I score of students before they were taught (mean=21.6, SD=3.21). The mean difference between the pre and post-test scores of students' retention ability in science after being taught using BMRT is 14.7. This difference was significant because the calculated $t_{calculated}$=24.3 was higher than the calculated $t_{critical}$ of 1.96 and (p=0.000<0.05) at the level of confidence, = 0.05, and 119 df. The alternative hypothesis was accepted, and the null hypothesis was disproved. This suggests that there is a sizable difference in the students who were taught science using a mixed learning approach's mean pre- and post-test retention abilities. The outcome also suggests that the BL approach has a statistically significant impact on students' capacity for scientific retention at the University of Abuja.

Table 4. Paired samples t-test result of achievement in science between pre- & post-test scores of students taught using six BMRT

	Test	n	Mean	Standard deviation	t_{cal}	df	p-value	Decision
Hypothesis 1	Pre-test	20	33.55	4.084	8.19	19	0.000	H_0 is rejected
	Post-test	20	22.85	2.777				
Hypothesis 2	Pre-test	20	37.40	4.860	14.75	19	0.000	H_0 is rejected
	Post-test	20	20.80	3.397				
Hypothesis 3	Pre-test	20	36.80	5.531	9.00	19	0.000	H_0 is rejected
	Post-test	20	21.30	3.389				
Hypothesis 4	Pre-test	20	38.50	4.850	11.42	19	0.000	H_0 is rejected
	Post-test	20	21.40	2.836				
Hypothesis 5	Pre-test	20	36.50	5.726	10.62	19	0.000	H_0 is rejected
	Post-test	20	20.60	2.909				
Hypothesis 6	Pre-test	20	35.00	4.702	9.70	19	0.000	H_0 is rejected
	Post-test	20	22.60	3.560				

Note. Source: Result from SPSS output & Decision rule: Reject HD if $p<0.05$

DISCUSSION OF FINDINGS

The purpose of the research study was to determine whether BLMs are effective for teaching science at universities. Because the mean achievement was 14.7, the pre-test mean score in **Table 1** indicates that there was an improvement in the students' pre and post test scores. This suggests that BMAT has an impact on the undergraduate students at the University of Abuja's learning and teaching of science. Adams and Onwadi (2020), Adams et al. (2021), who also discovered a similar finding, demonstrate that there was no significant difference between the pretest and post-test groups. The difference in the mean achievement scores of pupils taught using BLM differs considerably, according to the t-test analysis from **Table 3** [$p=0.000<0.05$]. As a result, the null hypothesis one H_{01} is disproved in favor of the alternative, which shows that the general mean scores of all university of Abuja students have significantly improved from their pre-test to post-test scores.

The results of Dina et al. (2020), Ibrahim (2020), Sivakumar (2019), Tyas et al. (2020), as well as Selvakumar and Sivakumar (2019), who reported that BL models are effective on students' academic achievement, agreed with this one.

The study also showed that, according to **Table 2** and **Table 4**, there was no discernible difference between undergraduate students' post-test-I and post-test-II retention abilities when BMRT was implemented. According to the analysis, the post-test-I participants' mean scores were 21.6 with an SD of 3.21, whereas post-test-I participants' scores were 364.3 with an SD of 5.14. After applying BMRT to assess student retention in science, there is a mean difference of 14.7 points between pre- and post-test scores. Based on the aforementioned two data, it is determined that BMRT is superior to BMAT in terms of participant retention performance. This result is in accordance with studies by Sivakumar and Selvakumar (2019) and Wichadee (2017), which found that BLMs are more successful when they combine traditional face-to-face instruction with virtual online instruction. These models aid pupils in developing their scientific knowledge and abilities.

Students feel at ease writing and prescribing in the classroom, so there is time to focus on learning about how to enhance outcomes by using various models (Eachempati et al., 2016).

CONCLUSION

The application of BLMs has been regarded as the new normal. The application of these models in teaching, especially in higher education, improves learning outcomes. Based on the results and discussion, the study evidently indicated that the achievement and ability to retain by undergraduates in learning of sciences improved when exposed to BLMs.

Recommendations

The findings of this study encourages educationist to apply BLMs because it enhances the academic performance and retention of students. Based on the findings from this study, the followings can be recommended:

1. Future teachers should receive the necessary training to develop the necessary competencies to use BL techniques. Every member of the university staff should learn at least the fundamentals of ICT, including how to use word processing, spreadsheets, databases, the internet, basic hardware, software maintenance procedures, and applications relevant to their fields. The government can promote this by allocating funds for ICT training for academic staff.
2. Teachers or lecturers should be able to recognize the various BLMs and learn how to create and apply the models in their instruction.
3. Calls for proper funding of public universities should be supported by the federal and state governments, TETFUND, as well as regulatory organizations like the Nigerian Universities Commission, Association of African Universities, and others through the provision of contemporary ICT resources in Nigeria, including, but not limited to, computers (desktop and laptop), printers, scanners, projectors, full software licenses, and digital storage devices.
4. To make it convenient for teachers to access the internet, service providers like MTN, Airtel, 9Mobile, and GLO should make affordable technological infrastructure, such as contemporary ICT devices and high-end internet services, available.
5. The Federal Capital Territory electricity distribution company should ensure an improvement or consistency in the community's electrical power supply, particularly in

Gwagwalada, the location of the University of Abuja's Mini Campus. This will make it possible for faculty, students, and residents of the area to use BL and other ICT electronic devices for teaching and learning.

6. Each tertiary institution's administration should allocate funds from domestically produced revenue to buy ICT equipment specifically for using BL methods in the classroom.

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Declaration of interest: Authors declare no competing interest.

Data availability: Data generated or analysed during this study are available from the authors on request.

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