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Learning Behaviour and Achievement of Students Learning Simple Pendulum Using Ubiquitous Application and Physical Laboratory

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ABSTRACT

The study investigated the learning behavior and achievement of physics students who learnt simple pendulum using the ubiquitous application, the physical laboratory and the lecture method. The aim is to find out if the ubiquitous physics application will enhance achievement and learning behavior as in the laboratory method where students interact with materials physically. Three coeducational senior secondary schools were purposively sampled and one intact Senior secondary 2 physics class was randomly selected from each school and assigned to groups. The pretest- posttest non-equivalent group design was used. A total of one hundred and four students (N=30. N=30, N=44) participated in the study. The result showed that the groups were significant for learning behavior (F(2, 101) = 57.830; p=0.000) and achievement (F(2, 101) = 392.582; p= 0.000) at posttest. Scheffe post hoc analysis showed that the means of all three groups (Ubiquitous application =45.85; physical laboratory =40.57; Lecture = 30.18) differed significantly from each other in their learning behavior. Scheffe post hoc analysis identified the source of the significance in mean achievement in the three groups to be between the ubiquitous and lecture groups as well as between the physical laboratory and lecture groups. The difference in the mean score of male and female subjects in Ubiquitous application and physical laboratory groups did not differ significantly. The Ubiquitous application was thus adjudged useful in learning of simple pendulum just as the physical laboratory. It was concluded that the Ubiquitous application could be a useful alternative to physical laboratory for teaching Simple pendulum in Nigeria and in other countries with similar challenges.

1.0 INTRODUCTION

The importance of science learning in schools cannot be overemphasized hence no nation desirous of economic, political, and sociological progress can afford to neglect it. The role of scientific knowledge and by implication, effective science education in boosting national prestige, military might, national income generation, food security, health care, and international rating of countries has been emphasized [1],[2]. The link between science and economic success has been variously described as the economics of science [3], new economies [4], [5], and Knowledge economy [6] while [7] noted a correlation between scientific wealth and economic wealth. Science and technology education are thus cornerstones of economic growth and national development. A country will be able to take its rightful place in the international community if it invests in science education. Devastating problems of food insecurity, insurgence, unemployment, health service decay and non-availability of portable water are consequences of poor science education. It is very important to note that today's science is the solution to tomorrow's problem too. This clearly explains why in Nigeria, there has been increasing national interest in improving the teaching and learning of science at all levels with an emphasis on physics as the base of technology and innovation.

However, Physics learning faces serious constraints, especially in the area of concept learning, memorization of numerous formulas, calculations, graphical and diagrammatic representations, and experimentations [8], [9], [10]. Experimental Physics is a core component of Physics as a discipline that enhances students' problem-solving skills as well as increases Physics learning participation and outcomes. High premium is placed on experimentation as a means of enabling students to conceptualize, verify rules, theories and test hypotheses as well as gain practical experience [13], [10], [11], [12]. The use of laboratories in teaching science dates back to the late 1800s [14] and redefined the goals of science teaching ever since. However, with the changing conception of what constitutes science literacy and advances in technology, there are serious questions about the role of the laboratory in science learning. Laboratory experiments have two primary purposes. The first is the verification of proofs that backs up ideas. The other is promoting student research project studies, providing students with opportunities to develop expertise, discover rules and regularities that govern nature and validating theoretical information by working on actual objects. The use of physical laboratories has significant impacts on students' reasoning, critical thinking, science understanding, process capability, and manual skills acquisition, thus allowing them to apply their knowledge, develop general conceptions, define new problems, explain observations, and make decisions [15], [16], [17]. As a result, the laboratory over the years has been the Centre of science education, particularly in Physics. Though the laboratory is so crucial in science education, its effective use is challenged by the absence of modern equipment, facilities, and insufficient time for practical activities and competent personnel to man the conduct of laboratory sessions in schools especially in developing countries like Nigeria. Studies have shown that certain technology supported strategies and applications can effectively help students engage in activities in physics [18]; [19], [20], [10]. The ubiquitous applications enable students to carry out practical investigations and generate graphs while working outside the physical laboratory. This is a welcome development for countries battling with equipment and infrastructure decline. During Physics lessons, students often attempt to envision practical scenarios. If the teacher is unable to help them to successfully perform well in this phase, they may configure the situation based on their naïve experiences thereby laying the foundation for misconceptions [21], [22] which often interfere with authentic science learning and result in poor student performance in the subject.

Academic achievement is a measure of a student's ability to demonstrate learning in line with stated objectives [23], as the extent to which a learner is profiting from instructions in the given area of learning [25], [24], and reflects in the level of skill and knowledge acquired. It is the result of education and indicates the degree to which learners, instructors, and educational establishments have fulfilled their learning objectives. Academic achievement is important because it predicts success later life [26], [27] Poor achievement in Physics has been a problem in science education over the years in Nigeria, especially in terminal examinations like the West African Examination Council (WAEC) and National Examination Council (NECO). For example, WAEC results reveal that 25% of students who sat for Physics in 2017 scored credit and above in the examination while 43% scored the same in 2018 and 2019 respectively. While the reason for this abysmal performance may be multivariate, it is necessary to explore the utility of available ubiquitous applications in helping teachers and their students to overcome issues associated with physical laboratory as well as improve achievement in physics.

2.0 THEORETICAL FRAMEWORK

A simple pendulum consists of a mass 'm' hanging from a string of length 'L' and fixed at a pivot point 'P' which when displaced to an initial angle and released, oscillates back and forth with periodic motion [28], [29]. It is a little metal ball with a great mass and a small radius (Fig. 1) compared to the length and mass of the light string from which it is hangs. A pendulum will oscillate in a periodic manner if it is set to swing back and forth. The period T is the amount of time needed to accomplish one oscillation. while frequency 'f'' is the number of oscillations per second. It is an inverse of the period (f = 1/T) and $T = 2\pi\sqrt{\frac{l}{g}}$ while g = acceleration due to gravity and can be determined from the equation

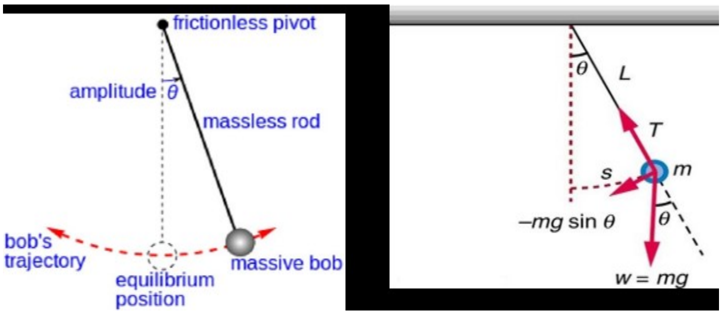

Figure 1: Simple Pendulum

2.1 Ubiquitous Physics Application and learning of Simple pendulum

Ubiquitous application for teaching physics are software programs developed for computer or mobile devices such as smartphones and tablets for the learning of physics at anytime and anywhere [30], [31], [32], [1]. They provide users with necessary services for learning supported by technology and communication using mobile and wireless sensors and location mechanism that collaborate with the surrounding. The ubiquitous physics application for learning simple pendulum can gather acceleration and velocity figures using a tablet's acceleration sensor. These values can then be converted into a graph to help users better understand the pendulum's period time. The application allows students to learn at any time and any place, encouraging experiential learning such as learning by doing, interacting and sharing, facilitating on-demand, hands-on or minds-on and authentic learning [33], [10]. The Ubiquitous-Physics application is not just a perfect instrument for calculating the period of a pendulum with precision and provide graphical interpretations, it can also relate students' ideas to laboratory experiment measurement. It also provides facilities for revisions and updating of knowledge from time to time [35]. Learners also have the privilege to choose the subjects and sequence of learning to follow. Research [36], [37], [38], [40] have shown that when learners have the privilege to learn in an individualized way, they tend to learn more effectively. In this modern age where students may be separated by distance and time from their schools and also where occurrences of pandemic that may cause prolonged or temporary stoppage of face-to-face contacts and physical presence, students can still engage in science investigations deploying ubiquitous applications of different sorts. Establishing the effectiveness of such applications in achieving important goals of education especially in Nigerian context is the target of this study.

Ubiquitous learning also known as u-learning [39], [40] has exerted great influence on the education landscape. Studies [40], [41], [42], [43], [44] have reported the impact of different technological device or tools on student's achievement, engagement and participation in science. Also, mobile devices have been found to be efficacious in inquiry-based science learning, support self-assessments and promote problem solving [45]. The effectiveness of ubiquitous learning environments in enhancing students' achievement, engagement through personalization, customization and interest has also been examined and found to be positively correlated with frequency of use [43] [52]. It has also been found to positively influence hypothesis-making, interpreting graphs, applying formula, conclusion-making and conceptual understanding in learners [10] study conducted in Nigeria examined the use of mobile learning as a pedagogical tool for Physics education in senior secondary schools showed that Physics students taught with mobile learning devices achieved and retained significantly better than those taught with expository method and the effect was not gender discriminatory. This present study explored the use of the ubiquitous application in the learning of simple pendulum compared to use of physical physics laboratory and exposition in secondary schools in Nigeria.

2.2. Learning Behavior in Physics

Learning behavior is the mental readiness of the students to learn which implicates resourcefulness, creative and imaginative thinking, love for learning, high interest in reading and writing, and better psychological adjustment to school [53] [35] explained that a student's behavior has effect on their ability to learn as well as that of others in the learning environment. McLeod & Kaiser, (2014) showed that students learning behavior is one of the variables that exert powerful effect on academic achievement.

Several explanations have been proposed to explain the relationship between learning behavior and academic achievement. For example, critical thinking, problem-solving and achievement [49] [56] [41], development of explorative and unique principles that govern a concept or process [15] and concept understanding [10] are consequent upon positive learning behavior of students. Studies [23] [52] showed that interpreting graphs helps improve conceptual understanding and problem-solving during experiments. Understanding students' learning behavior while using the ubiquitous application is thus an important aspect of this study

2.3. Physical Laboratory and Students Achievement in Physics

The laboratory method of teaching science has often been acknowledged as an essential component of good science instruction. It affords students opportunity to interact with materials, handle equipment [56] and verify laws and principles by following laid down experimental procedures of science while carrying out investigations themselves. It's effectiveness in helping students acquire skills of observations, equipment handling and manipulation, dexterity, inferring, recording as well as perseverance have been acclaimed. It enables students to comprehend complicated abstract ideas and allows them to participate in the process while also developing an appreciation for scientific methodology. The authors believe that information and abilities gained by laboratory methods are more durable and permanent since they are learned through personal experience, observation, testing, verification and engagement. Available functional laboratory equipment encourages students to participate in laboratory activities, allowing them to identify problems, pose relevant questions, conduct efficient and effective experiments, make judgments on alternative hypotheses, and interpret data. As a result, students learn how to discover, learn from discovery, and learn through discovery [23] [56], [34] investigate effects of laboratory experiments and interactive simulation techniques within the framework of 5E model on academic achievement in learning of a unit on Force and Movement in 6th grade science courses in secondary school reported that the interactive simulations were more effective than laboratory method in increasing students' academic achievement thus suggesting the efficacy of other techniques in improving science learning outcomes aside the laboratory. It becomes expedient to find out what the outcome will be when compared with the ubiquitous application.

2.4. Gender and Students Achievement

The influence of gender on academic performance has been a subject of debate especially in the learning of physics. There is a latent belief that physics is s masculine subject and explains the low female choice and participation in physics related careers. The study of gender in science learning is informed primarily on the socio-cultural role differences between girls and boys [26] and not on biological basis. Many researchers have carried out series of studies to find out if the gender of students has any influence on the effectiveness of any instructional strategy employ by teachers in classroom teaching and learning. For instance, [18] in their study found that there were no significant differences in the performance of girls and boys. [47] found that gender (male and female), location (urban and rural) have positive significant difference in achievement while [51] found no significant difference among boys and girls learning science using cooperative instructional strategies.

3.0 METHODOLOGY

3.1. Research Questions

To accomplish this study, the following research questions were asked.

To accomplish this study, the following research questions were asked.

1. Is there significant difference in the mean learning behavior score of students taught simple pendulum using the ubiquitous physics application, physical laboratory and lecture method?
2. Is there significant difference in the mean achievement score of students taught Simple pendulum using ubiquitous physics application, physical laboratory and lecture method?
3. Is there significant difference in the achievement score of male and female students taught simple pendulum using a Ubiquitous physics application

and physical laboratory?

4. Is there any relationship between learning behavior and achievement scores of students taught simple pendulum using ubiquitous physics application in the sample?

3.2. Research Hypotheses

In order to direct this investigation, the following null hypotheses were stated and tested at the 0.05 level of significance.

1. The mean learning behavior score of students taught simple pendulum using ubiquitous physics application, physical laboratory and lecture method did not differ significantly.
2. The mean achievement score of students taught simple pendulum using ubiquitous physics application, physical laboratory and lecture/ expository method did not differ significantly.
3. The mean achievement score of male and female students taught simple pendulum using ubiquitous physics application, and those taught using the physical laboratory did not differ significantly.
4. The relationship between the learning behavior and achievement scores of students that studied simple pendulum using ubiquitous physics application were not significantly.

3.3. Experimental Design

The non-randomized quasi-experimental non-equivalent group pretest- posttest- control group design was employed for the study. The independent variable is instructional methods (ubiquitous application, physical laboratory method and lecture/expository). Sex (male and female) is the moderating variable while the dependent variables are student academic achievement and learning behavior scores. A total of 104 physics students in senior secondary class 2 in Ika North East Local Government area of Delta State were sampled. The samples were drawn from three purposively selected coeducational senior secondary schools. The criteria for selection was the presence of at least one graduate physics teacher who has not less than five years teaching experience and has been presenting students for the West African Senior school certificate examination. The essence of these parameters is to ensure that all the teachers involved possess adequate knowledge and experience for handling the topics which are

1. Simple pendulum experiment
2. Investigating the relationship between period (T) and length (L) of a simple pendulum
3. Effect of angle (ϴ) on the period (T) of oscillation of a simple pendulum.
4. Effect of mass of a pendulum bob on Period (T).

The study lasted for eight weeks. The first two weeks were spent preparing the physics teachers for the experimental techniques of the study while the following four weeks were spent in the actual teaching using the experimental and control treatments.

An intact class in each of the three sampled schools was randomly assigned to treatment group (1st experimental= ubiquitous application, 2nd experimental = physical laboratory and control group = expository /lecture group). Since the 1st experimental school did not allow students to use mobile phones in the school, permission was sought in writing from the school management to allow the students to use it for the period of the study.

3.4. Experimental procedures

Week 1: orientation and practice of the use of the U-app by the physics teacher of the 1st experimental group as well as the topics to be taught, inspection of the lesson plans and other pedagogic discussions. A total of fifteen mobile phones with installed android version of the Ubiquitous application were handed over to the physics teachers of the group. For the 2nd experimental group, the physical laboratory was prepared, ensuring that the number of materials (retort stand rods with base, clamps, masses, strings/ threads, metre rule, stop clocks, protractors and graph books were available and adequate for the number of students that will be involved in the activities. The physics teacher in the third intact class which is the control group was given the lesson plan and briefed on the procedures of the expository treatment.

Week 2: A 25-item multiple choice Achievement test in simple pendulum with reliability coefficient of 0.845 found by Kuder Richardson Formula_21 reliability index was administered to the students to collect pretest data. Kuder Richardson_21 is suitable for dichotomously scored tests where a wrong item is score "0" and a correct one is scored "1". The obtained value was considered high, and thus the instrument was adjudged consistent and reliable. Another instrument, the learning behavior inventory which is a 15-item 4-point modified Likert scale questionnaire scored from 4 to 1 (Strongly Agree to Strongly Disagree) and in the reverse order for negative items was also administered to the students to collect pretest data. Crombach Alpha reliability coefficient of the learning behavior inventory was found to be 0.802, a value considered to be appropriate for the study.

Weeks 3 to 6: Each week the physics teachers taught the lesson adhering to the lesson plan provided by the researcher. Students carried out the activities were applicable as directed in the lesson plan under the supervision of the physics teachers.

		Sum of Squares	Df	Mean Square	F	Sig.
PRETEST	Between Groups	1.447	2	.724	1.232	.296
	Within Groups	59.312	101	.587		
	Total	60.760	103			
POSTTEST	Between Groups	1541.645	2	770.822	391.582	.000
	Within Groups	198.817	101	1.968		
	Total	1740.462	103			

Week 7: Revision of all the learned concepts under the guide of the teacher. Teacher gives the students some revision exercises on the four concepts covered

Week 8: a reshuffled version of the achievement test and the learning behavior inventory were administered to the

students as post- test.
The resulting data were subjected to analysis of variance, Pearson correlation coefficient and scheffe post hoc in cases where the difference was found to be significant.

4.0 RESULTS

H_{01}: The mean learning behavior score of students taught simple pendulum using ubiquitous physics application, physical laboratory and lecture method did not differ significantly

Table 1: Descriptive statistics showing groups, Means and Frequencies

Group	Number (N)	Male	Female	Mean
Ubiquitous Physics Application	30	18	12	45.83
Physical Laboratory	30	21	09	40.57
Lecture Method	34	18	16	30.18
Total	104	57	37	

Out of the 104 subjects sampled for the study, 30 (Male=18, Female = 12) used the ubiquitous application, 30 (males= 21; female = 9) used the physical laboratory while 34 (male = 18 and female = 16) were taught simple pendulum using the lecture method. The mean score for the groups were 45.83, 40.57 and 30.18 for the ubiquitous application, physical laboratory and lecture method (control) groups respectively.

Table 2: Analysis of variance of Learning Behavior Scores of Students Taught Using the Ubiquious Physics Application, Physical Laboratory and Lecture method.

	Sum of squares	DF	Mean square	F	Sig
Corrected model intercept	4718.075	2	2359.038	57.830	0.00
Treatment	4120.079	101	40.793		
Total	8838.154	103			

Significant level =0.05

Table 2 shows the F-value, $F(2, 101) = 57.830$; $p= 0.000$. This is less than the 0.05 alpha level set for the study. It thus means that the difference in learning behavior scores of students taught simple pendulum using the ubiquitous application, physical laboratory and lecture method differed significantly. As a result, the null hypothesis one, which states that the mean learning behaviour score of students taught simple pendulum using ubiquitous physics application, physical laboratory and lecture/expository method did differ significantly and is thus rejected. The source of the differences was further investigated using Scheffe's post-hoc analysis. The table 3 below displays the result of scheffe post-hoc analysis.
Table 3: Scheffe's post-hoc analysis of the sources of the difference in the Mean Learning Behaviour scores of students in the three groups.
Table 3 presents the results of the ANOVA pre-test, which compares the scores of students who were taught using a physical laboratory and ubiquitous physics application with those who were taught using a lecture technique. According to the table, at the 0.05 alpha level, the F-value, $F (2, 101) = 1.232$, was not significant. This suggests that the pretest results of the students in the three groups do not significantly differ from one another. Prior to the start of treatment, the three groups were only somewhat comparable. ANOVA, however, revealed $F(2, 101) = 392.582$ and a p-value of 0.000 at the posttest. This is significant at $p\leq 0.05$ alpha threshold set for this study.
With this, the null hypothesis two, which states that the mean achievement score of students taught simple pendulum using ubiquitous physics application, physical laboratory and lecture/ expository method did not differ significantly was thus rejected. This implies that there was a significant difference in achievement score of students taught simple pendulum using ubiquitous application, physical laboratory and lecture method.
Scheffe's post-hoc analysis to identify the sources of the differences was applied. The post-hoc analysis is displayed in table 5 below.
Table 5: Scheffe's post-hoc analysis of the sources of the difference in the mean Achievement scores of students taught using the ubiquitous physics application, physical laboratory, and lecture method.

The mean difference is significant at 0.05 level.

Table 5 indicates that there is no statistically significant difference between students exposed to physical laboratory ($\bar{X} = 16.60$) and ubiquitous physics application ($\bar{X}= 17.43$)

TREATMENT	N	Mean ($\bar{X}$)	Mean Difference(p-value) ubiquitous physics application	Physical Laboratory	Lecture Method
ubiquitous physics application	30	17.43		0.83 (0.076)	8.18 (0.000)*
Physical Laboratory	30	16.60	-0.83 (0.076)		7.35 (0.000)*
Lecture Method	44	9.25	-818 (0.000)*	-7.35 (0.000)*	

in terms of mean achievement scores. The mean achievement of learners exposed to the lecture method ($\bar{X}= 9.35$) and those exposed to the ubiquitous physics application ($\bar{X} = 17.43$) differs significantly, though. The mean achievement scores of students exposed to the lecture method ($\bar{X}= 30.18$) and those exposed to the physical

		Students Learning behavior	Achievement
Students Learning behavior	Pearson Correlation	1	.739**
	Sig. (2-tailed)		.000
	N	30	30
Achievement	Pearson Correlation	.739**	1
	Sig. (2-tailed)	.000	
	N	30	30

laboratory ($\bar{X}= 40.57$) likewise showed a significant difference. The source of the difference found in hypothesis two is traced to scores of ubiquitous and physical laboratory when compared to the scores from lecture method group (control group)

H_{O3}: The mean achievement score of male and female students taught simple pendulum using ubiquitous physics application, and those taught using the physical laboratory did not differ significantly.

Table 6: Analysis of Variance of Achievement Scores of male and female Students taught simple pendulum using the Ubiquitous physics application and physical laboratory.

Tests of Between-Subject Effects

Dependent Variable: POSTTEST

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	10.467[a]	2	5.233	1.956	.151
Intercept	1608.318	1	1608.318	601.076	.000
Sex	.050	1	.050	.019	.892
Treatment methods	10.050	1	10.050	3.756	.058
Error	152.517	57	2.676		
Total	17537.000	60			
Corrected Total	162.983	59			

a. R Squared = .064 (Adjusted R Squared = .031)

Table 6 displays the results of an analysis of variance (ANOVA) comparing the achievement scores of male and female students who were taught simple pendulum using a physical laboratory with those who used the ubiquitous physics application. It shows a p-value of.892 and the calculated F-ratio, F (1, 57) =.019. The difference is not significant at the 0.05 alpha level established for this investigation because the p-value of.892, is higher than the alpha level of 0.05. The null hypothesis, which claims that the mean achievement score of male and female students taught simple pendulum using ubiquitous physics application, and those taught using the physical laboratory did not differ significantly and as such is accepted. This means that the use of ubiquitous physics applications and physical laboratories enhances the achievement scores of male and female students equally.

Ho_4 : The relationship between the learning behavior and achievement scores of students that studied simple pendulum using ubiquitous physics application were not significantly.

Table 7: Pearson Product Correlation Coefficient of the relationship between learning behavior and achievement of students studying simple pendulum using ubiquitous physics application in secondary schools

Significance level = 0.05

Table 7 shows the Pearson Product Moment Correlation (r) analysis of relationship between learning behavior and achievement of students studying simple pendulum using ubiquitous physics application in the sample. The p-value (0.000) of the correlation coefficient (r=.739) is less than the alpha level of 0.05. The null hypothesis was therefore rejected. This indicated that there was a strong positive relationship between learning behavior and achievement of students who studied simple pendulum using ubiquitous physics application in the sample. It also indicates that the learning behavior of the students in the sample can predict their achievement and vice versa.

5.0 DISCUSSION OF RESULTS

The findings of this study were discussed in accordance with the hypotheses tested. The first hypothesis sought to determine if the difference in mean learning behavior score of students taught simple pendulum using ubiquitous physics application, physical laboratory and lecture method is significant. The finding revealed that there is a significant difference in learning behavior score of students taught simple pendulum using ubiquitous physics application, physical laboratory and those taught with lecture method. The superior learning behavior score of the Ubiquitous physics application users may be related to the interest enhancing quality of electronic devices which has been found to boost students' motivation for learning in all subjects especially in science. This attributed to certain qualities of the U-Physics application such as availability of the recorded work for revision and updating of knowledge from time to time [52] privilege to decide what to learn and in what order, and easy interpretation of graphical expressions. Various studies [43] [42] [58] [33] have reported that when students study in a style that works for them, they learn more effectively. This may be responsible for the higher learning behavior score of the Ubiquitous Physics application users compared to their counterparts in the physical laboratory and lecture method groups.

The second hypothesis was to determine there is variation in students' achievement scores between those taught simple pendulum using ubiquitous physics application, physical laboratory and lecture method. The results showed a substantial difference in their achievement scores in favor of the ubiquitous application and physical laboratory groups. The justification for this finding could be that use of ubiquitous application and physical laboratory enabled the students engage themselves in meaningful learning activities and interaction with materials that the lecture method did not offer. This finding is in line with [53] who found that there is a significant achievement difference between the experimental group that was taught with the laboratory teaching method and the control group that was taught with the traditional approach in favor of the experimental group. The finding is also in line with [52], [59] and [23] who explained that physical laboratory gives students opportunity for engagement both physically and mentally in learning as well as finding convincing evidence about the science learnt thus enhancing academic achievement and retention. This same effect was reported by [40] [41] [42] [43] [44] who recorded better achievement of the Ubiquitous application as a learning tool. The minimal but non significance of the difference in the mean achievement scores of the Ubiquitous application and the physical laboratory groups points to the similar effects of both methods especially in engagement, participation in activities, practicality and interest generation which researchers [13], [26][10] have earlier reported.

The third hypothesis sought to find out if there is disparity in the achievement scores of male and female students who were taught Simple pendulum using the ubiquitous Physics application and physical laboratory.

Males and females in the two groups did not differ significantly. This indicates that, both methods were beneficial to both sexes. The finding aligns with [45] who conducted a similar study in Nigerian senior secondary schools and found no significant difference between male and female Physics students taught with mobile applications.

The fourth hypothesis focused on the relationship between learning behavior and achievement scores of students taught simple pendulum using ubiquitous physics application. A significant relationship between learning behavior and achievement of students taught simple pendulum using ubiquitous physics application was found. This finding agree with [10] and corroborates that of [64] who found that mobile technology- use positively influenced Physics students' achievement and learning behavior. It also aligned with [and [47] who found that Ubiquitous-application stimulates students' active participation in data search, comparison, and field observation during in-field learning activity. This finding also agreed with Sullivan and [68] which stated that positive Learning behavior enable learner to explore and discover unique examples or principles of any concept.

6.0 CONCLUSION, LIMITATIONS AND FUTURE DIRECTIONS

The study concluded that the use of Ubiquitous physics application is effective for teaching simple pendulum as much as the use of physical laboratory. This implies that that science teachers can leverage on the pervasive nature of mobile technology in teaching simple pendulum where physical laboratories equipment is unavailable due to paucity of funds and also in times of physical separation from the classroom such as in distance education and school disruptions as experienced during the pandemic. In addition, the attitude- boosting characteristics of the electronic and mobile devices is an assert to teaching since affective dispositions correlate positively with science achievement. It is also important to note that mobile learning has helped to individualize and diversify teaching and learning mode, the impact of which cannot be disregarded.

This study only utilized the application for learning simple pendulum. It can be applied in other aspects of practical work in physics and other domains of science teaching and learning. Future studies may explore its effect in developing the process skills of science and the 21st century skills in science learners.

Finally, the findings of this study are relevant in developing countries where science facilities constitute a challenge and globally where eventualities occur. Its usefulness in helping students with exceptional learning mode preferences as well as individuals displaced by natural and socio-political unrest to continue to learn science practically is a strong contribution of this study.

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