

Effects of Cell Phone-Assisted Spelling and Pronunciation Intervention on Students' Achievement in Biology among Secondary Schools by Mathematical Knowledge of Set Theory

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Abstract

The study explored the effects of cell phone-assisted spelling and pronunciation intervention on students' achievement in biology, including how the mathematical knowledge of set theory affected the achievement of students in biology. The study adopted the pre-test and post-test control group quasi-experimental design. The study sample was one hundred and one (101) SSII students in Yenagoa metropolis, Bayelsa State, Nigeria, who were selected through purposive sampling. One intact class from two schools was randomly assigned as the experimental and control groups and was taught with the intervention and the lecture strategy, respectively. Instruments used in the study include two instructional guides, along with the Biology Achievement Test (BAT) and the Set Theory Proficiency Test (STPT) with a reliability of 0.83 and 0.82, respectively, using the Kuder-Richardson 21 (KR-21) formula. The research questions were analyzed through mean and standard deviation, while Analysis of Covariance (ANCOVA) was used to analyse the hypotheses at a 0.05 significance level. The study's findings showed that students taught with the intervention had significantly better achievement in biology than those taught with the lecture strategy. The finding further indicates that the mathematical knowledge of set theory did not affect students' achievement in biology when taught with instructional strategies. Among others, it was recommended that e-learning strategies like cell phone-assisted spelling and pronunciation intervention should be adopted in biology learning in the classroom.

Keywords: Achievement, Biology, Achievement.

Introduction

Biology is a scientific domain of knowledge primarily concerned with studying all kinds of living organisms, the phenomenon that characterizes them, and their world. The biology field is the primary source of understanding of life on earth, making it an indispensable field in enhancing life and sustaining it due to the functionalities that come with its knowledge. It is a broad field and, as such, is characterized by a wide range of sub-fields, domains, and

applications, which all play significant roles in our world (Owolabi et al., 2019; Ramon & Bello, 2019).

Based on its significance and the popularity of biology amongst secondary school science students, ensuring good performance in the subject is essential. However, there is a present trend of underachievement in biology subject (Adewale et al., 2016). This trend of poor achievement is prominent in data collected from external examinations like those conducted by the West African Examination Council (WAEC) and the National Examination Council (NECO). A vast number of students are not proficient in biology, as most are unable to achieve the required credit pass in biology in these external examinations (Adekunle & Femi-Adeoye, 2016; Bichi et al., 2019).

Myriad reasons have been associated with being responsible or contributing to students' poor grades in biology. Poor instructional strategy is one of the most common sources of difficulty with the biology subject. This issue concerns the lecture method commonly used in learning institutions. It has been severally cited as incapable of ensuring meaningful learning, especially in scientific fields like biology (Okoye & Onwuachu, 2018). However, in recent times, a series of modifications have been made to enhance the strategy, including the inclusion of more learner-centred activities like question-and-answer sessions.

The intricacies of biology concepts pose another significant challenge for students due to their abstract nature (Etobro & Fabinu, 2017). This challenge manifests in their struggle to comprehend the distinctive and specialized terminologies characterizing the field readily. The complexity of biological phenomena often transcends conventional learning experiences, requiring students to navigate through intricate ideas and terminology unique to the field, which is a hurdle to learners and might contribute to poor achievement in the subject.

Therefore, there is an imperative need for innovative and efficient strategies to facilitate classroom instruction, overcoming the inherent limitations of traditional lecture methods and effectively tackling the abstract nature of biology terminologies. This study is focused on exploring the cell phone-assisted spelling and pronunciation intervention as a more effective approach to handling biology teaching activities.

The cell phone-assisted spelling and pronunciation intervention is quite an innovative approach and involves the learning of biology vocabulary in the classrooms with the aid of cell phones. Thus, This intervention comprises two units: the vocabulary (spelling, pronunciation, and even meanings) intervention and the cell phone-assisted instruction. The spelling and pronunciation intervention, when combined with meanings, can be said to

belong to the heading of vocabulary instruction, which in turn is a significant part of the language (Henry & David, 2021).

The role language plays in any field of knowledge, though usually subtle, is prominent and significant. The effective communicative process needed to undergo any successful educational activity or process depends mainly on the language, which is the most fundamental aspect of any communication channel. Communication can only occur if all individuals in the channel understand the language. The field of biology, like other knowledge domains, has its unique language, comprised of a vocabulary with a myriad of terminologies that are needed to communicate and understand ideas and concepts in the field (Wanjiru, 2015; Mulwa, 2015; Nordquist, 2019). This is the basis for the vocabulary intervention as the students need to be trained not just to know the spellings and pronunciations of the various terminologies that characterize biology concepts but also their meanings and applications. To understand a biology topic as a whole, one must first understand the different units that make it up.

Considering the importance of the vocabulary of biology in understanding biology concepts, it might not be a popular area of interest for researchers, as evidenced by the lack of relevant studies. Also, students in biology classrooms rarely have opportunities to learn and master the spellings, pronunciation, and meanings of the terms in the biology vocabulary. As such, this can be attributed as a factor causing difficulty and contributing to the poor achievement rate in the subject. Tibell and Harms (2017) state that there are significant obstacles to learning a biology topic, and to overcome them, it is essential to explicitly address the general abstract concepts that underlie the biological processes. Agreeing with this assertion, Bailey (2019) states that one of the keys to successful biology achievement is understanding the terminology.

Other than vocabulary instruction, cell phone-assisted instruction constitutes the second component of the cell phone-assisted spelling and pronunciation intervention. Cell phone-assisted instruction is under the scope of e-learning, which involves using computer technologies to enhance learning experiences (Bari et al., 2018). Cell phones (otherwise known as mobile phones) in this context are the computer technologies to be used for e-learning purposes. Cell phone-assisted intervention is an instructional strategy that employs mobile devices and their resources as a tool in the educational process. Using cell phones as an e-learning gadget has several benefits, including increased portability, mobility, and flexibility, especially relative to other e-learning devices (Klimova & Prazak, 2018; Klimova & Poulouva, 2016).

Other benefits of cell phone-assisted instruction include lower costs, availability of a wide range of educational resources across all formats in cell phones, easy access to the internet connectivity to aid the search for knowledge and learning materials, adaptability to and provision of varied teaching methodologies, promotion of communication and collaborations through the various communicative features available in the cell phone, the ease of use of cell phones, etc. (Celik & Yavuz, 2018; Uther, 2019; Nasution & Siddik, 2020). Morris et al. (2016) state that cell phone-assisted instruction/intervention holds many implications for the educational process, including the potential for better student achievement and performance. But as Yakubu and Dasuki (2018) state, for all of its potential, the use of cell phone-assisted instructional strategies is quite limited in developing countries like Nigeria, and there is a significant insufficiency of studies exploring its utilization in education.

With the potential of cell phones and vocabulary-based intervention in enhancing learning outcomes, this study thus takes an innovative approach to combine the two. The cell phone-assisted spelling and pronunciation intervention, therefore, focuses on providing students with training on biology vocabulary with the aid of cell phones towards the end goal of enhancing the learning outcomes of biology and facilitating better achievement in the subject. Cell phones can be used to carry out biology vocabulary intervention in several ways. Most prominent among these is the use of dictionary apps and web resources that are available and easily accessed on cell phones. Modern dictionary apps cover all three areas of vocabulary instruction, including spelling, pronunciation, and meaning. Traditionally, dictionaries provide accurate spellings and definitions of terms that can be used for spelling and meaning intervention, respectively. Also, cell phone dictionaries typically come with a text-read-aloud (text-to-speech) function that can be used for the pronunciation aspect of the intervention. (Hsieh, 2019; Geikhmam, 2023). There exist several mobile-based applications and web resources covering biology content (Aryal, 2022). The list also includes biology dictionaries. Other resources available on phones that can be used for the vocabulary intervention include biology terminology content on YouTube and the web, biology web blogs, etc.

Being a relatively new instructional approach, there is a significant absence of studies exploring cell phone-assisted spelling and pronunciation intervention in a biology classroom. A look at the available studies shows that the vast majority of studies with a similar intervention were conducted outside the subject scope of this study, with most focused on an English language learning classroom rather than a biology classroom. This can be seen in the research studies by Mir and Bashir (2021), Fouz-Gonzalez (2017), Deris and Shukor (2019),

Namaziandost et al. (2021), etc. It is noteworthy that the majority of these studies indicate positive outcomes for the use of the strategy in the teaching and learning process.

The studies by Namaziandost et al. (2021), Fouz-Gonzalez (2017), and Mir and Bashier (2021) explored the use of cell phone apps for teaching vocabulary to English learners. They reported it to have a statistically significant beneficial effect on the student's achievement. The study by Pede (2017) assessed using an online mobile game to learn science vocabulary and reported beneficial outcomes. Reed et al. (2018) assigned students to complete electronic Frayer Models (a graphic organizer used for vocabulary development) on life science and reported it to significantly improve the students' science content knowledge.

Apart from the easily observed variables that can influence students' learning outcomes and achievement, there still exists some background variables that might play a significant role in a student's educational perceptions and outcomes. This includes how they respond to innovative strategies like the cell phone-assisted spelling and pronunciation intervention and its effectiveness. One such variable is their prior knowledge and experiences. It has been shown repeatedly that skills and knowledge previously acquired by students play fundamental roles and are often transferred to learning new concepts, even in a drastically different field. Based on this premise, this study also explores the variable of the student's mathematical knowledge of set theory as a possible determinant of students' achievement with the biology concept of classification of living things (the content scope of this study). Set theory is a significant area in mathematics and is a branch of mathematics that studies the collection of objects known as sets (Cunningham, 2016). These sets could exist in any form, including numbers, alphabets, shapes, other variables, etc.

The set theory deals with grouping and organization. The skills and knowledge gained from its learning can be transferred and prove useful when learning concepts in biology centred around organization, of which the "classification of living things" is one. Studies on the possible relationship between knowledge of set theory and the learning of concepts in biology are primarily non-existent, as this area hasn't received much focus. Due to this, studies exploring another mathematical-based variable in the form of numerical ability are cited below.

Sa'adiyah et al. (2021) investigated the effects of numerical ability on students' achievement when taught with two collaborative-based classroom approaches. The findings of the study showed that numerical ability had a significant impact on students' achievement in only one of the classrooms explored, but not the other. The studies by Santos and Boyon (2020), Basriyah et al. (2020), and Suigharti and Habeahan (2018) assessed numerical ability and its

effects on students' STEM, thermodynamics, and chemistry achievement, respectively. The findings of the studies showed numerical ability to be a significant determinant of students' achievement.

In line with the above, this study is thus centred on exploring the use of cell phone-assisted spelling and pronunciation intervention in learning the biology concept of classification of living things. In secondary schools, with mathematical knowledge of set theory considered as the moderator variable.

The framework of the cell phone-assisted spelling and pronunciation intervention is in line with the activity theory. In the activity theory, the core of an activity involves a subject (human doer) working towards the object (the thing to be done) and employing the use of tools, which goes a long way to determining the outcome of the activity (Wheeler, 2018). Tools in activities can be primary (physical), secondary (psychological; language, ideas, models) or tertiary (communities, contests or environments). Tools have been shown to either enhance or limit the process of any activity and acquiring the appropriate tool is pivotal in any activity (Alcindor & Correia, 2020; Pohio, 2016). In this study, the physical tool refers to the cell phones. On the other hand, the psychological tool that has to do with language is also accounted for in this study through the spelling and pronunciation intervention. The subject refers to the teachers and the students, and the object relates to the achievement goals.

Statement of the Problem

Biology plays a significant, indispensable role in man's daily life due to the functionality that comes with the understanding of the nature of life and living things. But for all of its importance and popularity, the performance rate in the subject has been observed to remain on the poor side. This underachievement is typically attributed to a myriad of reasons, most prominently among which is the inadequacies of the conventional lecture method (through which biology education is typically carried out) and the inability of students to understand terms and concepts in the subject (primarily associated with the abstract nature of biology). The cell phone-assisted spelling and pronunciation intervention is an innovative remediation to address these issues. However, with the strategy being relatively new, no studies of this nature have been conducted before. Most of the related available studies are set in higher institutions and areas outside the scope of biology, most commonly English Studies. This necessitated this study to assess the effectiveness of this intervention in enhancing the biology learning outcomes in the classification of living things. This study also determines the moderating effects of mathematical knowledge of set theory on the dependent variable.

Research Questions

Two research questions were stated to guide the study for data collection.

1. What is the mean achievement score of students in biology when taught with the cell phone-assisted spelling and pronunciation intervention and those taught with the lecture strategy?
2. What difference exists in the mean achievement scores of students with high and low mathematical knowledge of set theory when taught biology with the cell phone-assisted spelling and pronunciation intervention and those taught with the lecture strategy?

Null Hypotheses

Two null hypotheses are tested at a 0.05 significant level

1. There is no significant difference in the mean achievement scores of students in biology when taught with the cell phone-assisted spelling and pronunciation intervention and those taught with the lecture strategy.
2. There is no significant difference in the mean achievement scores of students with high and low mathematical knowledge of set theory when taught biology with the cell phone-assisted spelling and pronunciation intervention and those taught with the lecture strategy

Methodology

This study utilised the pre-test and post-test control groups quasi-experimental design. Two public secondary schools were purposively selected to participate in the study based on the following criteria: the schools must be public secondary schools, biology teachers at these schools must be professionally qualified, and must be willing to participate in the study.

One intact class from each school was randomly assigned as the experimental and control group to be taught using cell phone-assisted spelling and pronunciation intervention and the lecture strategy, respectively. One hundred and one (101) students participated in the study. Two instructional guides, namely, Instructional Guide on Cell Phone-Assisted Spelling and Pronunciation Intervention (IGCPASPI) and Instructional Guide on Lecture Strategy (IGLS), with two instruments: Biology Achievement Test (BAT) and Set Theory Proficiency Test (STPT). The IGCPASPI and IGLS were teaching guides for the experimental and control groups, respectively. The BAT was used to measure students' achievement in the biology topic "classification of living things." The STPT was used to measure students' knowledge of the mathematical concept of set theory. The instruments were validated through expert review. Kuder-Richardson 21 (KR-21) Formula was used to determine the BAT and STPT

instruments' reliability after being distributed to 30 students outside the study. This yielded a reliability of 0.83 and 0.82 for the BAT and STPT, respectively.

The first week of data collection was used to train the teachers on utilising the IGCPASPI and IGLS. The second week was used to administer the pre-test on BAT and STPT. The third and fourth weeks were used for the treatment with the instructional strategies. Week five was used for the re-administration of BAT as a post-test. Mean and standard deviation were used to analyse the research questions, while Analysis of Covariance (ANCOVA) was utilised to test the null hypotheses, with the pre-test scores considered as covariates.

Results

Research Question One: What is the mean achievement score of students in biology when taught with the cell phone-assisted spelling and pronunciation intervention and those taught with the lecture strategy?

Table 1

Summary of Mean and Standard Deviation of Students' Pre-test and Post-test Scores on the Effects of Instructional Strategies on Students' Achievement in Biology

Instructional Strategies	n	Pre-test Scores		Post-test Scores		Mean Gain
		Mean	SD	Mean	SD	
Cell-Phone-Assisted	50	29.84	8.64	68.64	9.68	38.8
Lecture Strategy	51	31.69	9.11	46.67	8.79	14.98
Total	101	30.77	8.88	57.54	14.37	26.77

Table 1 shows that the post-test mean score of students taught with the cell phone-assisted spelling and pronunciation intervention strategy (mean = 68.64, SD = 9.68) is greater than the score of students taught with the lecture strategy (M = 46.67, SD = 8.79). The table further shows that students taught with the cell phone-assisted spelling and pronunciation intervention had a greater mean gain score (38.8) than students taught with the lecture strategy (14.98). Thus, students taught using cell phone-assisted spelling and pronunciation intervention had higher achievement than those taught with the lecture strategy. Consequent to the observed differences, the ANCOVA was carried out to ascertain if the difference was statistically significant.

Research Question Two: What difference exists in the mean achievement scores of students with high and low mathematical knowledge of set theory when taught biology with the cell phone-assisted spelling and pronunciation intervention and those taught with the lecture strategy?

Table 2

Summary of Mean and Standard Deviation of Pre-test and Post-test Scores on the Effects of Instructional Strategies on the Biology Achievement of Students with High and Low Mathematical Knowledge of Set Theory

Instructional Strategy	MKST	n	Pre-test Scores		Post-test Scores		Mean Gain
			Mean	SD	Mean	SD	
Cell Phone-Assisted and Pronunciation Lecture Strategy	High	19	30.74	9.34	70.74	0.05	40.0
	Low	31	29.29	8.29	67.35	9.97	38.06
	Total	50	29.84	8.64	68.64	9.68	38.8
Lecture Strategy	High	21	33.14	10.59	48.38	8.09	15.24
	Low	30	30.67	7.95	45.47	9.18	14.8
	Total	51	31.69	9.11	46.67	8.79	14.98
Total	High	40	32.0	9.96	59.0	14.11	27.0
	Low	61	29.97	8.09	56.59	14.57	26.62
	Total	101	30.77	8.88	57.54	14.37	26.77

Table 2 shows that for students taught with cell phone-assisted spelling and pronunciation intervention, the post-test mean score of students with high mathematical knowledge of set theory ($M = 70.74$, $SD = 0.05$) was greater than that of students taught with low mathematical knowledge of set theory ($M = 67.35$, $SD = 9.97$). For students taught with the lecture strategy, the post-test mean score of students with high mathematical knowledge of set theory ($M = 48.38$, $SD = 8.09$) was greater than that of students with low mathematical knowledge of set theory ($M = 45.47$, $SD = 9.18$). The total post-test mean scores of students with high mathematical knowledge of set theory ($M = 59.0$, $SD = 14.11$) were shown to be greater than those of students with low mathematical knowledge of set theory ($M = 56.59$, $SD = 14.57$). The table further indicates that the total mean gain scores of students with high mathematical knowledge of set theory (27.0) was greater than that of students with low mathematical knowledge of set theory (26.62). Consequent to the observed differences, ANCOVA was conducted to determine whether the difference was statistically significant.

Null Hypothesis One: “There is no statistically significant difference existing in the mean achievement score of students in biology when taught with the cell phone-assisted spelling and pronunciation intervention and those taught with the lecture strategy.”

Table 3

One-way Analysis of Covariance (ANCOVA) of Post-test Scores of Students' Achievement in Biology when Taught with Cell Phone Assisted Spelling and Pronunciation Intervention and those taught with the Lecture Strategy.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12202.046 ^a	2	6101.023	70.866	.000	.591
Intercept	26422.764	1	26422.764	306.914	.000	.758
Pretest	11.850	1	11.850	.138	.711	.001
Instructional Strategies	11978.528	1	11978.528	139.137	.000*	.587
Error	8437.003	98	86.092			
Total	355088.000	101				
Corrected Total	20639.050	100				

a. R Squared = .591 (Adjusted R Squared = .583) *Significant ($p < 0.05$)

Table 3 shows that the students taught with the cell phone-assisted spelling and pronunciation intervention had a significantly better mean achievement score in biology than those taught with the lecture strategy ($F_{1,98} = 139.137$, $p < 0.05$, partial eta squared = .587). It had an effect size of 58.7 per cent. Therefore, the null hypothesis, which states that “there is no statistically significant difference existing between the mean achievement score of students in biology when taught with the cell phone-assisted spelling and pronunciation intervention, and those taught with the lecture strategy”, was rejected.

Null Hypothesis Two: “There is no significant difference in the mean achievement scores of students with high and low mathematical knowledge of set theory, when taught biology with the cell phone-assisted spelling and pronunciation intervention, and those taught with the lecture strategy.”

Table 4

2 x 2 Factorial Analysis of Covariance (ANCOVA) of Post-test Scores of the Biology Achievement of Students with High and Low Mathematical Knowledge of Set Theory when taught with the Instructional Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12456.232 ^a	4	3114.058	36.534	.000	.604
Intercept	26546.220	1	26546.220	311.438	.000	.764
Pretest	26.382	1	26.382	.310	.579	.003
Instructional Strategies	11556.547	1	11556.547	135.580	.000	.585
Set Theory	253.730	1	253.730	2.977	.088*	.030
2-way Interaction:						
Instructional Strategies * Set Theory	1.000	1	1.000	.012	.914*	.000
Error	8182.818	96	85.238			
Total	355088.000	101				
Corrected Total	20639.050	100				

a. R Squared = .604 (Adjusted R Squared = .587) *Not Significant ($p > 0.05$)

The result in Table 4 shows that there is no significant interaction effect of mathematical knowledge of set theory on students' achievement in biology ($F_{1,96} = .012$, $p = .914$, partial eta squared = .000). Thus, the null hypothesis states that "there is no statistically significant difference in the mean achievement scores of students with high and low mathematical knowledge of set theory, when taught biology with the cell phone-assisted spelling and pronunciation intervention, and the lecture strategy" was upheld.

Discussion of Findings

The study's findings show that the students taught with the cell phone-assisted spelling and pronunciation intervention had a significantly better mean achievement score in biology than those taught with the lecture strategy.

This finding is in agreement with those of Namaziandost et al. (2021), Fouz-Gonzalez (2017), and Mir and Bashier (2021), who explored the use of cell phone apps for teaching vocabulary to English learners and reported it to have a statistically significant beneficial effect on students' achievement. The study by Pede (2017) assessed the use of an online mobile game

to learn science vocabulary and reported beneficial outcomes which coincide with this study's findings. Also, this finding agrees with that of Reed et al. (2018), which explored using the Frayer Model on life science along with online-based vocabulary teaching to learn life science and reported it to significantly improve the students' science content knowledge.

It is important to note that the studies used for comparison share minimal similarities to this study since adopting this strategy in a biology context is relatively new and hasn't been explored before, with most similar studies focused on language learning rather than the learning of specific subject content. Notably, none of the studies used for comparative analysis above explores using a truly identical strategy as cell phone-assisted spelling and pronunciation intervention.

The study's findings also show no significant interaction effect of mathematical knowledge of set theory on students' achievement in biology when taught with instructional strategies.

This finding partially agrees with Sa'adiyah et al. (2021), which explored the effects of numerical ability on students' achievement when taught with two collaborative-based classroom approaches. The findings of the study showed the numerical ability to have a significant impact on students' achievement in only one of the classrooms explored, but not the other.

This finding disagrees with those of Santos and Boyon (2020), Basriyah et al. (2020), and Suigharti and Habeahan (2018), which assessed numerical ability and its effects on students' STEM, thermodynamics, and chemistry achievement, respectively. The findings of the studies showed numerical ability to be a significant determinant of students' achievement.

The mathematical knowledge of set theory was chosen as a moderating variable due to the nature of the content scope of the study: classification of living things. As the content deals with organisation, it makes sense to assume that students' knowledge of another organization-based concept area, like set theory, might give them an advantage in learning this particular biology concept. However, observation from the fieldwork proves otherwise, and this might be because the classification of living things lacks any real connection to mathematics, and the concept area of classification of living things and set theory are different for the mathematical ability of students to give them any substantial advantage.

Conclusion

Based on the study's findings, it can be concluded that students perform better in biology when taught with the cell phone-assisted spelling and pronunciation intervention. Thus, it is a better strategy for learning biology and can enhance students' achievement in the subject if applied to the classroom as an intervention. Furthermore, students' mathematical knowledge

of set theory does not affect their achievement in the biology topic area observed. Thus, individuals with low knowledge of set theory can perform just as well as those with high knowledge, and no instructional considerations need to be made in this regard.

Recommendations

Based on the study's findings, the following recommendations are made;

1. Adopting e-learning strategies like cell phone-assisted spelling and pronunciation intervention in biology teaching and learning should be encouraged.
2. State government should organize workshops for teachers on utilizing innovative strategies like cell phone-assisted spelling and pronunciation intervention and keep them updated on the latest teaching and learning innovations.
3. Teacher education programmes should equip pre-service teachers with ICT skills for teaching science subjects.
4. The government should take adequate steps to ensure the provision of necessary facilities needed to run e-learning-based strategies in secondary schools

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