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Global Journal of Modern
Research and Emerging Trends (GJMRET)
Vol. 1, Issue 7, December 2025 // ISSN: 1595-076X

Hands-On and Virtual Learning Instructional Strategies on Biology Students' Academic Achievement on Respiration in Abak, Akwa Ibom State

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DOI: https://doi.org/10.5281/zenodo.17851489

Citation: Usanga, O. U., Nkantah, M. N., & Ikpaha, S. G. (2025). Hands-On and Virtual Learning Instructional Strategies on Biology Students' Academic Achievement on Respiration in Abak, Akwa Ibom State. *Global Journal of Modern Research and Emerging Trends, 1(7).*

Abstract

The study investigated educational hands-on and virtual learning instructional strategies on biology students' academic achievement on respiration in Abak, Akwa Ibom State. Three research questions were raised and three null hypotheses guided the study. The design for the study was quasi-experimental pretest, post-test equivalent group design. The population of the study consisted all 3,620 Senior Secondary School Two students offering biology in all the 10 public secondary schools in Abak Local Government Area. A sample size of one hundred and fifty-three (153) senior secondary two biology students were selected using purposive sampling technique. The instrument for data collection was Biology Achievement Test. The reliability of the instruments was determined using Kuder Richardson 21 (KR-21) and gave 0.77. Mean and Standard Deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at $p<0.05$ level of significance. The findings of the study showed a significant difference in the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning instructional strategies. Gender was found not to be a

significant factor affecting students' academic achievement. Based on the findings, it was recommended that biology teachers should be encouraged to adopt hands-on as instructional strategy for effective teaching of respiration.

Keywords: Hands-on, Virtual Learning, Academic Achievement, Respiration

Introduction

Biology is a natural science that deals with living world; how the world is structured, how it functions and what these functions are, how it develops, how living things came into existence, and how they interact with one another and with their environment. Biology is a perquisite subject for many fields of learning that contributes immensely to the technological growth of the nation (Adesola *et al*., 2022). These include medicine, pharmacy, nursing, agriculture, forestry, biotechnology, brewery, environmental sciences and geology. Biology has contributed to the growth and development of new and better drugs and vaccines against many human and animal diseases and has also contributed towards the conservation of the environment and endangered species (Samuel and Obikezie, 2020). In addition, the basic knowledge and skills acquired from the subject can be of tremendous help to man and the society (Umoru and Onoja, 2017). The impact of Biology on the life of living organisms is wide; all ensuring that the required standard of living for both plants and animals are maintained (Werner, 2020). There is no doubt about the immense contribution of Biology to the economic growth and development of a nation. The benefits of Biology for the development of any nation are too numerous to mention, and this is because Biology plays a key role in industrialization and other sectors of the economy.

There are different concepts in Biology and there are ways of teaching the concepts effectively. Some Biology topics can sometimes be difficult especially when describing things that cannot be seen or abstract concepts that cannot fully comprehend at the first time or unbelievable it could exist (Haruna, 2021). Some of the topics taught in Biology that students perceive as abstract are water transport in plants, protein synthesis, respiration, photosynthesis, gaseous exchange, energy, cells, mitosis and meiosis, organs, physiological processes, hormonal regulation, oxygen transport, genetics and central nervous system (WAEC Examination's Report, 2024). Research studies have shown that a number of concepts in Biology which include respiration contain some topics which pose difficulty for Biology students to understand (Akilu and Suleiman, 2024). Respiration is considered to be one of the most difficult topics to teach and learn in Biology by teachers and students in many parts of the world (Anidu and Onah, 2020).

Students have a lot of misconceptions about respiration which act as barriers to understanding the topic. Concepts in respiration include many interrelated ideas and facts.

Respiration is a biological process through which living organisms release energy from food substances (especially glucose) to carry out life activities. It is one of the essential characteristics of living things. Respiration occurs in all living cells, both plants and animals. It is the process by which organisms exchange gases between their body cells and the environment. Respiration is the process of getting oxygen into the body and releasing carbon dioxide out of the body. The process of respiration includes the exchange of oxygen and carbon dioxide between the blood and the cells of the body. Respiration is a process in living organisms involving the production of energy typically with the intake of oxygen and the release of carbon dioxide from the oxidation of complex substances (Weibel *et al*., 2020). It is important because it produces energy that is essential for the normal functioning of the body. Respiration provides cells with oxygen and expels toxic carbon dioxide. Cells need energy for movement, multiplication, synthesis of essential molecules and maintaining body temperature. Bailey (2024) stated that there are two types of respiration, namely; aerobic and anaerobic respiration. Aerobic respiration occurs in the presence of oxygen. This process happens mainly in the mitochondria of cells and releases a large amount of energy. Anaerobic respiration occurs in the absence of oxygen. It releases less energy than aerobic respiration. Thus, learning respiration requires effective transfer of knowledge and skills that facilitate understanding of the concept. It is important therefore, for science teachers to adopt appropriate instructional strategies such as hands-on and virtual learning that may strengthen students' knowledge.

Hands-on is an instructional strategy where students are guided to gain knowledge by experiment. It is a way of teaching where students have resources for testing what they learn. That is, students learn by trying and manipulating the resources. Hands-on is a learning method where students modify materials, handle and test their learning's with materials. Wenderoth (2015) posit that hands-on learning brings laboratory tasks to classrooms and vice versa, where students are involved in using, testing materials and observing the working modules. Hands-on method has to do with a teacher giving the students opportunity to manipulate the objects they are studying. Haury and Rillero (2015) opined that hands-on learning method involves engaging an individual in a total learning experience which enhances the individual`s ability to think critically. Hands-on learning method is a means to increase students' academic achievement and

understanding of scientific concept. This is achieved by manipulating objects which makes abstract knowledge more concrete and clearer. Through hands-on learning method students are able to engage in real life illustrations and observe the effect of changes in performances and retention. This learner-centered method offers concrete illustration of concept of respiration and allows students to see, touch, and manipulate objects. Thus hands-on learning is practical base that creates retention, generates students' interest towards the concept taught. However, hands-on may be combined with other teaching strategies to improve students' academic achievement. One of such strategies is virtual learning.

Virtual learning strategy is a learning environment in which students convert theoretical knowledge into practical knowledge by conducting experiments. It is electronically programmed in a computer in order to simulate the real experiments inside the real laboratories. Virtual learning are online education tools that bring a new dimension to learning science by using visualization techniques such as animation, simulation, and filmed videos (Kapici *et al*, 2019). It is an approach to hands-on learning experience employing computer-based simulations that focus on presenting views and ways of working that are similar to their physical counterparts. Virtual learning are used to attract learners' attention and sustain their motivation. Virtual learning provides interactive environment where learners can simulate scientific study (Salmerón-Manzano and Manzano-Agugliaro, 2018). For instance, the simulated environment has the potential to enhance learners' skills, attitudes, and understanding of biological concepts. Alneyadi (2019) stated that virtual learning of science are considered the main underpinning in practical electronic learning, seeing that virtual learning strategy closely resemble real labs. Ramesh (2019) opined that virtual learning strategy is a learning environment in which students convert their theoretical knowledge into practical knowledge by conducting experiments irrespective of their gender.

Gender is a wide range of biological, behavioural, physical and mental characteristics that differentiates the female and male population (Okeke, 2020). It is taking on responsibilities, roles, opportunities, constraints and needs of males and females in all aspects of social context (Lyne, 2023). It is the identifiable features of male and females whose social, cultural and moral values conform to the standards of the community they belong. However, Irungu *et al*. (2019), Obijiofor and Obumneke (2020), Oladejo *et al.* (2021) well as Enebechi (2023) found that gender has no significant difference on students' achievement. Also, Mwihia (2020), Taiye (2021) as well as Ani *et al.* (2022) posited that male and female students, when presented with equal opportunities,

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perform on the same. These conflicting results and the inconsistency existing in literature on gender, pose a need to check if gender affects academic achievement of students taught the concept of respiration based on the two instructional strategies-hands –on and virtual learning instructional strategies used in the study.

Statement of the Problem

Students' misconceptions to difficult and abstract concepts in biology cannot be reduced if teachers continually use only the convention method in teaching. These misconceptions can be reduced or avoided through the use of interactive and activity based teaching and learning methods to bring the abstract concepts to concrete and clearer terms, this will enhance understanding and retention of the biological concepts, which further improves academic achievement of students. Using hands-on and virtual learning strategies may eliminates or bridges the gap between abstracts and reality as learners actively engage in total learning experience which enhances their ability to think critically, Understanding and retention of concepts that are made clearer and concrete. It then becomes necessary to explore the efficacy these alternative methods of redressing this situation. The question now is can hands-on and virtual learning strategies improve students' achievement in biology? Which of them will prove more effective in facilitating students' academic achievement in the concept of cellular respiration? Thus, the researcher seeks to investigate hands-on and virtual learning strategies on biology students' academic achievement on respiration in Abak, Akwa Ibom State.

Purpose of the Study

The study investigated hands-on and virtual learning strategies on biology students' academic achievement on respiration in Abak, Akwa Ibom State. The study objectives were to;

i. ascertain the difference between the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies.
ii. determine the difference between the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies.
iii. examine the interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration.

Research Questions

i. What is the difference between the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies?
ii. What is the difference between the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies?
iii. What is the interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration?

Research Hypotheses

The following null hypotheses were formulated to guide the study and were tested at 0.05 level of confidence.

i. There is no significant difference in the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies.
ii. There is no significant difference in the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies.
iii. There is no significant interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration.

Methodology

The study design is quasi-experimental with non-randomized pretest, posttest group. The study was conducted in two co-educational public secondary schools in Abak Local Government Area, Akwa Ibom State. The population consisted all the 3,620 Senior Secondary School Two students offering biology in all the 10 public secondary schools in Abak Local Government Area, Akwa Ibom State. The sample size of the study was one hundred and eighty-three (153) Senior Secondary Two students. The sample was drawn from two co-educational secondary schools using purposive sampling technique. The selected schools met the criteria of having qualified biology teachers and schools that have registered candidates for West African Senior School Certificate Examination and National Examinations Council for the past 15 years. Biology Achievement Test (BAT) was used for data collection. BAT was designed to measure the students' performance on the concept of cellular respiration. It consisted fifty (50) multiple choice items with four (4) options A - D with only one correct answer and three distracters

drawn from the concept of forest conservation. The instruments was face validated by an experienced biology teacher with 10 years teaching experience and a biology lecturer in Biology Education, University of Uyo. Kuder-Richardson 21 (KR-21) was used in determining the reliability index of the Biology Achievement Test. The choice of this reliability test is due to its ability to measure a single reliability coefficient that reflects the consistency of responses across different items in the test with a reliability index of 0.77, this indicate that the reliability is good.

Experimental Procedure

The biology teachers in the sampled schools were used as research assistants with students in intact classes. Each of the classes was assigned to experimental group one and two respectively. To qualify as research assistants, the two biology teachers were trained for one-week. Well prepared lesson packages were used by the research assistants in teaching respiration in their respective groups for four weeks. Experimental group one was taught respiration using hands-on teaching strategy. The researcher began teaching the topic respiration at the level the students could understand. Building on the understanding, how the organs work together in the respiratory system: the lungs, the nose, the trachea, the bronchi. Everybody has a set of two lungs. The lungs are similar to balloons, when we breathe in our lungs fill with air, when we breathe out, we are breathing out carbon dioxide. Our lungs work together with our heart to carry oxygen all over our body. The air first enters our body through the nose. The trachea is a tube that allows the air to go to the lungs. Experimental group two was taught respiration using virtual learning strategy. Research assistant introduced respiration by asking the students to take a deep breath, feel their chest bulge, exhale and mention the organs in their bodies that help them to breathe air. The activity was repeated for three consecutive times, observing their body's respiratory system in action. The activity helped the students to understand the parts of the respiratory system and their functions. Video on the mechanism of respiration in various living organisms was played for the students to watch, paused the video and asks the students to state the respiratory systems organs in the human system. The students quietly watched the video and wrote down the main points and attempt answering questions.

The data obtained from the achievement test were analyzed using Mean, Standard Deviation and Analysis of Covariance (ANCOVA). Mean and Standard Deviation were used to answer research questions while ANCOVA was used to test the null hypotheses at 0.05 level of significance.

Results and Discussions

Research Question 1: What is the difference between the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies?

Table 1: Descriptive statistics showing the difference between the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies

		Pretest		Post test		
Methods	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean Diff
hands-on	79	22.16	3.30	45.82	2.72	23.66
virtual learning	74	21.21	3.68	42.02	3.25	20.81

Data in Table 1 shows the achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies respectively. The result shows that biology students taught using hands-on and virtual learning strategies respectively gained mean performance scores of 23.66 and 20.81 respectively. From this result, it can be deduced that biology students taught using hands-on strategy achieved better than those taught using virtual learning strategy. Therefore, there is difference between the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies, in favour of those taught using hands-on strategy

Research Question 2: What is the difference between the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies?

Table 2: Descriptive statistics showing the difference between the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies

			Pretest		Posttest		
Methods	Gender	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean Diff
Hands-on	Male	35	21.65	2.64	45.52	2.57	23.87
	Female	44	22.59	3.76	46.07	2.85	23.48
Virtual	Male	35	21.19	3.61	42.07	3.02	20.88
	Female	39	21.23	3.67	41.96	2.81	20.73

Data in Table 2 shows the difference between the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies respectively. The results shows that male Biology students gained higher mean achievement scores in Biology than the female counterpart when taught using hands-on (23.87 versus 23.48) and virtual (20.88 versus 20.73) respectively. These results indicate that there is a difference between the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies.

Research Question 3: What is the interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' academic achievement mean scores on respiration?

Table 3: Descriptive statistics showing the interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration

		Pretest		Post test		
Gender	**Methods**	$\bar{X}$	**SD**	$\bar{X}$	**SD**	**Mean Gain**
Male	Hands-on	21.66	2.64	45.52	2.58	23.88
	Virtual	21.68	3.26	33.74	2.70	12.06
Female	Hands-on	22.6	3.76	46.06	2.86	23.48
	Virtual	21.70	4.34	34.90	3.92	13.16

Table 3 shows the interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration. The result shows that male Biology students taught using hands-on strategy gained a higher academic achievement score (mean gain = 23.88) than male Biology students taught using virtual strategy (mean gain = 12.06). Result also shows that female taught using hands-on strategy secured higher mean academic achievement (mean gain = 23.48) than their counterparts taught using virtual strategy (mean gain = 13.16). This implies no possible interaction effects of teaching strategies (hands-on and virtual teaching strategies) and gender on Biology students' academic achievement mean scores on respiration.

Hypothesis 1: There is no significant difference in the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies.

Table 4a: Summary of ANCOVA for difference in the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies

Source	Type III Sum of Squares	Df	Mean Square	F-value	P-value	Decision at p<0.05
Corrected Model	3570.681	3	1190.227	139.477	0.000	*Sig
Intercept	5427.607	1	5427.607	636.036	0.000	
Pretest	42.252	1	42.252	4.951	0.028	
Strategies*	3498.008	2	1749.004	204.958	0.000	
Error	1271.489	149	8.533			
Total	258277.000	153				
Corrected Total	4842.170	152				

***Sig = Significant at p<0.05**

Data in Table 4a shows the summary of Analysis of Covariance (ANCOVA) of posttest achievement of biology students when taught using hands-on and virtual learning strategies respectively. The calculated F-value for the main effect of teaching strategies at 2, 152 is 204.958 while its corresponding calculated level of significance is 0.000 alpha. This level of significance is less than 0.05 in which the decision is based. The null hypothesis is rejected, hence there is significant difference in the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies. For the fact that the hypothesis was significant, further analysis was done to determine the direction of the significant difference and achievement. The result of the Post Hoc test using Duncan's test is presented in Table 4b.

Table 4b: Summary result of Duncan's test for differences in the mean performance scores based on the teaching strategies

Strategies	N	Subset	
		1	2
Virtual	79	42.019	
Hands-on	74		45.820
Sig.		1.00	1.00

Data in Table 4b, the result shows the difference between the mean achievement scores of biology students taught using hands-on strategy is higher than those taught with virtual strategy However, the two teaching strategies were significant as $p<.05$.

Hypothesis 2: There is no significant difference in the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies respectively.

Table 5: Summary of ANCOVA testing difference in the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies

Source	Type III Sum of Squares	Df	Mean Square	F-value	P-value P-value	Decision at p<0.05
Corrected Model	161.752	2	80.876	2.592	0.078	*Not Sig
Intercept	5281.496	1	5281.496	169.264	0.000	
Pretest	64.434	1	64.434	2.065	0.153	
Strategies	1584.042	2	792.412	1.979	0.067	
Gender	89.079	1	89.079	2.855	0.093	
Error	4680.418	150	31.203			
Total	258277.000	153				
Corrected Total	4842.170	152				

***Not Sig = Not Significant at p>0.05**

Data in Table 5 shows the summary of Analysis of Covariance (ANCOVA) for difference between the mean achievement scores of male and female biology students taught respiration using hands-on and virtual learning strategies. The calculated F-value for the main effect of instructional strategies at 1, 152 is 2.855, while its corresponding

P-value level of significance is 0.093 alpha. This level of significance is greater than 0.05. The null hypothesis is retained, hence there is significant difference in the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies.

Hypothesis 3: There is no significant interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration.

Table 6: Summary of ANCOVA testing difference interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration.

Source	Type III Sum of Squares	df	Mean Square	F-value	P-value	Decision at p<0.05
Corrected Model	1793.906	3	298.984	34.800	0.000	*Not Sig
Intercept	2713.049	1	2713.049	315.783	0.000	
Pretest Score	20.231	1	20.231	2.355	0.016	
Methods	1663.54	2	831.770	96.813	0.000	
Gender	4.121	1	4.121	0.480	0.165	
Strategies * Gender	4.782	2	2.391	0.279	0.287	
Error	627.180	150	4.296			
Total	129138.500	153				
Corrected Total	2421.085	152				

***Not Sig = Not Significant at p>0.05**

Table 6 shows the summary of Analysis of Covariance (ANCOVA) for interaction effects of strategies (hands-on and virtual) and gender on Biology students' achievement mean scores when taught respiration. The calculated F-value for the main effect of teaching methods at 1, 152 is 0.279, while its corresponding P-value level of significance is 0.287 alpha. This level of significance is greater than 0.05. The null hypothesis is retained, hence there is no significant interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' mea academic achievement mean scores on respiration.

Discussion of Findings

The findings on the difference in the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies indicated a significant difference. Findings of the study showed that there is significant difference in the academic achievement mean scores of biology students taught respiration using hands-on and virtual learning strategies respectively in favour of hands-on strategy. The significant difference might be due to the fact that hands-on strategy enables students to be actively involved in the teaching/learning process, thus facilitating their understanding of the subject matter taught. The result is in line with the findings of Timothy (2015) as well as Umoru *et al*. (2023) that there is statistically significant difference in the mean achievement scores of science students using hands on activity strategy.

The findings on male and female biology students taught respiration using hands-on and virtual learning strategies indicated a non-significant difference. Findings of the study shows that there is no significant difference between the mean achievement scores of male and female biology students taught respiration using hands-on and virtual learning strategies. These results indicate that both hands-on and virtual strategies favours the male students. Therefore, is no significant difference in the academic achievement mean scores of male and female biology students taught respiration using hands-on and virtual learning strategies. This might be due to the fact that the two teaching strategies are students friendly improving the achievement of male and female students equally. This study is in line with the findings of Obijiofor and Obumneke-Okeke (2020) as well as Enebechi (2023) who found that gender has no significant difference on students' achievement. However, this study is contrary to the studies of Taiye (2021) as well as Ani *et al.* (2022) who found that both male and female had significant effect on students' achievement in sciences.

Hypothesis Three was tested and the results shows that there is no significant interaction effects of teaching strategies (hands-on and virtual learning) and gender on biology students' academic achievement mean scores on respiration. The result shows that male Biology students taught using hands-on strategy gained a higher academic achievement score than male biology students taught using virtual strategy. Result also shows that female taught using hands-on strategy secured higher mean academic achievement than their counterparts taught using virtual strategy. This implies no possible interaction effects of teaching strategies (hands-on and virtual) and gender on Biology students'

academic achievement on respiration. Therefore, the null Hypothesis Three was retained. This implies that gender did not combine with the strategies to affect the students' achievement in the concept of respiration. The finding of the study is in line with that of Oladejo *et al.* (2021) who found that there is no statistically significant relationship between gender interactions and academic achievement of learners in sciences. However, this finding is contrary to the study of Mwihia (2020) who found that there is statistically significant relationship between gender interactions and academic achievement of learners in sciences.

Conclusion

Based on the findings of the study, it was hereby concluded that the two teaching strategies investigated, hands-on was more effective than virtual teaching strategy in facilitating students' achievement in respiration. Also, students' gender, had no significant influence on students' achievement. Again, the interaction effects investigated shows no significant interaction.

Recommendations

1. Students should make use of hands-on teaching strategy in learning the concept of respiration to improve their academic achievement in biology.
2. Biology teachers should be dynamic in imparting knowledge and skills to students so as to improve male and female students' academic achievement in biology.
3. Biology teachers should deploy hands-on strategy in teaching respiration so as to improve students' academic achievement in biology.

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