EFFECTS OF COMPUTER-ASSISTE INSTRUCTIONAL PACKAGE ON THE ACHIEVEMENT OF CELLULAR RESPIRATION AMONG SENIOR SCHOOL STUDENTS IN IBADAN, NIGERIA

Ph. D. Oral Defence

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CERTIFICATION

This is to certify that this research was carried out by ODEKUNLE, Olusegun Tayo (02/25OC398) at the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin.

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EFFECTS OF COMPUTER-ASSISTED INSTRUCTIONAL PACKAGE ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN CELLULAR RESPIRATION IN IBADAN, NIGERIA

PH. D. ORAL DEFENCE

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02/25OC398

DEDICATION

This research project is dedicated to the glory of God Almighty and my loving and ever caring mother, Deaconess Deborah Odekunle

ACKNOWLEDGEMENTS

To God be the glory, great things he hath done in my life. Because He lives, His love and mercy over me endureth forever. I therefore return all glory, thanks, praises and adoration to Him for He is a living God.

My special thanks and sincere gratitude goes to my supervisor Professor Isaac Olakanmi Abimbola who is indeed a father, for patiently reading through the write up, giving constructive criticisms, advice and sacrificing his time and wealth of experience in guiding and encouraging me to make this work a reality. May the good God bless you and your entire household, Sir (Amen.)

I specifically appreciate the positive efforts of the Head of Department, Dr. Mulkah A. Ahmed and other lecturers in the Department. Prof. M. O. Fajemidagba, Prof. A. S. Olorundare, Prof. Esther O. Omosewo, Prof. Medinat F. Salman, Dr. Ganiyu Bello, Dr. A. O. Akanbi, Dr. O. S. Oyelekan, Dr. Khadijat S. Ameen, Dr. A. M. Akanmu, Dr. J. E. Upahi, Mr. K. O. Afolabi, Mr. S. B. Jimoh, Dr. R. E. Mohammed, Dr. Hafsat A. Imam, Mrs. Saidat M. Adeniji, Mrs. Aduke. R. Ahmed and Mrs. Bashirat. T. Imam. Your valuable contributions towards the project were appreciated. My profound gratitude also goes to Professor P. O. Fatoba, of the Department of Plant Biology, who is my Internal Examiner, for creating time out of his tight schedule to make useful suggestions regarding this thesis. May good God bless him abundantly (Amen). The contribution of Prof. Bisi Onasanya, and Prof. M. O. Yussuf of Educational Technology in ensuring a good

production of computer-assisted instructional package is appreciated. I sincerely appreciate my good friend in person of Glenn Wolkenfeld of Science Music Videos for sharing his video packages with me for the success of this study; you are a sent Angel to me.

I am greatly indebted to my parents Late Pa E. O. Odekunle, and Deaconess Deborah Odekunle, for her motherly care, commitment, prayer, understanding, and moral support. You are the best mother I have ever seen. I will not forget the contribution of my in-laws, Elder and Mrs. Bola Akerekan and Engr. Kayode Bello for their various supports towards the success of this programme.

I wish to express my sincere gratitude to my beloved sister, Mrs. B. L. Ajala (Nee Odekunle). May God bless you greatly. I want to specially thank Prof. Biodun Akinpelu and Prof. Bolanle Danmole for their moral support, May God greatly reward you all. The cooperation received from the teachers and students of the sampled schools is hereby acknowledged. Most especially Pastor Olaitan, Mrs. Adebayo, Mr. B. T. Boladale and Mr. Paul, your contribution make this work a success. Also, I will like to share my gratitude with my friends with my friends and families : Adebayo Femi, Lawal Opeyemi, Yekeen Peter, Wumi Adeyemo, Mrs. O. O. Adeoye, Mrs. B. Atotileto, Dr. M. O. Ayanda, Olugbenga Odekunle, Titilope Olaoye, Pastor Olabisi Odekunle and others; your care for me is highly valued.

I am grateful to Rev'd (Dr.) and Mrs. E. B. Omidiji, Pastor Ayodeji Aleshinloye and Rev'd and Pastor (Mrs.) Solomon Adebara for their selfless

prayer on a daily basis that has brought me success, may God bless your home and Ministries.

Finally, I want to extend my profound gratitude to my loving and caring wife, the lubricant of my engine, and my wonderful children Iyanuoluwanimi and Inioluwanimi Odekunle. Your various contributions and dedication are highly appreciated. I love you deeply.

May the Almighty God bless all those who have contributed to my life positively in the course of the journey of this study (Amen).

ABSTRACT

The West African Examinations Council Chief Examiners' reports showed that performance in Biology at the senior school certificate level has not been encouraging. Studies in Biology have affirmed that the method employed by teachers could be responsible for the poor performance, and students' inability to attempt questions on cellular respiration. The use of Computer-Assisted Instruction (CAI) has been shown to be an effective teaching strategy that could improve students' achievement in biology. The objectives of this study were to investigate: (i) effects of Computer-Assisted Instructional Package (CAIP) on students' achievement in cellular respiration (ii) the influence of gender, (iii) score level, (iv) school type, and (v) their interaction effects on the students' achievement when exposed to CAIP.

A quasi-experimental, pretest, posttest, and control group, involving a 2x2x2x3 design was adopted for the study. Fourteen research hypotheses were formulated and tested. Four intact classes, involving 107 Senior School (SS) One students (48 males and 59 females) from two public and private secondary schools, were purposively sampled in Ibadan, Oyo State, Nigeria. A CAIP and an Achievement Test on Cellular Respiration (ATCR) were used for data collection, after validation. ATCR had a reliability co-efficient of 0.84, determined using Cronbach's alpha method. Mean score, standard deviation, *t*-test and ANCOVA were used to analyse the data collected.

Findings of the study were that:

(i) the achievement of the SS students exposed to CAIP on cellular respiration and those taught with Conventional Method of Instruction (CMI) indicated a significant difference, in favour of students taught with CAIP, $F_{(1, 104)} = 133.22$, $p < 0.05$;

(ii) no significant difference existed in the achievement of the students, based on gender.

(iii) there was a significant difference among high, medium, and low scoring students taught cellular respiration using CAIP, in favour of the experimental group, $F_{(2, 39)} = 5.38$, $p < 0.05$;

(iv) there was a significant difference in the achievement of students in public and private schools taught cellular respiration with CAIP, in favour of the experimental group, $F_{(1, 40)} = 0.18$, $p < 0.05$;

(v) there was a significant interaction effect of treatment and score levels; gender and school type on the achievement of SS students exposed to CAIP, $F_{(2, 101)} = 8.07$, $p<0.05$; $F_{(1, 102)} = 4.04$, $p<0.05$, respectively.

The study concluded that CAIP enhanced the achievement of students from the participating public and private schools, and low scoring students benefitted the most from CAIP. This implies that, exposing students to CAI as an instructional

strategy, helps them to understand cellular respiration better than those exposed to CMI. The study recommended, that a CAIP, like the one used for this study, should be made available for teachers' and students' use in our secondary schools for effective teaching-learning process.

Keywords: Computer-Assisted Instruction, Conventional Method of Instruction, score levels, school types, Cellular respiration, Academic Achievement, Gender.

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CHAPTER ONE

INTRODUCTION

Background to the Problem

Biology is pivotal to many sciences and applied science related courses such as medicine, pharmacy, nursing, microbiology, agriculture, biochemistry, anatomy, physiology, and so on. Therefore, no student who intends to study any of these courses can do without biology. Biology is significant because it is a natural science which studies living things and how they interact with one another and their environment. It examines the structure, function, growth, origin, evolution, and distribution of living organisms. Also, it classifies and describes organisms, their functions, and how species come into existence (Krutula, 2015). The relevance of biology in day to day human activities is unlimited. However, it is unpleasant that students performance at secondary school level of education in this subject is not encouraging, and this has been an issue of great concern to stakeholders in education (Akinfe, Olofinniyi & Fashiku, 2012).

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Ahmed (2008) reported that in spite of the importance of biology among Nigerian students, performance at Senior Secondary School level had been poor. Poor performance in biology according to Odekunle (2011) implies low or failure grades by students in SSCE. Such grades range from D7 to F9 which employers of labour and institutions of higher learning do not accept as passes (Odekunle, 2011). Abimbola (2013) observed that the performance level for the

individual science subjects did not show any significant rise for more than twenty-year period between 1991 and 2011 except occasionally for chemistry and physics which were above 50%. Candidates' performance in biology over these years has never been up to 50%, perhaps because non-science students used to register for biology as a core science subject (Table 1).

However, there was a slight improvement in biology examinations results in 2013 to 2016 with a 50% and above credit pass. This sudden improvement might be associated with improved teaching strategies from the teachers and other factors. Such an improvement might be sustained since biology subject is no longer offered by non-science students, resulting to fewer science students to take part in biology examinations.

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Table 1

Candidates' Performance in May/June Senior School Certificate Examinations in Biology, Chemistry and Physics in Nigeria from 1991-2014

YEAR	TOTAL SAT	CREDITS PASSES	%	TOTAL SAT	CREDITS PASSES	%	TOTAL SAT	CREDITS PASSES	%
1991	285,690	72,988	25.60	116,526	12,117	10.30	96,742	17,037	16.80
1992	355,582	99,919	28.10	140,856	26,763	19.00	122,809	20,018	16.30
1993	481,034	138,057	28.70	170,537	39,224	23.00	152,276	37,155	24.40
1994	508,384	57,956	11.40	161,232	38,212	23.70	146,000	21,462	14.70
1995	453,353	85,684	18.90	133,188	48,880	36.70	120,768	22,825	18.90
1996	506,628	80,554	15.90	144,990	48,572	33.50	132,768	16,994	12.80
1997	609,026	96,226	15.80	172,383	40,682	23.60	157,700	14,824	9.40
1998	634,021	218,420	34.45	185,430	39,682	21.40	172,223	19,530	11.34
1999	745,I02	207,213	27.81	223,307	69,404	31.08	210,271	64,280	30.57
2000	659,020	127,256	19.31	201,369	64,217	31.89	193,052	58,031	30.06
2001	995,345	231,418	23.25	301,740	109,381	36.25	287,993	99,242	34.46
2002	882,119	278,112	31.52	268,824	90,488	34.90	254,118	120,768	47.76
2003	909,101	392,249	44.15	282,120	143,839	50.93	275,369	130,982	47.65
2004	1,027,938	253,487	24.69	269,774	105,133	38.94	265,262	135,359	51.04
2005	1,072,607	375,850	35.04	349,996	178,274	50.91	344,411	142,943	41.53
2006	1,152,045	559,854	48.60	308,104	170,670	55.34	375,824	218,199	58.16
2007	1,238,163	413,211	33.37	422,681	194,284	45.92	218,593	180,797	43.24
2008	1,259,964	427,644	33.94	418,423	185,949	44.47	415,113	200,345	48.38
2009	1,903,552	644,733	33.87	422,091	194,035	45.97	429,174	186,940	43.56
2010	1,300,418	427,644	33.90	465,643	236,059	50.70	463,755	237,756	51.30
2011	1,505,199	579,432	38.50	565,692	280,250	49.54	563,161	360,096	63.94
2012	1,646,150	587,044	35.66	627,302	270,570	43.13	624,658	429,415	68.74
2013	1648363	854,743	51.73	539,296	143,218	72.34	637,023	297,988	46.77
2014	1365384	766,971	56.17	636,268	397,649	62.49	635,729	386,270	60.76
2015	1,390,234	798,246	57.42	680,357	412,323	60.60	684,124	410,543	60.01
2016	1,200,367	740,345	61.68	706,873	408,122	57.74	705,125	415,655	58.95

***Sources*:** The West African Examinations Council (WAEC). Adapted from Abimbola (2013), Olorundare (2014) & WAEC, Yaba Office (2017).

The desire to know the factors responsible for poor performance in biology has been the focus of researchers for some time now. It has been observed that poor performance in the sciences is caused by poor quality of science teachers, lack of suitable and adequate science equipment, overcrowded classrooms among others (Kareem, 2003). Students perform poorly in biology because the biology classes are usually large and heterogeneous in terms of ability level. In addition, the laboratories are ill-equipped and the biology syllabus is overloaded (Ahmed, 2008). This poor performance has been attributed to myriads of factors such as poor parenting, and poor attitude of students towards their studies (Akinfe et al., 2012).

Several teaching strategies had been promoted to teach biology such as discovery, guided-inquiry, lecture and demonstration method to mention a few. Most classes involve rote learning, where students depend on memorization without having a perfect understanding of the subject (Gambari, Yaki, Gana, and Ughova, 2014). The persistent use of this method makes students passive rather than active learners. It does not promote insightful learning and long-term retention of some abstract concepts in biology (Gambari, Yaki, Gana, and Ughova, 2014). Ahmed and Abimbola (2011) also identified that poor teaching strategies adopted by teachers at Senior Secondary School level of education in Nigeria have been identified as one of the major factors contributing to poor performance of students in biology. Bassey (2005) opined that several problems are associated with the

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conventional method of teaching. This indirectly results in poor performance of students. Bassey (2005) also attributed the syndrome in the educational sector to lack of perceived competence among the learners. However, Adegbite (2000) views on the causes of poor performance differ, Adegbite (2000) posited very strongly that wrong location of the marketplace, highways, airport, and industrial areas constitute an academic unfriendly environment for learners.

Yap (2016) poisted that Conventional method of teaching does not motivate students, as a result, they lose interest in the subject. This is more often seen in science subjects in general and biology in particular. Ramanjeet, Sushama, and Anil, (2012) have identified defective teaching strategies as one of the reasons of poor performance of students in sciences. As a result of this, the use of instructional technology, such as Computer-Assisted Instruction (CAI) has become a part and parcel of the teaching-learning process.

Computer-Assisted Instruction (CAI) is an interactive instructional technique whereby a computer is used to present the instructional material and evaluate the learning that takes place (Wikieducator, 2008). The potential benefits of Computer-Assisted Instruction (CAI) cannot be underrated in the contemporary world. There is a plethora of established findings on the instructional value of the computer, particularly in advanced countries the United Kingdom, United State of America, Japan and others. There are now several CAI packages on reasonable number of subjects. It is obvious that the current trend in research all over the

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world is the use of computer facilities and resources to improve students' learning. This may be the reason why Chang, Sung, and Lin (2006) opined that many exercises that depart from the traditional method are now readily accessible on the web even though teachers do not use these facilities. They further shared that the interactive approaches to lecturing significantly enhance learning.

In a review of empirical studies on CAI, Cotton (1997) concluded, among others, that the use of CAI as a supplement to conventional method of instruction produces higher achievement than the use of conventional method of instruction alone; research is inconclusive regarding the comparative effectiveness of conventional method of instruction alone and CAI alone. It has been reported that computer-based education (CBE and other computer applications) produced higher achievement than traditional alone; they retain what they have learnt better with CAI than with conventional method of instruction alone and CAI activities appeared to be at least as cost-effective as and sometimes more costly effective than the other instructional methods, such as teacher-directed instruction and tutoring.

Furthermore, CAI has been found to enhance students' performance than the conventional method of teaching in Counselor education (Karper, Robinson & Casado-Kehoe, 2005). However, Mill (2001) findings revealed that CAI was found to be as effective as the classroom for fact-based learning, but not as effective for topics requiring critical thinking or mathematical problem-solving. In addition,

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students taught using the conventional method of instruction combined with the use of computer performed significantly better than students taught using the conventional method of instruction in a college setting (Akour, 2006). Similarly, college students taught statistics using lecture plus CAI obtained higher averages on a midterm and final exams than students taught using lecture method only (Basturk, 2005). Furthermore, how CAI is delivered can affect its effectiveness and that new studies are needed to clarify the effect of CAI in contemporary student environment (Jenk & Springer, 2002).

Gender has been linked with the performance of students in several studies without any definite conclusion. Studies have shown that gender is a pertinent issue in Biology Education, and it is prominent among the factors identified as being responsible for learners' poor learning outcome. Gender in science is the classification of the role of males and females (Odekunle, 2011). Previous studies suggested that relative traditional teaching and the use of CAI can give rise to gender inequalities in classroom interaction and achievement (Ramanjeet et al., 2012). Ramanjeet et al. (2012) are of the opinion that boys often monopolize the computer in CAI setting and they feel more comfortable than girls with using computers. Previous studies revealed that male students performed better than females in Physics, Chemistry, and Biology (Yusuf & Afolabi, 2010). Keziah (2011) in their study on internet using patterns of Nigeria teacher-trainees, found

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that more female students were personally connected to the internet than their male counterparts; but the male students surf the internet more than females.

This indicated a male dominance in skills, which is more important than mere possession of the computer. This study revealed a worry that gender barriers which have earlier been identified to hinder females in science and technology may be persistent to this present era of the information superhighway (Achuonye, 2006; Onwuegbuna & Onwuegbuna, 2006). Yusuf and Afolabi (2010) concluded that gender has no influence on the academic performance of male and female students exposed to CAI either individually or co-operatively. However, the influence of gender on academic achievement will be investigated in this study.

The rate of poor academic performance of students in Nigeria has resulted to economic and social wastage and this has become a great concern to all stakeholders in education. Bandele (2003) noted that the importance of physical facilities cannot be overlooked. Facilities like modern laboratories, computer laboratories, libraries, and classrooms are to be put in place in all schools. Bandele (2003) further reported that findings on effects of facilities in private and public secondary schools on students' academic achievement are inconclusive.

Alimi et al. (2012) reiterated that the type of schools either public or private did not make any difference on students' academic performance. However, Ajayi (2006) found that school type makes a difference in student academic performance.

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In addition, Philias and Wanjobi (2011) reiterated that type of schools; (single-sex or mixed, private or public) has an effect on the academic achievement of students in Mathematics.

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Organizing children into high, average, and low ability groups actually creates differences in what children learn by exposing them to different kinds of material. Although, some children in high ability groups may benefit from such arrangements, those who lose most are the children placed in average and low ability groups. Such grouping practices tend to compound racial, ethnic, and economic differences in schools, as poor children and children of colour are least likely to be served in enriched, gifted, or high ability tracks. These children are more likely to end up in vocational or low ability groups (Oakes & Lipton, 1999). Grouping children creates distance among them and tends to amplify and solidify whatever actual differences originally existed (Sapon-Shevin, 1994; 1999).

Statement of the Problem

Over the years, performance in biology has been dwindling and not encouraging. Okoye and Okeke (2007) in their study found that in 2002, 2003 and 2004, the percentages of candidates who passed West African Senior School Certificate Examinations (WASSCE) at credit level and above (Grades 1-6) in biology was 30.3%, 42.1%, and 30.2%, respectively. Similarly, Egbunonu and Ugbaja (2011) reported that only 30.29% of the biology students who sat for the

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WASSCE between 2000 and 2005 passed at credit level and above (A1-C6). Furthermore, the Nigerian Television Authority (NTA) on March 17th, 2010 reported that National Examinations Council (NECO) recorded 74% failure in biology in their Nov/Dec. 2009 SSCE examinations result (Osuafor & Okonkwo, 2013). The West African Examinations Council Biology Examinations results over twenty-six (26) years as shown in Table 1 revealed that the performance of students has not been encouraging and Biology has not recorded much 50% and above credit pass over the years as it is observed in Chemistry and Physics (Abimbola, 2013). However, there was a slight improvement in biology examinations results in 2013 to 2016 with a 50% and above credit pass. This sudden with might be associated with improved teaching strategies from the teachers and other factors. Such an improvement might be sustained since biology subject is no longer offered by non- science students, resulting to fewer science students to take part in biology examinations.

Yet with this improvement in biology examinations performance, West African Examinations Council Chief Examiners' report showed that there is a wide gap in knowledge of students in cellular respiration, that candidates were unable to tabulate correctly the differences between gaseous exchange and aerobic respiration. Candidates could not also outline the activities that can result in oxygen debt. Candidates wrote carbon monoxide in the air; overcrowding,

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deforestation, while the expected answer was running; boxing; swimming or any correct examples of strenuous activities (WAEC, 2013).

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In 2008, the West African Examinations Council Chief Examiners' report showed a decline in candidates' performance in biology especially the theoretical aspect (WAEC, 2008). It was also reported that cellular respiration was not a popular question in theoretical section and not many candidates attempted it. Those who attempted it scored poor marks and many candidates could not write the correct equations for aerobic and anaerobic respiration but rather defined the concepts and so lost the marks. Some candidates who attempted the equation could not balance it; most of them got the reactants correctly but could not correctly list the products (WAEC, 2003; 2010).

For a nation that is yearning for scientific and technological advancement, these result records of SSCE results in table one is not encouraging. If we are to have better results, there is the need to make frantic efforts in improving our pedagogical styles to enhance a better understanding of difficult biological concepts (Oyelekan & Olorundare, 2009). This is why this research focused on Computer-Assisted Instruction as a possible panacea to students' poor performance in Biology.

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Cellular respiration is a sub-topic under the topic "some properties and function of the cell" in the new biology curriculum for Senior Secondary School 1–

3. According to Idodo-Umeh (2010), cellular (internal or tissue) respiration is the oxidation of food substance in the cells (particularly in the mitochondria) to release energy in form of Adenosine Triphosphate (ATP) for the performance of work.

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$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38ATP$$

Glucose Oxygen Carbon (iv) Oxide Water Energy

Cellular respiration has been reported to be one of the topics that students find very difficult to understand among the biological concepts (Fadipe, 2011). Teaching the Sciences for Optimum Learning Outcomes (August, 2012), a training workshop organized for science teachers in public secondary schools in Oyo State, cellular respiration was on the list, among other topics that biology teachers find difficult to teach very well or students find difficult to understand. WAEC Chief Examiner's Report in (2003, 2006, & 2010) revealed that some candidates lost marks as they could not properly spell "aerobic" respiration while many candidates could not write a word equation for anaerobic respiration. This indicated that the level of students understanding in cellular respiration was very low.

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Researchers, such as Yusuf and Afolabi (2010); Ramanjeet, et al. (2012); Yap (2017) acclaimed that students exposed to individualized computer instructional package might have better results over others. However, very few empirical studies exist in Nigeria regarding the use of CAI in biology education. Thus, much remains to be empirically studied the effect of CAI in biology

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education, in relation to the gender, school types, score levels and students' academic achievement in Nigeria, these were the focus of this research work.

Purpose of the Study

The study investigated effects of the use of a computer-assisted instructional package on students' achievement in cellular respiration. Specifically, the study examined the:

1. difference between achievement in cellular respiration of the Senior Secondary School students exposed to computer-assisted instruction and those exposed to the conventional method of instruction.
2. influence of gender on Senior Secondary School students' achievement in cellular respiration, when exposed to computer-assisted instruction and conventional method of instruction.
3. influence of school type (public and private) on Senior Secondary School students' achievement in cellular respiration, when exposed to computer-assisted instruction and conventional method of instruction.
4. non-science of computer-assisted instruction and conventional method of instruction on the performance levels of Senior Secondary School students' achievement in cellular respiration.
5. interaction effects of treatment, gender, school types and performance levels on Senior Secondary School students' achievement in cellular respiration.

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Research Questions

The following research questions were answered in this study:

1. Is there any difference in the achievement of Senior Secondary School students taught cellular respiration when exposed differently to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI)?

2. Is there any difference in the achievement of Senior Secondary School students taught cellular respiration when exposed differently to CAI and CMI based on gender?

3. Is there any difference in the achievement of public and private Senior Secondary School students taught cellular respiration when exposed differently to CAI and CMI?

4. Is there any difference in the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI based on performance levels (high, medium and low scores)?

5. Is there interaction effect of treatment and gender on the achievement of Senior Secondary School students taught cellular respiration?

6. Is there interaction effect of treatment and school types on the achievement of Senior Secondary School students taught cellular respiration?

7. Is there interaction effect of treatment and performance levels on the achievement of Senior Secondary School students taught cellular respiration?

8. Is there interaction effect of gender and school types on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI?

9. Is there interaction effect of gender and performance levels on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI?

10. Is there interaction effect of school type and score levels on the achievement of Senior Secondary School students in cellular respiration when exposed to CAI and TI?

11. Is there interaction effects of treatment, gender and school types on the achievement of Senior Secondary School students taught cellular respiration?

12. Is there interaction effects of treatment, gender and performance levels on the achievement of Senior Secondary School students taught cellular respiration?

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13. Is there interaction effects of treatment, school types and performance levels on the achievement of Senior Secondary School students taught cellular respiration?

14. Is there interaction effects of treatment, gender, school types and performance levels on the achievement of Senior Secondary School students taught cellular respiration?

Research Hypotheses

The following hypotheses were tested in this study:

$H0_1$: There is no significant difference between the achievement of Senior Secondary School students taught cellular respiration when exposed to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI).

$H0_2$: There is no significant difference between the achievement of male and female Senior Secondary School students taught cellular respiration when exposed to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI).

$H0_3$: There is no significant difference between the achievement of public and private Senior Secondary School students taught cellular respiration when exposed to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI).

$H0_4$: There is no significant difference in the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI based on performance levels (high, medium and low scores).

$H0_5$: There is no significant difference in the interaction effect of treatment and gender on the achievement of Senior Secondary School students taught cellular respiration.

$H0_6$: There is no significant difference in the interaction effect of treatment and school types on the achievement of Senior Secondary School students taught cellular respiration.

$H0_7$: There is no significant difference in the interaction effect of treatment and performance levels on the achievement of Senior Secondary School students taught cellular respiration.

$H0_8$: There is no significant difference in the interaction effect of gender and school types on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI.

$H0_9$: There is no significant difference in the interaction effect of gender and performance levels on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI.

$H0_{10}$: There is no significant difference in the interaction effect of school type and performance levels on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI.

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$H0_{11}$: There is no significant difference in the interaction effects of treatment, gender and school types on the achievement of Senior Secondary School students taught cellular respiration.

$H0_{12}$: There is no significant difference in the interaction effects of treatment, gender and score levels on the achievement of Senior Secondary School students taught cellular respiration.

$H0_{13}$: There is no significant difference in the interaction effects of treatment, school types and performance level on the achievement of Senior Secondary School students taught cellular respiration.

$H0_{14}$: There are no significant difference in the interaction effects of treatment, gender, school types and performance levels on the achievement of Senior Secondary School students taught cellular respiration.

Scope of the Study

The scope of this study was restricted to Ibadan, Oyo State, Nigeria for convenience sake. The study was carried out in some selected Senior Secondary Schools that satisfied the following criteria: functioning computer laboratories; computer literate students; co-educational school and good SSCE tracking results of five years. An intact class of Senior Secondary School one (SS1) offering biology was used from each selected schools while cellular respiration was taught as a topic. The cellular respiration tutorial interactive package was used as a

computer instructional package for the experimental group while the control group was exposed to Conventional Method of Instruction. The purpose of the package was to make the teaching-learning process of cellular respiration more interactive with immediate feedback assessments. The whole lesson contains an introduction, unit one, unit two, unit three and comprehensive quiz with various contents such as videos, pictures, and texts and each unit contained evaluation test.

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Significance of the Study

This study is of significance to teaching-learning process as CAI is learner-centered package, the finding of this study would have a positive impact on the teaching-learning process, by promoting individualized study among the students. It would engage the students in self-instruction, and encourage them to master the content of a subject completely with the provision of an instant feedback associated with the assessment tests.

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The new biology curriculum emphasized on student's activities, inquiry and discovery method of instruction delivery. This study would help teachers to make use of appropriate learning package to support their teachings and enable teachers to make biology class more attractive to the students. Since CAI is apparently a modern method of teaching that could yield a positive result in student's academic achievement, it may be needed to be employed.

The research study could be beneficial to curriculum developers as it would enable them to develop a better curriculum that would improve biology education in Nigeria and other countries. The CAI package could be of help to the deaf and dumb students of biology. Additionally, results from this study could be of help to curriculum developers in recommending appropriate methods of instruction for specific biology topics.

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For any educational policy to be well implemented, funding is one of the major factors that must be well considered. This study is an eye-opener concerning the modern method of instruction delivery requesting the policymakers to allocate adequate funds to achieve a qualitative science teaching and meet the needs of biology education in secondary school. Computers have long been used in education and today their use is having an ever greater impact and results on society, thanks to the increasing educational success of the internet and easier access to it. This broad field, which may include any kind of learning process aided by information and communication technologies, is usually referred to as e-learning. For this reason, a significant amount of research and development on both technological and educational issues in e-learning has been taking place with striking results. More research and application works are needed in order to produce more cases of success and to generalize e-learning in industries, universities, and schools. This study would open the eyes of researchers to CAI packages, that more is still needed to be done.

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Clarification of Major Terms and Variables

The following terms and variables as used in this study are clarified below:

Computer-Assisted Instruction (CAI): This is an interactive teaching strategy whereby a computer is used to present the instructional material and monitor the learning that takes place.

Conventional Method of Instruction (CMI): Conventional or traditional method of instruction refers to a teaching method involving instructor (teacher) and the students (learners) interacting in a face-to-face manner in the classroom. The teacher teaches naturally without a specified methods of teaching.

School Type: It is categorized into two for this research study as (a) public secondary schools owned by the government and (b) private secondary schools owned by an individual or private organization.

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Gender: It means the state of being male or female (typically used with reference to social and cultural differences rather than biological ones)

Cellular Respiration: is the oxidation of food substances in the cells to release energy in form of ATP molecules.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \rightleftharpoons \underset{\text{carbon(iv)oxide}}{6CO_2} + \underset{\text{water}}{6H_2O} + \underset{\text{energy}}{38ATP}$$

Academic Achievement: This is an outcome of a test or an assessment of a student.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Relevant literature for this study was reviewed under the following sub-headings:

1. Theoretical Framework for the Study
2. E-learning and the Use of Instructional Resources
3. Computer-Assisted Instruction (CAI)
4. Objectives and Content of Biology Curriculum for Senior Secondary Schools and Cellular Respiration
5. Studies on the influence of Gender on Senior Secondary School Biology Students Achievement
6. Studies on the Influence of Score Levels on Senior Secondary School Biology Students Achievement
7. Studies on the Influence of School Types and Modern Facilities on Senior Secondary School Biology Students Achievement
8. Appraisal of Reviewed Literature

Theoretical Framework for the Study

One of the learning theory supporting this study is centered on constructivism. The concept of constructivism has roots in classical antiquity, going back to Socrates's dialogues with his followers, in which he asked directed questions that led his students to realize for themselves the weaknesses in their thinking. The Socratic dialogue is still an important tool in the way constructivist

educators assess their students' learning and plan new learning experiences. In this century, Jean Piaget and John Dewey are the major proponent of evolution of constructivism (Papert & Harel, 1991).

Dewey called for education to be grounded in real experience. He wrote, "If you have doubts about how learning happens, engage in sustained inquiry: study, ponder, consider alternative possibilities and arrive at your belief grounded in evidence." Inquiry is a key part of constructivist learning. Lev Vygotsky, Jerome Bruner, David Ausubel, and Seymour Papert have contributed new perspectives to constructivist learning theory and practice (Papert & Harel, 1991).

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However, constructivism states that learning is an active, contextualized process of constructing knowledge rather than acquiring it. Knowledge is constructed based on learner experiences and hypotheses of the environment. Learners actively test these hypotheses through social negotiation. Each person has a different interpretation and construction of knowledge process. Proponents of this theory believe that, the following factors are associated with constructivism: encourages active engagement, promotes motivation, promotes autonomy, responsibility, independence, tailors learning experiences and develops creativity and problem-solving skills among learners (Driscoll, 2000; & Duffy, Lowyck & Jonassen, 1993)

Constructivists believed that learners should be able to create their knowledge. This form one of the basis of computer-assisted instruction. However, the central principles of this approach are that learners can only make sense of new situations in terms of their previous understanding. Learning involves an active process in which learners construct meaning by linking new ideas with their previous knowledge." (Naylor & Keogh, 1999, p.93) Gokalp (2016), posited that constructivism transforms the student from a passive recipient of information to an active participant in the learning process.

Another related learning theory to computer-assisted instruction is mastery learning theory. Bloom (1984), propounded a theory that everyone can learn by given them sufficient time and personal attention, and opined that learners have to construct their own knowledge individually and collectively. Bloom's model of mastery learning calls for students to receive individualized instruction as necessary until they master all the course material (Bloom, 1984). Mastery learning does not focus on content but on the process of mastering it. Major objectives representing the course or unit define mastery of the subject. The material is divided into smaller, sequentially organized units. Mastery learning includes numerous opportunities for feedback to the teacher. Each unit is preceded by a brief diagnostic test. The results of the diagnostic tests are used to determine supplementary instruction to help the students overcome problems. The students

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must demonstrate mastery of the individual units before moving on to other units (Huet, 1996).

Another model of mastery learning is Keller's Personalized System of Instruction (Keller, 1968). Keller's model has four distinguishing characteristics. First, the instructor presents the information utilizing more written materials than the traditional lecture method. Instead of the verbal method of instruction, the teacher selects and creates appropriate reading materials as well as provides the student with learning objectives and study questions. Secondly, students finish assignments at their own pace. Third, students must demonstrate their mastery of objectives before they are allowed to proceed. Finally, the teaching resources are devoted to helping students overcome their deficiencies (Keller, 1968). The concept of mastery learning has been further enhanced by the use of computers in education. The computer allows for very individualized instruction. Each child can work at his or her own pace. This is one of the cornerstones of mastery learning and characteristic of computer-assisted instruction (Vockell, 1990).

Computers allow for a great amount of testing and analysis of the data gained from the test. Each child can be tested before a concept is covered in the class. The students' mastery of individual concepts in the lesson can be determined. This allows the teacher to concentrate on the shortcomings of the students. The information concerning the learner's needs is easily accessible and understood by the instructor (Vockell, 1990). After the student has mastered the

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objective or concept proponents the learner can move on to the next topic or stage of instruction. Theories of learning have been used in designing CAI that engages students in higher order learning, both in the military and civilian sectors. Examples of CAI systems that have been used to provide this type of learning include (a) operating a space capsule, (b) flying a plane, (c) managing a nuclear reactor station, and (d) repairing a missile system (Shlechter, Bessemer, & Kolosh, 1992). Some of these systems have been evaluated in a controlled manner in order to determine their effectiveness. Thus, mastery learning theory of constructivism was considered with students participated in this study, to establish the ideas of their proponents.

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E-learning and the Use of Instructional Resources

E-learning refers to the use of electronic media and information and communication technologies (ICT) in education. E-learning, broadly inclusive of all forms of educational technology in learning and teaching. E-learning is inclusive of, and is broadly synonymous with multimedia learning, technology-enhanced learning (TEL), computer-based instruction (CBI), computer-based training (CBT), computer-assisted instruction or computer-aided instruction (CAI), Internet-based training (IBT), web-based training (WBT), online education, virtual education, virtual learning environments (VLE) (which are also called learning platforms), m-learning, and digital educational collaboration. These alternative

names emphasize a particular aspect, component or delivery method. (Wikipedia, 2014).

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E-learning includes numerous types of media that deliver text, audio, animation, images, streaming video, which include technology applications and processes such as audio or video tape, satellite TV, CD-ROM, and computer-based learning, as well as local intranet/extranet and web-based learning. Information and communication systems, whether free-standing or based on either local networks or the Internet in networked learning, underlay many e-learning processes (Tavangarian, Leypold, Nölting & Röser, 2004).

E-learning can occur in or out of the classroom. It can be self-paced, asynchronous learning or maybe instructor-led, synchronous learning. E-learning is suited to distance learning and flexible learning, but it can also be used in addition to face-to-face teaching, in which case the term blended learning is commonly used. E-learning is inclusive terms that describe educational technology that electronically or technologically enhances learning and teaching. Luskin (2010) a pioneer of e-learning, advocates that the "e" should be interpreted to mean "exciting, enthusiastic, energetic, emotional, extended, excellent, and educational" in addition to "electronic." This broad interpretation focuses on new applications and developments, and also brings learning and media psychology into consideration (Wikipedia, 2014). Parks suggested that the "e" should refer to "everything, everyone, engaging, easy"(Eric, 2013).

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Educationally, the extent to which e-learning assists or replaces other learning and teaching approaches are variable, ranging on a continuum from none to fully online distance learning (Bates & Poole, 2003; OECD, 2005). A variety of descriptive terms have been employed (somewhat inconsistently) to categorize the extent to which technology is used. For example, 'hybrid learning' or 'blended learning' may refer to classroom aids and computer system or may refer to approaches in which traditional classroom time is reduced but not eliminated, and is replaced with some online learning (Strauss, 2013). Another scheme described the level of technological support as 'web enhanced', 'web supplemented' and 'web dependent'. E-learning may either be synchronous or asynchronous. Synchronous learning occurs in real-time, with all participants interacting at the same time, while asynchronous learning is self-paced and allows participants to engage in the exchange of ideas or information without the dependency of other participants′ involvement at the same time. Synchronous learning involves the exchange of ideas and information with one or more participants during the same period of time. A face-to-face discussion is an example of synchronous communications. In e-learning environments, examples of synchronous communications include online real-time live teacher instruction and feedback, Skype conversations, or chat rooms or virtual classrooms where everyone is online and working together at the same time (Wikipedia, 2014).

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Asynchronous learning may use technologies such as email, wikis, blogs, and discussion boards, as well as web-supported textbooks, hypertext documents, audio video courses, and social networking using web 2.0. At the professional educational level, training may include virtual operating rooms. Asynchronous learning is particularly beneficial for students who have health problems or have child care responsibilities and regularly leaving the home to attend lectures is difficult. They have the opportunity to complete their work in a low-stress environment and within a more flexible timeframe in asynchronous online courses; students proceed at their own pace. If they need to listen to a lecture a second time and over again, or think about a question for a while, they may do so without fearing that they will hold back the rest of the class (Vidyadeyi, 2014).

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Through online courses, students can earn their diplomas more quickly, or repeat failed courses without the embarrassment of being in a class with younger students. Students also have access to an incredible variety of enrichment courses in online learning, and can participate in college courses, internships, sports, or work and still graduate with their class. Both the asynchronous and synchronous methods rely heavily on self-discipline, self-motivation, and the ability to communicate in writing effectively (Vidyadeyi, 2014).

Akinsola (2003) defined resources as the sum total of all the factors used directly or indirectly for the purpose of educational training support, facilitates or encourages the acquisition of knowledge and skill. Utilization of learning materials

should be provided in good quality and quantity in Science Technology Engineering and Mathematics (STEM) classrooms as the way forward for an effective teaching-learning process (Umeoduogu, 2000; Onwuachu, 2011).

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Material resources refer to information carrying technologies (teaching aids) that are used for instructional purposes with the hope of delivering educational information very quickly are varied widely (Kola, 2007). Onwuachu (2011) opined that adequate utilization of material resources is the way forward for effective and meaningful teaching and learning in any educational programme, particularly Biology.

All over the world, many human activities have been taken over by ICT. Central to this technology, is the computer, the use of which has dominated human activities especially in the last two decades and which is complemented by a whole lot of other electronic devices, all of which are now collectively regarded as information and Communication Technology (ICT). The adoption of ICT into education has often been premised on the potential of this ‘new' technological tool to revolutionalize an outmoded educational system and as such better prepare students and the average citizen for the information age and or accelerate national development efforts (Albiriu, 2006; Oyelekan, 2011).

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There is a growing emphasis on e-learning. E-learning is defined as those approaches that exploit interactive technologies and communication system to

improve the learning experience. (DFES, 2003). This effective e-learning initiative brings together benefits derived from a range of technologies and other related initiatives such as laptops for teachers, data projectors, interactive whiteboards, satellite technology, computer suites or clusters and online resources (Oyelekan & Aderogba, 2011).

However, Condie and Munro (2006) listed other benefits attributed to e-learning include motivation and engagement, independent learning and autonomy, key or core skills such as collaborative learning and communication, all of which can contribute to improvement of knowledge, understanding, and skills. These can, in turn, have an impact on attainment. To meet up with the stated goals of Biology curriculum and to actualize the roles of Biology in national economic development, there is need for adequate provision and utilization of material resources to enhance teaching and learning so as to empower the students toward being productive, self-reliant and sufficient after their education career hence contributing towards national development. Mapaderun (2002) and Obah (2008) emphasized that the availability and adequacy of resources utilization promote effective teaching and learning activities in schools while their inadequacies affect the academic achievement negatively. Information and Communication Technology (ICT) is one technology that has revolutionalized the human way of life.

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Computer-Assisted Instruction (CAI)

Computer-based education (CBE), computer-based instruction (CBI) and E-learning are the broadest terms and can refer to virtually any kind of computer use in educational settings, including drill and practice, tutorials, simulations, instructional management, supplementary exercises, programming, database development, writing using word processors, and other applications. These terms may refer either to stand-alone computer learning activities or to computer activities which reinforce material introduced and taught by teachers (Cotton, 1991). Computer-Assisted Instruction (CAI) can be defined as the use of a computer to provide course content instruction in the form of drill and practice, simulations and tutorials. The term is used synonymously with CBL (Computer-Based Learning), CBI (Computer-Based Instruction), and CAL (Computer-Assisted Learning) (Chambers & Sprecher, 1983).

Computer-Assisted Instruction (CAI) is a narrower term and most often refers to drill and practice, tutorial, or simulation activities offered either by themselves or as supplements to traditional, teacher-directed instruction. Computer-managed instruction (CMI) is an instructional strategy whereby the computer is used to provide learning objectives, learning resources, record keeping, progress tracking, and assessment of learner performance. Computer-based tools and applications are used to support the teacher or school administrator in the management of the learner and instructional process. Computer-Enriched

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Instruction (CEI) is defined as learning activities in which computers, (1) generate data at the students' request to illustrate relationships in models of social or physical reality, (2) execute programmes developed by the students, or (3) provide general enrichment in relatively unstructured exercises designed to stimulate and motivate students (Cotton, 1991).

CAL (Computer-Based Learning), started in the 1950s and 1960s, mainly in the USA. Pioneers such as Suppes (Stanford University), Kemeny and Kurtz (BASIC, 1960s (Kemeny and Kurtz, 1968; 1985) and Bitzer (PLATO, University of Illinois (Hart, 1981; 1995)) were among the first to use the computer as part of the learning process. The early CAI programs were rudimentary by today's standards, with mainly text-based interfaces. Bitzer was one of the first to realise the importance of graphics and sound in the teaching process. Initially, CAL programs simply tried to teach a particular topic without a basis on any particular educational philosophy.

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The Time-Shared Interactive Computer Controlled Information Television (TICCIT) (Merrill, 1983; 1988) at the Brigham Young University was based on a specific instructional framework that dictated the actual hardware. The Logo project (Papert, 1980; 1993) was probably the first CAL system that was based on a specific learning approach (the experimental, discovery learning approach).

A self-learning technique, usually offline/online, involving the interaction of the student with programmed instructional materials. Computer-assisted instruction (CAI) is an interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning that takes place. CAI uses a combination of text, graphics, sound and video in enhancing the learning process. The computer has many purposes in the classroom, and it can be utilized to assist a student in all areas of the curriculum. CAI refers to the use of the computer as a tool to facilitate and improve instruction. CAI programmes use tutorials, drill and practice, simulation, and problem-solving approaches to present topics, and they test the student's understanding. (Wiki Educator, 2008).

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Typical CAI provides the following:

i. Text or multimedia content ii. Multiple-choice questions iii. Problems iv. Immediate feedback

iv. Notes on incorrect responses vi. Summarizes students' performance vii. Exercises for practice and viii. Worksheets and tests.

CAI brings with it several potential benefits as a teaching-learning medium. These include self-directed learning, self-paced learning, exercising of various senses and the ability to represent content in a variety of media. With self-paced learning, learners can move as slowly or as quickly as they like through a programme. If they want to repeat some task or review some material again, they can do so as many times as they want. The programme will not complain about

repetitions. Learners can skip over a topic if the information is already known, making the learning process more efficient.

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With self-directed learning, learners can decide what they want to learn and in what order. Learners have different learning styles and use different learning strategies. Various studies (Entwistle, 1981; Schmeck 1988; Ford and Chen, 2001) have shown that when learners can learn in a way that suits them, improvements in the effectiveness of the learning process normally ensues.

Humans are multi-sensory animals. The more senses through which we receive information, the easier it is to remember. According to Fletcher (1990), people remember 20% of what they hear, 40% of what they see and hear and 75% of what they see, hear and do. The fact that the computer can exercise various senses and present information in a variety of media can enhance the learning process. Meskill and Mossop (1997) reported that computers encourage learning as they provide a stimulating environment and promote enthusiasm. Computers may help the reticent students who may be afraid to make mistakes in a classroom situation (Chun, 1994; Meskill & Swan, 1996). They are good for online reference which is useful in a language learning situation (for example, online dictionaries) (Leffa, 1992).

Auxiliary benefits, such as freeing up teacher time and can cater for students of different abilities. Also, the ability to provide quicker (and perhaps more

directed) feedback is another benefit of CAI. In addition, Wiki Educator (2008) summarizes advantages of CAI as follow:

• One-to-one interaction;

• Great motivator;

• Freedom to experiment with different options;

• Instantaneous response/immediate feedback to the answers elicited;

• Self-pacing - allow students to proceed at their own pace;

• Helps teacher to devote more time to individual students;

• Privacy helps the shy and slow learner to learn;

• Individual attention;

• Learn more and more rapidly;

• Multimedia helps to understand difficult concepts through multi-sensory approach; and

• Self-directed learning – students can decide when, where, and what to learn.

CAI is not without its problems. With self-access programmes, learners can be left on their own for a longer period and may feel overwhelmed by the information and resources available. On the other hand, there may be too much direction from the computer if classroom methods are transferred to the computer. Dawson (1997) stated that the tendency to use multimedia "gimmicks" should be avoided and that due attention must be paid to current theories on language acquisition. However, this does not mean that multimedia should be avoided.

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Some researchers (Levy, 1997; Meskill and Mossop, 1997) believed that meaningful multimedia practices are possible and can result in more learning. Malfunctioning equipment can not only result in lost time but also create a negative attitude towards CAI. While the ability to follow links in a Web-based learning system can be of benefit, learners may lose time in navigation. CAI is not yet a mature field. While various CAI models exist, not all CAI programmes offer all the benefits of CAI. Sometimes what is theoretically advocated is not implemented in practice (either due to lack of knowledge or technological unfeasibility). Sometimes, the effective or good practices are not easy to identify. More research work will help to advance the field of CAI. One interesting research area is that of Web-based Adaptive Educational Systems (WAES), where the system adapts to the learner, providing different levels of information, help, and feedback (Brusilovsky, 2000).

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Limitations of CAI was summarised by Wiki Educator (2008) as follows:

• may feel overwhelmed by the information and resources available;

• overuse of multimedia may divert the attention from the content;

• learning becomes too mechanical;

• Nonavailability of good CAI packages; and

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• lack of infrastructure.

According to (Levy, 1997), CAI systems fall into two basic types; tutor or tool. Although the term CAI often refers to computer tutors. In the tutor classification, the computer has the information to be learned and controls the

learning environment. A CAI tool enhances the teaching process, usually by focusing on one particular learning task and aiming to improve it. Within the tutor classification, there are four modes: drill and practice, tutorials, simulations and games (Gloor, 1990). Drill and practice (also known as "Drill and Kill") are suited to the behaviourist model, with repeated practice on lower-level cognitive skills. Although often frowned upon, it can be useful in certain contexts.

The tutorial mode is probably one of the most common ones within CAI. In this mode, the computer presents the information, guides the learner through the system, allows the learner to practice and then assesses the learner.

In simulation mode, the learner works with a simulation of the real world. Simulation is used where it is not practical or feasible to provide the learning in "real-life" (for example, pilot training).

In games mode, there is generally a competitive element (e.g. time constraints or a race). The idea is to reinforce the knowledge that the learner is assumed to have. While it is often more difficult to develop CAI programmes in the simulation and games modes, learners tend to find them entertaining and challenging. Furthermore, there is also Discovery and Problem-solving approaches. Discovery approach provides a large database of information specific to a course or content area and challenges the learner to analyze, compare, infer and evaluate based on their explorations of the data. Problem Solving**:** This

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approach helps children develop specific problem-solving skills and strategies (Wiki Educator, 2008).

Comparing the relative effectiveness of different instructional methods can help determine the method that produces greater learning and is thus deemed more effective. In addition, since the conventional method of instruction and CAI differ in many ways, one conclusive way to compare them is in terms of their relative effectiveness in producing learning.

A further differentiation beyond definitions is thus required to clarify differences between the two instructional modes. A clearer distinction will emerge if a comparison is made of features that are common in CAI against those that are common in traditional classroom instruction. Such a comparison was provided by Steinberg (1990), who observed that CAI and traditional classroom instruction differ in modes of communication, instructor-learner interactions, and environment. In the following sections, descriptions of some of these differences based on Steinberg's factors are provided

Live instructors use several modes of communication, mostly oral and physical. They use body language to give encouragement or indicate approval or disapproval where appropriate. In CAI, the dominant mode is visual. Although oral communication technology in CAI is available, it is not yet common. While noting

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that current technology allows for human speech to be incorporated into CAI, Steinberg (1990) observed that most CAI lessons are primarily visual.

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While classroom students listen, read, and observe, CAI students are rarely expected to listen; they tend to only read and observe. Classroom students communicate by speaking or writing, while their CAI counterparts do so by typing, touching a display screen, or manipulating a tool such as a mouse.

The way interaction occurs in traditional classrooms and CAI lessons also differ. In classroom instruction, only one student at a time responds overtly to the instructor, while other students in the class do it covertly, if at all. In CAI, lessons can be highly individualized, and every student has an equal chance of responding to every question. Live instructors can attempt to assess students' learning by observing their behaviour and then taking appropriate actions. However, the computer can only evaluate students' overt responses. In judging the responses, the computer is less flexible than the human instructor. Unless flexible judgment is programmed into a CAI lesson, it cannot differentiate between responses that are similar in meaning.

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Additionally, a computer can only answer questions if it is programmed to do so. On the other hand, a human instructor can answer just about any question or suggest resources for finding the answer. Traditional classroom instruction is usually group-paced. The teacher sets the sequence of instruction, and instruction

is usually linear, with every student following the same path. CAI, on the other hand, is usually individually-paced with branching paths. The computer, learner, teacher, or some combination can control instructional sequence.

Steinberg (1990) noted that environmental factors are common knowledge in one mode but not in the other. For instance, in the traditional classroom instruction, it is often self-evident for students to know how well they are doing. This capability in CAI is only possible when the lesson is designed to do so. In terms of learner-learner interaction, learners usually interact with other learners in the traditional classroom while CAI students' seldom do. Repetition of identical lessons is readily available in CAI but not easy to produce in the traditional classrooms.

Cotton (1997), cited in Yusuf and Afolabi (2010), discussed that the use of CAI as a supplement to conventional method of instruction produces higher performance than the use of conventional method of instruction alone, research is inconclusive regarding the comparative effectiveness of conventional method of instruction alone and CAI alone, and that computer-based education (CAI and other computer applications) produce higher achievement than conventional method of instruction alone.

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In addition, students learn instructional content faster with CAI than with the conventional method of instruction alone, they retain what they have learned better with CAI than with the conventional method of instruction alone. Karper,

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Robinson, and Casado-Kehoe (2005) cited in Yusuf and Afolabi (2010) showed that CAI has been found to enhance students' achievement than the conventional method.

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Objectives and Content of Biology Curriculum for Senior Secondary Schools and Cellular Respiration

Curriculum can be defined as the planned and guided learning experiences and intended outcomes, formulated by the systematic reconstruction of knowledge and experiences under the auspices of the school, for the learners continuous and willful growth in personal social competences (Tanner, 1980). Also, Goodlad and Su (1992) define curriculum as a plan that consists of learning opportunities for a specific time frame and place, a tool that aims to bring about behavior changes in students. In variably, curriculum collectively describe the teaching, learning and assessment materials available for a specific course of study.

The 2009 Biology Curriculum was adapted and revised from 1985 edition developed by Comparative Education Study and Adaptation Centre (CESAC). The objectives of this curriculum have been derived from the National Policy on Education (2004) and the main objectives are to prepare students to acquire:

i. adequate laboratory and field skills in biology;

ii. meaningful and relevant knowledge in biology;

iii. ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture; and

iv. reasonable and functional scientific attitude (NERDC, 2009).

In pursuance of the stated objectives, the contents and context of the curriculum place emphasis on field studies, guided discovery, laboratory techniques and skills along with conceptual thinking. The curriculum intended to provide a modern biology course as well as meet the needs of the learner and the society through relevant and functionality in its contents, methods, processes, and applications. It covers the major themes of:

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Theme one: Organization of Life

Theme two: Organisms at Work

Theme three: The Organisms and its Environment

Theme four: Continuity of life

These themes are of direct relevance to the society and learner. In planning the new biology curriculum, the spiral approach to sequencing a science course was adopted. In the approach, the concepts to be taught are arranged in such a way that they run throughout the three-year post basic course, with the concepts being discussed in greater depth as the course progresses.

The curriculum is organized into six sections which are the level of the content in use, it includes the following:

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i. topic;
ii. performance objectives;
iii. content;

iv. activities –teacher and students;

v. teaching and learning materials; and

vi. evaluation guide (NERDC, 2009).

Under the current biology curriculum, Cellular respiration is a sub-topic under the topic 'some properties and functions of the cell', which belong to theme one, organisation of life, of the senior secondary one section of the curriculum. Respiration is the process by which complex food substances are broken down, in a stepwise series of reactions, in cells, to produce energy with carbon dioxide and water as waste products. Cellular respiration (tissues respiration) involves the chemical activities of the cells in which glucose is broken down by a series of reaction controlled by enzymes to release energy. The energy so released is stored in the form of Adenosine Triphosphate (ATP). ATP is the form in which energy exists, stored and used by all living cells for the various metabolic processes. Respiration occurs in all living cells. The energy produced during respiration is used by the organism for such activities as the synthesis of proteins, lipids, and protoplasm, germination, cell division and enlargement leading to growth, movement, transmission of nerve impulses, active transport, and maintenance of body temperature. Organisms vary in the amount of energy they use. A very active organism, such as a horse uses much more energy than a sluggish one such as a snail.

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There are two main types of cellular respiration. These are aerobic and anaerobic respiration. Respiration that occurs in the presence of oxygen is described as aerobic while that which occurs in the absence of oxygen is anaerobic. Respiration occurs in cells and for that reason, it is called cellular or tissue respiration.

Aerobic respiration is the type of respiration which requires oxygen to break down glucose (substrates) into the water, carbon dioxide and energy (ATP). Aerobic respiration can be represented by the chemical equation below:

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6C0_2 + 6H_2O + \text{Energy}$

(Glucose) (Oxygen) (Carbon dioxide) (Water) (ATP)

The breaking down of glucose in the body passes through several pathways before it can produce energy. These pathways are *Glycolysis*, *Acetyl-CoA Formation* and *Citric acid Cycle (Krebs cycle)*.

Glycolysis is a series of chemical reaction which involves the breaking down of glucose to a 3- carbon molecule called pyruvic acid. During glycolysis, no oxygen is required and it takes place in the cytoplasm of the cells. Very little energy is produced or generated during glycolysis, a net formation of 8 ATPs is produced from the complete oxidation of one glucose molecule during glycolysis.

Glycolysis

$C_6H_{12}O_6 \longrightarrow 2C_3H_4O_3 + 2H_2 + 2ATP$

Glucose NAD Pyruvic acid

Glycolysis can be divided into four phases.

1. *The input of ATP*: The first steps in glycolysis require the input of energy in form of two ATP molecules. A phosphate group is transferred from ATP to glucose molecule, a process called phosphorylation to form glucose-6-phosphate.

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The glucose-6-phosphate atoms are rearranged to form fructose-6-phosphate, which is then converted to fructose -1, 6-diphosphate by the addition of another phosphate group from another ATP.

2. *Sugar cleavage:* Fructose-1,6-diphosphate is cleaved into two three-carbon molecules, glyceraldehyde-3-phosphate, and dihydroxyacetone phosphate. Dihydroxyacetone phosphate is rearranged to form glyceraldehyde-3- phosphate; consequently, two molecules of the glyceraldehyde-3-phosphate result.

3. *NADH production:* Each glyceraldehyde-3-phosphate molecule is oxidized (loses two electrons) to form 1,3-diphosphoglyceric acid, and nicotinamide adenine dinucleotide (NAD^+) is reduced (gains two electrons) to NADH. Glyceraldehyde-3-phosphate also loses two hydrogen ions, one of which binds to NAD^+.

Note: NAD^+ is the oxidized form of nicotinamide adenine dinucleotide and NADH is the reduced form.

4. *ATP and Pyruvic acid production:* The last four steps of glycolysis produce two ATP molecules and one pyruvic acid molecule from each 1,3-diphosphoglyceric acid molecule.

Each glucose molecule that enters glycolysis forms two glyceraldehyde-3-phosphate molecules at the sugar cleavage phase. Each glyceraldehyde-3-phosphate produces two ATP molecules, one NADH molecule, and one pyruvic acid molecule. Each glucose molecule, therefore, produces four ATP, two NADH, and two pyruvic acids. Because the start of glycolysis requires the input of two ATP molecules, however, the final yield of each glucose molecule is two ATP, two NADH, and two pyruvic acid molecules.

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If the cell has adequate amounts of oxygen, the NADH and pyruvic acid molecules are used in aerobic respiration to produce ATP. In the absence of sufficient oxygen, they are used in anaerobic respiration.

Processes in Glycolysis involves the following steps:

STEP I: Glucose is phosphorylated (an addition of phosphate group to the glucose) to Glucose-6-phosphate in the presence of *hexokinase* enzyme, one ATP is utilized.

STEP II: Glucose-6-phosphate isomerizes to Fructose-6-phosphate under the influence of *phosphohexose isomerase*.

STEP III: Fructose-6-phosphate is phosphorylated to fructose-1,6-diphosphate in the presence of *phosphofructokinase*, one ATP is utilized.

STEP IV: Fructose-1,6-diphosphate is cleaved (broken down) into 2 trioses (glyceraldehyde-3-phosphate and dihydroxyacetone phosphate) catalyzed by an *aldolase*. Each triose phosphate molecule can isomerize into the other under the influence of *triosephosphate isomerase*.

STEP V: Glyceraldehyde-3-phosphate undergoes oxidative phosphorylation to produces 1,3-diphosphoglycerate in the presence of *coenzyme NAD (nicotinamide adeninedinucleotide) and Glyceraldehyde-3-phosphate dehydrogenase*.

STEP VI: There is a transfer of phosphate from 1,3-diphosphoglycerate to ADP (adenosine diphosphate) to produce 3- phosphoglycerate and one ATP, under the influence of phosphoglycerate *kinase*.

STEP VII: 3-Phosphoglycerate isomerizes to 2-phosphoglycerate under the influence of *phosphoglycerate mutase*.

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STEP VIII: There is dehydration of 2-phosphoglycerate to phosphoenolpyruvate in the presence of *enolase*.

STEP IX: There is a transfer of phosphate from phosphoenolpyruvate to ADP to produce pyruvate and one ATP, under the influence of *pyruvate kinase*.

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Note: Pyruvate is the main product of glycolysis and for each NADH (reduced *nicotinamide adenine dinucleotide*) produced is equivalent to (≡)3ATP,

In glycolysis, ATP produced is summarized as:

- Glyceraldehyde-3-phosphate to 1,3-diphosphoglycerate = 2NADH ≡ 6ATP
- 1,3-diphosphoglycerate to 3-phosphoglycerate produced = 2ATP
- Phosphoenolpyruvate to pyruvate produced = 2ATP

Total 10ATP

In the following reactions, ATP is utilized

- Glucose to glucose -6- phosphate = 1ATP
- Fructose-6-phosphate to fructose-1,6-diphosphate = 1ATP

2ATP

Net ATP gain = 10ATP – 2ATP = 8ATP

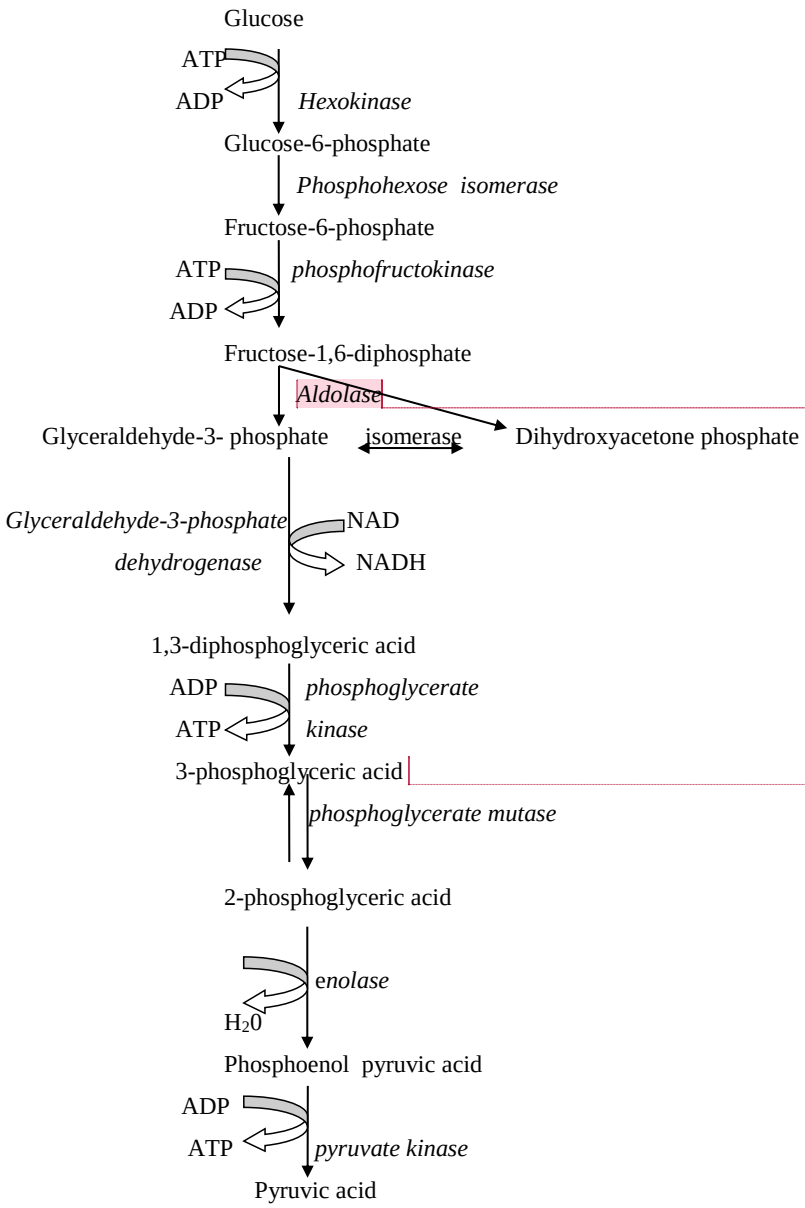

Figure 1. **Glycolysis pathway**

Source: Ndu et. al. (1999)

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Acetyl – CoA Formation**:** In the second phase of aerobic respiration pyruvic acid moves from the cytosol (cytoplasm) into a mitochondrion, this is separated into an inner and outer compartment by the inner mitochondrial membrane. Within the inner compartment, enzymes remove a carbon atom from the three carbon pyruvic acid molecule to form carbon dioxide and a two-carbon acetyl group. Energy is released in the reaction and is used to reduce NAD^+ to NADH. The acetyl group combines with coenzyme A (CoA) to form acetyl-CoA. For each two pyruvic acid molecules from glycolysis, two NADH and two carbon dioxide molecules are formed.

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Citric Acid Cycle (Krebs cycle). The Krebs cycle (name after the discoverer, the British biochemist, Sir Hans Krebs), is also known as Citric Acid Cycle or Tricarboxylic Acid Cycle (TCA. It involves a series of cyclic enzymatic reactions. Pyruvate is oxidatively decarboxylated (removal of CO_2) using NAD^+ (nicotinamide adenine dinucleotide) and CoenzymeA to give Acetyl CoA and NADH. Acetyl CoA is an important intermediate in the breaking down of sugar. It links glycolysis to Krebs cycle. It is also formed in the broken down of fats and proteins. The citric acid cycle begins with the production of citric acid from the combination of acetyl-CoA and a four-carbon molecule called oxaloacetic acid. A series of reactions occurs, resulting in the formation of another oxaloacetic acid,

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which can start the cycle again by combining with another acetyl-CoA. During the reactions of the citric acid cycle, three important events occur.

1. *ATP production:* For each citric acid molecule, one ATP is formed.

2. *NADH and $FADH_2$ production:* For each citric acid molecules three NAD^+ molecules are converted to NADH molecules, and one flavin adenine dinucleotide(FAD) molecule is converted to $FADH_2$. The NADH and $FADH_2$ molecules are electron carriers that enter the electron-transport chain and are used to produce ATP.

3. *Carbon dioxide production*: Each six-carbon citric acid molecule at the start of the cycle becomes a four-carbon oxaloacetic acid molecule at the end of the cycle. Two carbon atoms from the citric acid molecules are used to form two carbon dioxide molecules. Thus the carbon atoms that make up food molecules such as glucose are eventually eliminated from the body as carbon dioxide. We literally breathe out part of the food we eat!

For each glucose molecule that begins aerobic respiration, two pyruvic acid molecules are produced in glycolysis, and they are converted into two acetyl-CoA molecules that enter the citric acid cycle. To determine the number of molecules produced from glucose by citric acid cycle, two "turns" of the cycle must, therefore, be counted; the results are two ATP, six NADH, two $FADH_2$, and four carbon dioxide molecules.

Processes in Krebs cycle involve the following steps:

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Step i: Acetyl CoA (2C) reacts with oxaloacetate (4C) to form citrate (6C) catalyzed by *citrate synthase*.

Step ii: Citrate (6C) is isomerized into isocitrate (6C), the enzyme is *aconitase*.

Step iii: Isocitrate (6C) is oxidatively decarboxylated in the presence of NAD^+, Mn^{2+} to produce α-ketoglutarate (5C) and NADH.

Step iv: α-Ketoglutarate (5C) is oxidatively decarboxylated (oxidation reactions in which a carboxylate group is removed, forming carbon dioxide) in the presence of NAD^+, CoA-SH, and *α-ketoglutarate dehydrogenase* complex to produce succinyl CoA and NADH.

Step v: Succinyl CoA is converted to succinate (4C) by the enzyme *succinate thiokinase*, in which one ATP is produced.

Step vi: Succinate is dehydrogenated in the presence of *succinate dehydrogenase* (containing FAD^+ (Flavin adenine dinucleotide)) to fumarate (4C) and $FADH_2$ (Reduced flavin adenine dinucleotide).

Step vii: Fumarate is hydrolysed to malate in the presence of *fumarase*

step viii: Malate is hydrogenated to oxaloacetate by *malate dehydrogenase*, a reaction requiring NAD^+.

Note: For each $FADH_2$ produced is equivalent to (≡) 2ATP

In Krebs cycle ATP produced is summarized as follows:

- Pyruvate to Acetyl CoA = 2NADH ≡ 6ATP
- Isocitrate to α-Ketoglutarate = 2NADH ≡ 6ATP
- α-Ketoglutarate to succinyl CoA = 2NADH ≡ 6ATP
- Succinyl CoA to Succinate = 2ATP
- Succinate to Fumarate = $2FADH_2$ ≡ 4ATP
- Malate to Oxaloacetate = 2NADH ≡ 6ATP

TOTAL = 30ATP

Therefore, total ATP generated from glycolysis = 8ATP

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Total ATP generated from Krebs cycle = 30ATP

Sum 38ATP

Therefore, in aerobic respiration, when a molecule of glucose is fully oxidized in the cell, we will have carbon(iv)oxide, water, and energy in the form of ATP. Here is a chemical equation for aerobic respiration

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$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 38\ ATP$$

Glucose Oxygen Carbon(iv)oxide Water Energy

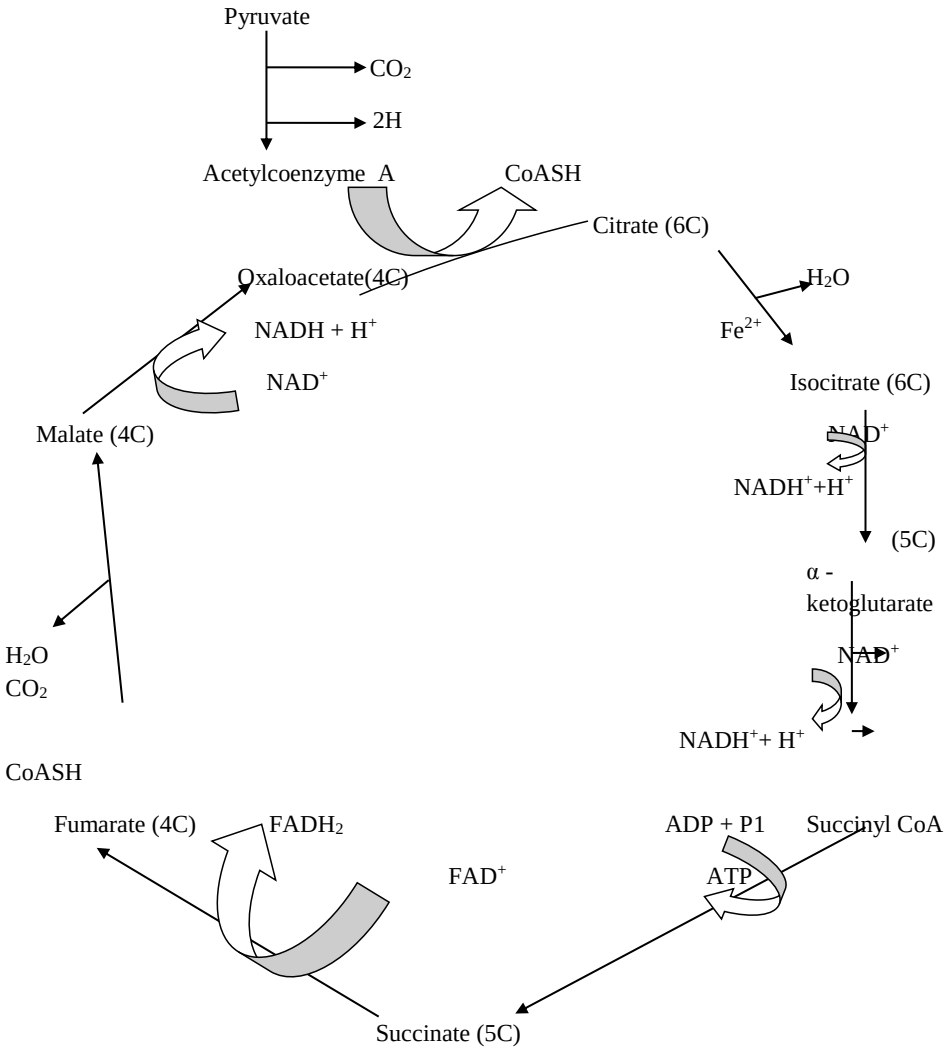

Figure 2. **Citric acid cycle (Krebs cycle)**

Source: Ndu et. al. (1999)

Importance of Adenosine Triphosphate (Chemical Energy)

Adenosine Triphosphate **(**ATP) is the standard unit in which all energy released during respiration is stored. Its importance includes the following:

1. Work: All living organisms (especially animals) need the energy to do work. Movements in animals such as swimming, walking, running, flying, respiration, heartbeat, blood pressure, talking require energy. This energy is supplied by ATP.
2. Electric organs: The electric organs of fish such as those of electric eel and *Malapterurus electricus* (electric fish) convert ATP into electric energy which forms electric current used for capturing prey and also acts as a weapon of defense. An electric eel can generate up to 400 volts, high enough to kill another fish.
3. The transmission of nerve impulses requires ATP.
4. Production of heat: Warm-blooded animals need heat produced internally to keep their bodies warm. These animals (mammals and birds) have constant body temperatures. The heat needed by the above animals is produced by ATP.
5. Active transport: The active transport of *ions* from a region of lower concentration to high concentration requires the energy of ATP. The working of contractile vacuoles in animals such as *Amoeba* and *Paramecium* is through the energy provided by ATP.

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6. Production of light: Some animals such as fireflies produce light. The energy needed for the production of light of fireflies comes from ATP. Animals producing light have two substances in them *luciferin* and *luciferase* (enzyme). When oxygen and ATP are added to the two substances, light is produced.
7. Synthesis of proteins, starch, cellulose, fats, and oils: The synthesis of the above products requires energy provided by ATP.
8. Cell division: ATP provides the energy required by the cell to divide.

Anaerobic respiration is a type of respiration in which glucose is broken down inside the cells in the absence of oxygen. Alcohol, carbon (iv) oxide, and 2ATP are the products for the plants, while lactic acid and 2 ATP are produced in animals. Some micro-organisms such as yeasts, bacteria, fungi, and endoparasites, such as tapeworms and roundworms respire anaerobically. Also, terrestrial trees growing in waterlogged soil respire anaerobically and are able to stay alive while the water lasts. Anaerobic respiration of yeast is referred to as alcoholic fermentation. In this respiration, the glucose is first converted to pyruvic acid. The pyruvic acid is then reduced to ethanol by accepting the hydrogen of NADH

1st Step:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{NAD}]{\text{Glycolysis}} \underset{\text{Pyruvic acid}}{2CH_3COCOOH} + 2H_2 + 2ATP$$

2nd Step:

$$\underset{\text{Pyruvic acid}}{CH_3COCOOH} \xrightarrow{NADH} \underset{\text{ethanol}}{C_2H_5OH} + CO2 + 2ATP + NAD^+$$

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Another type of anaerobic respiration is Lactic Acid Fermentation. In this type of respiration, the glucose is broken down to pyruvic acid. The pyruvic acid is then reduced to lactic acid by NADH without the production of carbon (IV) oxide. Lactic acid fermentation often occurs in the muscles of animals after a very fast race or strenuous exercise. For example, in the skeletal muscles of athletes, when the rate of use of oxygen, during a race, exceeds the rate of oxygen supply. The vigorous exercise creates an anaerobic condition in which lactate accumulates. The athlete may experience muscle pain, the body is said to have an *oxygen debt.* At the end of the exercise, the individual continues to breathe rapidly for some time, supplying much oxygen to the muscles until the lactic acid is oxidized to carbon dioxide and water. The lactic acid formation is represented by the equation:

1. $C_6H_{12}O_6 \xrightarrow[NAD]{Glycolysis} 2CH_3COCOOH + 2H_2 + 2ATP$
   Glucose → Pyruvic acid

2. $2CH_3COCOOH \xrightarrow{NADH} CH_3CHOHCOOH + 2NAD + 2ATP$
   Pyruvic acid → Lactic acid

Note: *General information about individuals who produce less energy for work.*

Oxygen and glucose are the major determinants of energy available within the cell, some people do produce less energy as a result of either insufficient oxygen or glucose. For example, a diabetic patient produces less energy as a result of under secretion of insulin hormones, which is needed for the metabolism of carbohydrate, oxidation of glucose in the muscle and regulation of blood glucose.

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Therefore, the deficiency or lack of insulin in diabetic patients leads to decrease in metabolism of glucose, thereby leading to less production of energy.

Other examples include asthmatic patients in crisis, mountain climbers at a very high altitude, people in a crowded environment or less ventilated place, people exposed to high level of smoke or exhaust, have access to low volume of oxygen which in turn yields less energy in the body system. Pregnant women do also produce less energy to do work since the amount of glucose produced is shared between mother and foetus.

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Uses of Anaerobic Respiration in Industries include:

1. Cassava, guinea corn, and locust beans are fermented by anaerobic bacteria.
2. Yeasts, which bakers use, respire anaerobically during the baking of bread. The carbon (IV) oxide produced makes the dough to rise.
3. During the production of wine, beer, and alcohol, yeasts are used to ferment sugar to alcohol.
4. Bacteria used in retting (partial decomposition of the stem to permit separation of the fiber from the woody portions) of jute respire anaerobically. The bacteria decompose the protein that holds the fiber together thus freeing the fibers which are processed into linen.

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Studies on the influence of Gender on Senior Secondary School Biology Students Achievement

According to the study carried out by Spotts, Bowman, and Mertz (1997) in the USA on gender and use of instructional technologies males rated their knowledge and experience with some innovative technologies higher than females. For frequency of use, no significant differences were found with the exception of video, where females indicated use was slightly more frequent. Both rated technologies are important to instruction. The other factors influencing technology use include time to learn a technology, increased student learning, ease of use, training and available information in a discipline.

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Huynh, Lee, and Schuldt (2005) discussed that a few decades ago, the computer was observed to be male-dominated and its usage belonged to techies which are comprised mostly of men. In their studies, it was found that there was no statistical significance in validating gender differences in the pattern of online interaction between male and female students. The research conducted by Mitra, Lenzmeier, Avon, Qu, and Hazen (2000) on gender and computer use in an academic institution explored the nature of the relationships between genders, categories of computer use and attitudes toward computers in a computer enriched environment where all students were provided with network access and laptop computers over a four-year period. The results indicated that women were fewer concerns about computers than men and the use level of computers by women was

less frequent than for men. This change in the relationship is a throwback to the earlier days of computing when research had indicated that men were more positively disposed toward computers than women were.

Achuonye and Olele (2009), in their study on the Internet using patterns of Nigerian teacher-trainees, found that more female students were personally connected to the internet than their male counterparts were; but that male students surf the internet more than females. This indicated a male dominance in skills, which is more important than mere possession of the computer. This study revealed a worry that gender barriers which have earlier been identified to hinder females in science and technology (Achuonye, 2006; Onwuegbuna & Onwuegbuna, 2006) may be persisting to this present era of information super-highway.

Shashaani (1997) working on CAI with a sample of 202 college students in the USA, found that females were less interested in computers and less confident than males; males were more experienced. Further analysis of the students' responses showed that one semester of computer training improved students' attitudes towards computers. While Bello (1990) did not find any form of influence being exerted by gender on student's performance. Yusuf and Afolabi (2010) concluded that gender has no influence on the academic performance of male and female students exposed to CAI either individually or co-operatively. This study,

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therefore, will investigate not only the effect of gender on the use of the computer but also the effect of the use of CAI on students' academic achievement.

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Studies on the Influence of Score Levels on Senior Secondary School Biology Students Achievement

Many educators believe that each child has some fixed ability level that defines the best he or she can possibly do. Thus, we talk about children "not working up to ability" and, conversely, "overachieving" (that is, doing better than we predicted they would). Using these putative differences as a basis, we label children as "smart," "average," or "slow." For children whose differences appear more salient, we use the terms "gifted" or "handicapped." We often adjust our curricula and expectations accordingly. In actuality, all people, including all children, vary along a number of dimensions, and it is generally not helpful to talk about ability as if it was a fixed, immutable potential for achievement.

How well any child does is a function of many variables, including the nature of the curriculum, the flexibility and support of those who surround the child, the child's self-concept, and the child's interest in the task. Therefore, if conditions were right, we could all do better. As Hunt (1961) noted: ‘It is highly unlikely that any society has developed a system of child rearing and education that maximizes the potential of the individuals which compose It’. Probably no

individual has ever lived whose full potential for happy intellectual interest and growth has been achieved.

Therefore, in some ways, we are all underachievers, and it makes sense for teachers to find ways to help all children achieve more and to create classrooms that nurture and support diversity. The work by Armstrong (1993) and Gardner (1983) on multiple intelligences help us recognize the many ways to "be smart," and understand that a single continuum of "ability" makes little pedagogical sense. Some teachers still believe that by narrowing the range of abilities in the classroom, children will learn better because tasks will be more appropriate. Actually, despite the fact that many teachers continue to group students by ability, research findings suggest that homogeneous grouping does not consistently help anyone learn more or better (Massachusetts Advocacy Center, 1990; Thousand, Villa & Nevin, 2002). In fact, organizing children into high, average-, and low-ability groups actually create differences in what children learn by exposing them to different kinds of material. Although, some children in high-ability groups may benefit from such arrangements, those who lose the most are the children placed in average- and low-ability groups. Such grouping practices tend to compound racial, ethnic, and economic differences in schools, as poor children and children of colour are least likely to be served in enriched, gifted, or high-ability tracks. These children are more likely to end up in vocational or low-ability groups (Oakes & Lipton, 1999).

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Ability grouping also takes a serious toll on children's self-concepts and on their opportunities to form meaningful relationships across groups. Children in the "slow group," the "low reading group," or what gets labelled as the "dumb class" are often painfully aware of the limited expectations adults have for them. Children so identified often face teasing and ridicule from their peers. Similarly, children who are put in top groups or moved to gifted classes are often labelled as "brains" or "nerds" and may find themselves socially isolated. Grouping children create distance among them and tend to amplify and solidify whatever actual differences originally existed (Sapon-Shevin, 1994; 1999).

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Students' ability or performance levels could be categorized into high, medium and low. The high scorers belong to the range of 75-100%, the medium scorers belong to the range of 50-74% and the low scorers belong to the range of 0-49%.

Studies on the Influence of School Types and Facilities on Senior Secondary School Biology Students Achievement

Musibau and Johnson (2010) observed that students' academic performance is becoming worse in public secondary schools. Many parents prefer to enroll their children in Government Colleges where better academic performance is guaranteed for their children. It also appears that some parents believe that their children cannot perform very well academically in co-educational school (mixed schools). To this end, many of them would prefer to register their children in single sexed

schools for Senior School Certificate Examination to enhance better academic performance.

As school population continues to increase, the effect of school type and sex on academic performance is generating much research interest. Keeves (1978) for instance, demonstrated that school type (Government, Catholic or other independent schools) did not make a contribution to the academic achievement of a sample of Australian adolescents independently of the influence of their home backgrounds. William et al. (1980) in another study of Australian Seventeen years revealed that other things being equal, students attending Catholic or other independent school had higher levels of achievement than students from Government Schools.

However, Keeves (1978) posited that type of school did not make a contribution to academic performance while Ajayi (1999) in his own study revealed that school type makes a difference in students' academic performance. According to Carpenter and Hayden (1985), the question of whether the type of school attended affects the academic performance of young people is one of continuing debate, both overseas and developing countries.

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The consequence of mass failure in public examination is the inability of learners to proceed to the higher educational institution. As a result of this poor performance, stakeholders in education are curious to know the causal factors

associated with the problem. Causes of the poor academic performance could include ownership of the school and inadequate facilities. Facilities are of everything used directly or indirectly for the benefit of education (Alimi, 2012).

Facilities could also be explained as the entire school part such as blocks of classrooms, staff-rooms, laboratories, workshops, libraries, computer laboratory, laboratory equipment, consumables, audio-visual aids, electricity, water, chairs, tables, stationeries, playground, storage spaces and others which a school has. It has always teacher-directed that facilities are very important in the development and improvement of education in Nigeria. A school without facilities, either private or public, may not be able to achieve the stated goals and objectives of the system. When facilities are available and skillfully utilized, they influence learning and make it more meaningful. Facilities in education are very important because they aid teaching and learning (Alimi, 2012).

Bandele (2003) noted that the importance of physical facilities cannot be underrated. Facilities like modern laboratories, libraries and classrooms are to be put in place in all our schools. Adesola (2005) found out that the level of available resources is indeed a plus to the teachers and goes to show the level of ingenuity and commitment of the teachers toward effective delivery of the lesson. There is the need for renovation of old buildings, chairs, desks, cabinets and acquisition of modern classrooms as earlier recommended by Alimi (2007).

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Akinfolarin (2008) identified facilities as a major factor contributing to academic performance in the school's system. These include classroom furniture, recreational equipment among others. Different studies conducted by Ayodele (2000) and Vandiver (2011) showed that a positive relationship exists between availability of facilities and students' academic performances.

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Research findings on the influences of facilities in private and public secondary schools on students' academic performance are controversial. Keeves (1978) found out that the type of school, classified as public or private did not make any difference on students' academic achievement. However, Ajayi (2006) found out that school type makes a difference in student academic performance. In addition, Philias & Wanjobi (2011) reiterated that the type of schools, (single-sex or mixed, private or public) has an effect on the academic performance of students in Mathematics.

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Besides, there have been contradictory findings on whether there is a significant difference in the academic performance of private and public schools. However, research by Olutola (1989) cited in Alimi *et al* (2012) who used a checklist of facilities in Kwara State and government policy on private schools to determine the relationship between educational facilities and school academic performance. The study showed that private schools with a high standard of prescribed educational facilities did perform better in SSCE examinations than public schools. Nwokocha and Amadike (2005), Ekundayo and Arogundade

(2007) as cited in Ekundayo and Alonge (2012) submitted that private schools students performed better than their public school's counterparts in public examinations. Therefore, this study justified the relationship that exists between types of school, facilities (CAI) and academic achievement.

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Appraisal of the Reviewed Literature

Kathleen (1991) summarises different works on the general importance of CAI as following: As well as enabling students to achieve at higher levels, researchers have also found that CAI enhances learning rate. Student learning rate is faster with CAI than with the conventional method of instruction. In some research studies, the students learned the same amount of material in less time than the traditionally instructed students; in others, they learned more material at the same time. While most researchers don't specify how much faster CAI students learn, the work of Capper and Copple (1985) led them to the conclusion that CAI users sometimes learn as much as 40 percent faster than those receiving conventional method of instruction.

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If students receiving CAI learn better and faster than students receiving conventional method of instruction alone, do they also retain their learning better? The answer, according to researchers who have conducted comparative studies of learning retention, is yes. In this research, student scores on delayed tests indicate

that the retention of content learned using CAI is superior to retention following conventional method of instruction alone (Kathleen, 1991).

The effects of CAI on other student outcomes have not been as extensively researched as CAI's effects on achievement, learning rate, retention, and attitudes. Some researchers have, however, investigated CAI's influence on other variables and found it to confer benefits on:

1. Locus of control. Capper and Copple (1985), Kinnaman (1990), and Louie (1985) found that CAI students have more of an internal locus of control/sense of self-efficacy than conventionally instructed students.

2. Attendance. CAI students had better attendance in Capper and Copple's 1985 study, Rupe's 1986 review, and the 1990 ISTE study.

3. Motivation/time-on-task. Bialo and Sivin (1990) and Capper and Copple (1985) found that CAI students had higher rates of time-on-task than traditionally instructed controls.

4. Cooperation/collaboration. Cooperative, prosocial behavior was greater with CAI in the work of Dickinson (1986); Mevarech, Stern, and Levita (1987); and Rupe (1986).

Is CAI more effective with some student populations than others? Many researchers have conducted comparative analyses to answer this question and have produced findings in several areas:

Younger Versus Older Students: Most comparative studies have shown that CAI is more beneficial for younger students than for older ones. While research shows CAI to be beneficial to students in general, the degree of impact decreases from the elementary to secondary to postsecondary levels (Becker, 1990; Ehman & Glen, 1987; Hasselbring, 1984; Kulik, Kulik, & Bangert-Drowns, 1985; Stennet, 1985).

Lower-Achieving Versus Higher-Achieving Students**:** These comparisons show that CAI is more effective with lower-achieving students than with higher-achieving ones. Again, both lower and higher-achieving students benefit from CAI. However, the comparatively greater benefits experienced by lower-achieving students, like those experienced by younger students, are largely due to the need these groups have for elements common to the majority of CAI programs--extensive drill and practice, privacy, and immediate feedback and reinforcement (Bangert-Drowns 1985; Bangert-Drowns, *et al*. 1985; Edwards, *et al*. 1975; Kinnaman 1990; Kulik, Kulik, & Bangert-Drowns 1985; Martin 1973; Okey 1985; Roblyer 1988).

Economically Disadvantaged Versus Higher- social economic status (SES) Students: Researchers note that CAI confers greater benefits on economically disadvantaged students than those from more privileged backgrounds. Lower SES students, too, benefit greatly from opportunities to interact privately with CAI drill-and-practice and tutorial programs (Bangert-Drowns, *et al*. 1985; Becker, 1990; Mevarech & Rich, 1985; Ragosta, Holland, & Jamison, 1982; Stennett, 1985).

Lower- Versus Higher-Cognitive Outcomes: Closely related to the above is the finding that CAI is more effective for teaching lower-cognitive material than higher-cognitive material. This research makes essentially the same point--that CAI is particularly effective for reinforcing the basic, fact-oriented learning most often engaged in by younger, lower achieving, and/or lower SES students (Ehman & Glen 1987; Hasselbring 1984).

Handicapped Learners: Research conducted with learning disabled, mentally retarded, hearing impaired, emotionally disturbed, and language disordered students indicates that their achievement levels are greater with CAI than with the conventional method of instruction alone. In some of this research, handicapped CAI students even outperformed traditionally taught, non-handicapped students (Bahr and Rieth 1989; Bialo and Sivin 1990; Hall, McLoughlin, & Bialozor 1989; Horton, Lovitt, and Slocum 1988).

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Males versus Females: This comparison was not addressed by enough researchers to draw firm conclusions. The 1988 meta-analysis of 82 studies of CBE conducted by Roblyer, *et al*. concluded that effect differences slightly favor boys over girls, with differences falling short of statistical significance. A few researchers undertook to compare the effectiveness of CAI in different curricular areas. Their findings, though not conclusive, indicate that CAI activities are most effective in the areas of science (Biology) and foreign languages, followed, in descending order of effectiveness, by activities in mathematics, reading, language arts, and English as a Second Language (ESL), with CAI activities in ESL found to be largely ineffective (Kathleen, 1991).

The results of the various research work reviewed submitted that students exposed to computer-assisted instruction might perform better than those who were taught with other teaching strategies. To establish these findings on the importance of computer-assisted instruction in biology education, the present study investigated the effects of a computer-assisted instructional package on senior school students' academic achievement in cellular respiration in Ibadan, Nigeria.

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CHAPTER THREE

RESEARCH METHODOLOGY

This chapter discussed the methodology that was used in this study, under the following sub-headings; research design, sample and sampling method, research instruments, validation of instruments, procedure for data collection, and data analyses technique.

Research Design

This study adopted a pretest- posttest, control group, quasi – experimental design.

The experimental design was represented as follows:

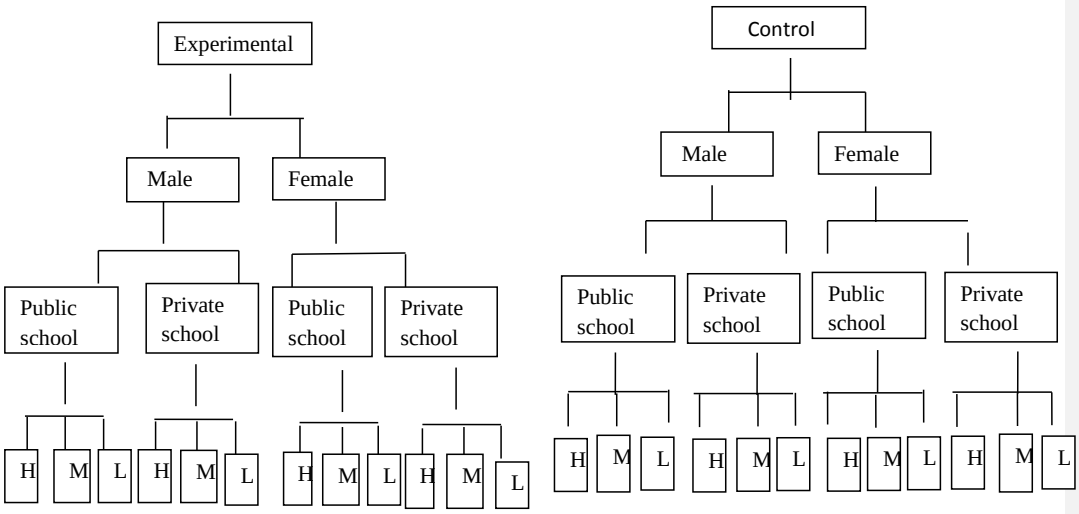
Experimental O_1 X O_2

Control O_3 O_4

Where O_1 and O_3 are the pretest observations for experimental and control groups, respectively, O_2 and O_4 are the posttest observations of experimental and control group, respectively. X is the treatment involving instruction using: Computer-Assisted Instruction (Experimental group)

This study adopted a 2x2x2x3 factorial design for analysis. Where the 2x2x2x3 represents 2 Research Groups (Experimental and Control) x 2 School

Type (Public and Private) x 2 Gender level (Male and Female) x 3 Performance Levels (High, Medium and Low).



Keys: H- High, M-Medium and L-Low

Figure *3*. Factorial Representation of score levels

Variables of the study were:

1. Independent Variable: This is the instructional strategy at two levels, which are
   (i) Computer-Assisted Instruction (CAI) (Experimental)
   (ii) Conventional Method of Instruction (CMI) (Control)
2. Moderator Variables:
   (i) School Types: Public and Private
   (ii) Gender: Male and Female

(iii) Students' Performance Levels: These are the students' terminal scores obtained from their previous biology examinations. They were categorized into high, medium and low. The high scorers belong to the range of 75-100%, the medium scorers belong to the range of 50-74% and the low scorers belong to the range of 0-49% (Adapted from Oyo State Joint Schools Promotion Examinations Grading, 2015).

3. Dependent Variable:

Students' Achievement in Cellular Respiration (The scores that students obtained from the Achievement Test on Cellular Respiration (ATCR)**)**.

Population, Sample and Sampling Technique

The population for the study was all biology Senior Secondary School I students in Ibadan, Oyo State, Nigeria. Four Senior Secondary Schools that satisfied the following criteria: functioning computer laboratories; computer literate students; easy access to students without choking timetable issues; co-educational school; prompt approval of the consent form and good SSCE (WAEC and NECO) tracking results of five years, were purposively selected for the study. This is because a research on CAI must necessarily be conducted in schools where computers are available for the students' use. Two schools were selected as the experimental group and the control group respectively. The sample for the experimental and control groups was made up of an intact class of SS one (Science class that offered biology) each from the selected private and public

schools with the total population of one hundred and ten (110) students which was made up of 49 males and 61 females.

Research Instruments

The instruments for this research were:

1. Computer-Assisted Instructional Package (CAIP)
2. Achievement Test on Cellular Respiration (ATCR)

Computer-Assisted Instructional Package (CAIP): The treatment instrument, Computer-Assisted Instructional Package (CAIP) on cellular respiration is a self tutor instructional interactive package developed with Microsoft visual basic.net, which contains images, video, and animations that added better description to the texts, while quiz maker software was used to develop the formative and summative evaluations. CAIP contain lessons on cellular respiration as it was described in the new biology curriculum, sub-topics to be covered in the package include; definition of respiration, types of cellular respiration, fermentation, uses of anaerobic respiration in industries, comparison between aerobic and anaerobic respiration i.e. similarities and differences, glycolysis, Krebs cycle, functions of ATP. CAIP was used to teach experimental group and the control group was taught traditionally.

Achievement Test on Cellular Respiration (ATCR): The test instrument was the researcher designed test instrument containing multiple-choice objective

test with four options. The test items were selected from the past questions of different examinations bodies such as: West African Examinations Council (WAEC), National Examinations Council (NECO) and Joint Admissions and Matriculation Board (JAMB) and researcher's self developed questions on cellular respiration. The test contents were based on a table of specification covering the six levels of cognitive domain of learning.

Validation of Research Instruments

Computer-Assisted Instructional Package (CAIP): The researcher developed a manuscript that contain a detailed lesson note on cellular respiration and procedural step by step level of teaching with questions and answers. The manuscript was given to the Researcher's Supervisor, lecturers from Science Education Department, lecturers from Educational Technology Department and experienced biology teachers for face and content validation. Modification and corrections were made on the manuscript as suggested before given to the programmer. At different interval, the researcher's supervisor and other lecturers in Science Education Department helped to monitor the progress of the package being designed to have a better output in terms of appearance, operation and logic of hyperlink, spelling, grammar, readability and clarity from the view point of persons unfamiliar with the content. In addition, end users' usability evaluation was done through a pilot study with some set of students outside the target

population for the study. The results obtained in the usability experience was used for the improvement of the package

Achievement Test on Cellular Respiration (ATCR): The tests instrument selected and modified from WAEC, NECO and JAMB past questions, undergone face and content validation by Researchers' Supervisor, biology teachers and students through items analysis. For the item analysis of the ATCR, one hundred (100) biology students of schools outside the target population in Ibadan were randomly selected. Ninety five (95) students attempted the questions while five (5) students did not attempt the questions with a reason that they were not around when the topic was taught. The question items consisted of fifty-five (55) questions with four options A, B, C and D. The results of students on ATCR were then utilized to determine the item difficulty and item discrimination of each item. Item difficulty, commonly known as *p*-value refers to the proportion of test takers that responded to the item correctly. The *p*-value ranged from 0.0 to 1.00 (0%-100%). A high *p*-value indicates an easy item. Above 0.90 very easy item, 0.20 - 0.90 moderate item and below 0.20 very difficult items (Shafizan, 2013; Abimbola, 2015).

Shafizan (2013) categorized discrimination index into the following range 0.40 and above very good items; 0.30 – 0.39 reasonably good but subject to improvement 0.20 – 0.29 marginal items usually needed and can be subjected to improvement and below 0.19 poor items to be rejected or improved by revision or

reconstruction (Ovwigho 2013). The difficulty index (*p*-value) and discrimination index (d-value) for each item were determined using the following formula:

For the item-difficulty index, $\frac{p}{N} = N_p$

Where: N_p represents the number of test takers in the total group who pass the items and

N represents the total number of test takers in the group.

For the item discrimination index, $\frac{d = U_p - L_p}{U}$

Where U_p = upper 27% of the students who passed the quiz items
L_p = lower 27% of the students who passed the quiz items
U = number of students upper or lower group
Source: Ebel (1972), Ovwigho (2014)

Wiersma and Jurs (1990) as cited in Susan (1997) stated that "27% is used because it has shown that this value will maximize differences in normal distributions while providing enough cases for analysis" (p. 145). As many students as possible are needed in each group to promote stability, at the same time, it is desirable to have the two groups to be as different as possible to make the discriminations clearer. Two items (-0.04 and -0.08) and other three items with very low discrimination index (0.04, 0.04 and 0.07) were deleted, while others were reconstructed to have a total of fifty (50) quiz items.

The reliability of the instrument, Achievement Test on Cellular Respiration (ATCR) was determined by Cronbach's alpha method on a random sampling of fifty students in a school outside those selected for both experimental and control

groups. There was an intervening period of three weeks between the test and retest exercise during school session. A reliability coefficient of 0.84 was obtained, which showed that the instrument is reliable.

Procedure for Data Collection

The researcher personally visited the schools with the letter of introduction, sought for the permission, assistance and approval of the school authorities for the study to be carried out in their school. Also, consent of the parents and students that participated in the study was sought to meet the ethical requirement in research (copy of the consent for is in appendix 4). The co-operation of the biology teachers and computer laboratory manager (experimental school) was sought for, and they served as research assistants. The biology teachers and computer laboratory manager undergone one day training on the Computer-Assisted Instructional Package (CAIP); how it works and the installation process. The existing examinations record of the students was requested for and categorized into different performance levels.

Both the experimental and control groups with a total population of 110 students made up of 49 males and 61 females were subjected to Achievement Test on Cellular Respiration (ATCR) as pre-test. Then, the students in the experimental group were individually exposed to CAI, which was installed on the desktop and laptop computers by the researcher and research assistants. The students in the

experimental group were introduced to the CAI format to make them familiar with the navigation buttons and use the package independently, while their biology teacher and computer laboratory manager were on ground to guide and assist students with difficulties. The control group students were exposed to the conventional method of instruction on the same content used for the experimental group. They were taught in traditional classrooms format. The treatment for both groups lasted for four weeks (first week for the research assistants and students training, installation of the package and pretest, second week for collation of the student's previous terminal score in biology, third week for treatment and the fourth week for the posttest). After the treatments, the two groups were exposed to Achievement Test on Cellular Respiration (ATCR) as posttest, out of the 110 students who took the pretest, only 107 students (48 males and 59 females) took the posttest Achievement Test.

Data Analysis Techniques

Mean score, standard deviation, *t*-test and Analysis of Covariance were used to analyse the data collected. Since intact classes were used, Analysis of Covariance (ANCOVA) was employed to take care of the initial inequalities and to ensure that any difference in achievement of students was as a result of the instructional strategy used, the pretest scores as covariates.

Scheffe's Post Hoc analysis was used to locate where significant difference exists between the two treatment mean scores. *t*-test was used to test hypotheses 1 and 2, while Analysis of Covariance was used to test for hypotheses 3-14.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

This chapter deals with collation, analysis and interpretation of the data obtained from this study. The research questions were answered using descriptive statistics while hypotheses were tested using inferential statistics.

The demographic characteristics of the students, their achievement based on the independent variables (instructional strategy in form of computer-assisted instruction and conventional method of instruction), moderator variables (school types, gender and performance levels) and the dependent variable as well as demographic characteristics of the students were presented in this chapter.

t-test statistics was used to test hypothesis 1,2 and 3 while Analysis of Co-variance (ANCOVA) statistics was used to test hypotheses 3-14.

Figure *5* shows the demographic characteristics of the students that participated in the study. The chart showed that 20 (46.51%) males and 23 (53.49%) females students participated in the experimental group {Computer-Assisted Instruction (CAI)} while 28 (43.75%) male and 36 (56.25%) females students participated in the control group {Conventional Method of Instruction (TI)}, respectively.

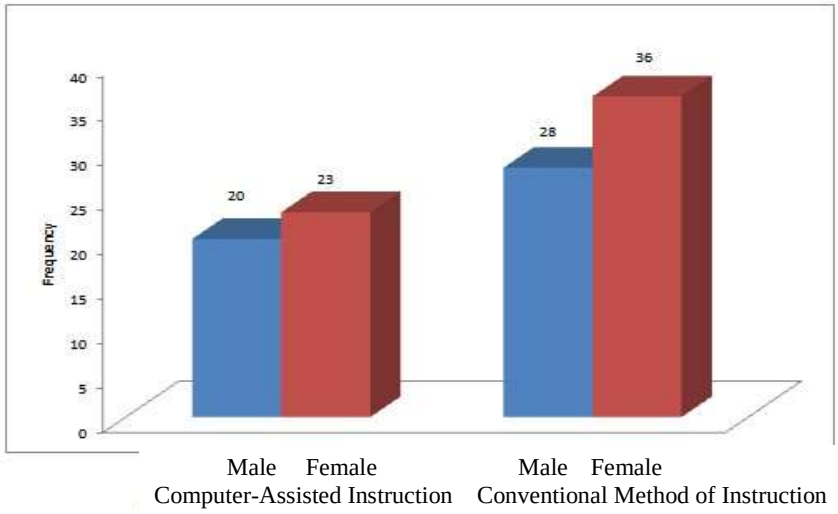


Figure 5. Distribution of students by their gender

The demographic characteristics of Senior Secondary School students by their school type was illustrated in Figure 6 which shows that 36 (56.25%) public school students and 28 (43.75%) participated in the control group (CMI) while the experimental group (CAI) consisted of 16 (37.21%) public school students and 27 (62.79%) private school students, respectively.

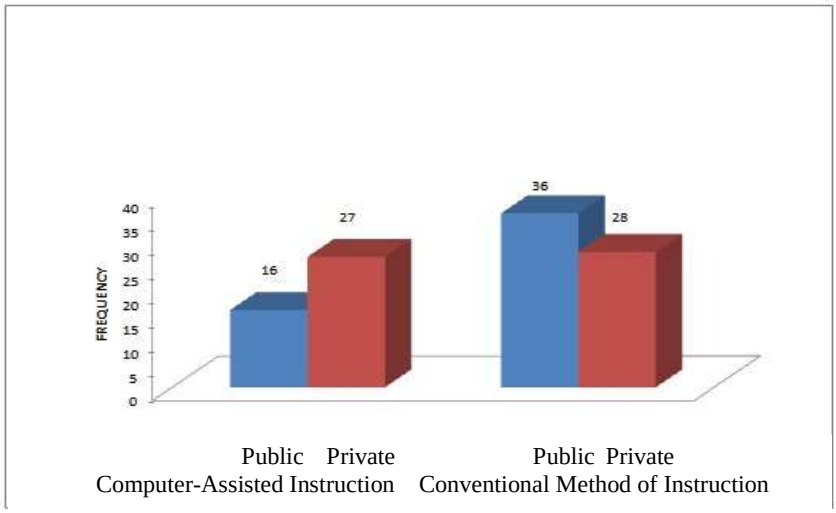


Figure 6. Distribution of students by school types.

The demographic characteristics of students by their performance levels as illustrated in Figure 7 shows that the experimental group (CAI) consisted of 17 (39.53%) low performing students, 23 (53.49%) medium performing students and 3 (6.98%) high performing students while 18 (28.13%) low performing students, 41(64.07%), medium performing students and 5 (7.81%) high performing students participated in the control group (CMI), respectively.

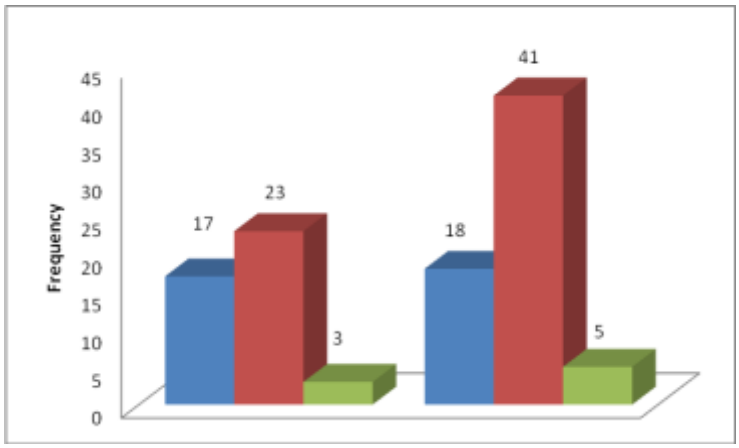


Figure 7. Distribution of students by performance levels.

Research Question 1: Is there any difference in the achievement of Senior Secondary School students taught cellular respiration when exposed differently to Computer- Assisted Instruction (CAI) and Conventional Method of Instruction (CMI)?

Table 2 reveals that there was a difference in the achievement of students exposed differently to CAI and those taught using CMI. This is evident from a higher mean score of 68.70 ±13.03 for those exposed to CAI as against a mean score of 43.78 ± 9.27 for those taught using CMI. The mean gain score of 40.93 for the experimental group (CAI) was higher than that of the control group (CMI) with a mean gain score of 20.47, the higher mean gain score was in favour of students exposed to the computer-assisted instruction (experimental group). This implies

that students in the experimental group (CAI) achieved more differently from those students in the control group (CMI).

Table 2

Achievement of Students Exposed to Computer-Assisted Instruction and Conventional Method of Instruction

Treatment	N	Pretest Mean± SD	Posttest Mean ± SD	Mean Gain Score
Computer-Assisted Instruction (CAI)	43	27.77 ± 11.37	68.70 ± 13.03	40.93
Conventional Method of Instruction (CMI)	64	23.31 ± 8.95	43.78 ± 9.27	20.47

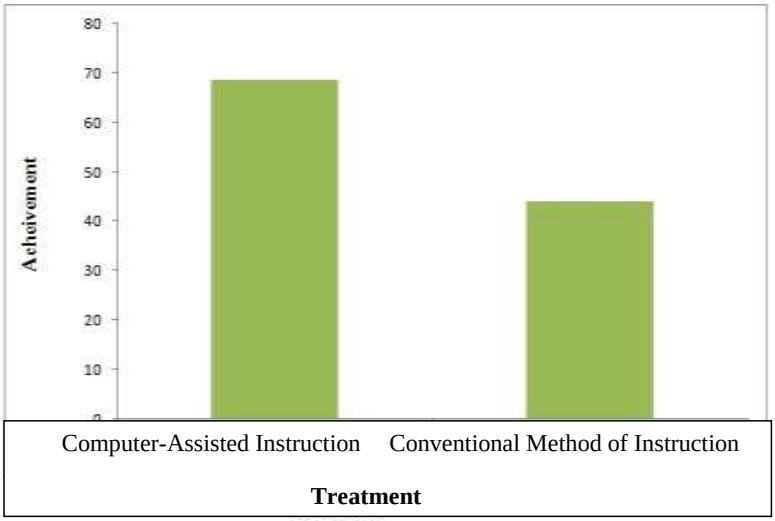


Figure 8. Bar chart showing the achievement means score of Senior Secondary School students taught cellular respiration using CAI and CMI.

Figure 8 also reveals a higher achievement mean score in the posttest of students exposed to CAI than those exposed to CMI.

Hypothesis 1: There is no significant difference between the achievement of Senior Secondary School students taught cellular respiration when exposed to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI).

The ANCOVA analysis of the data for the treatment, experimental (CAI) and control (CMI) in Table 3a reveals that there were significant difference in the achievement of Senior Secondary School Students' exposed to CAI and those exposed to CMI because the significant probability (0.000) obtained at $F(1, 104) = 133.22$ at $p<0.05$, the null hypothesis which states that there is no significant difference between the achievement of senior secondary school students taught cellular respiration when exposed to computer assisted Instruction and those exposed to traditional Instruction is rejected

Table 3a

ANCOVA showing difference in the Achievement of Senior Secondary School Biology Students when exposed to Computer-Assisted Instruction and Conventional Method of Instruction

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected model	18709.43[a]	2	9354.71	99.17	.000
Intercept	25868.30	1	25868.30	274.24	.000
Pretest	2741.96	1	2741.96	29.07	.000
Treatment	12566.04	1	12566.04	133.22	.000**
Error	9810.05	104	94.328		
Total	338160.00	107			
Corrected Total	28519.48	106			

**denotes F is significant at p value < 0.05

Table 3b revealed that there were significant differences in the achievement of Senior Secondary School students' achievement taught cellular respiration using CAI and those exposed to CMI because the *t*-test value is 10.83 when $p<0.05$, since the p-value is less than 0.05, the null hypothesis which states that there is no significant difference between the achievement of Senior Secondary School students taught cellular respiration when exposed to computer-assisted Instruction and those exposed to conventional method of instruction is rejected.

Table 3b

The t-test Analysis of the Difference in the Achievement of Senior Secondary School Students taught Cellular Respiration when Exposed to Computer-Assisted Instruction and Conventional method of instruction

Group	N	$\bar{x}$ ± SD	Df	*t*	Sig
CAI	43	68.70 ± 13.03	70	10.83	0.00
CONTROL	64	43.78 ± 9.27			

Research Question 2: Is there any difference in the achievement of Senior Secondary School students taught cellular respiration when exposed differently to CAI and CMI based on gender?

Male and female students exposed to CAI has a posttest mean scores of (65.50 and 71.48), respectively while the male and female students exposed to CMI has a posttest mean scores of (44.07 and 43.56), respectively as shown in Table 4. The means scores of the male and female students exposed to CAI (male =65.50 ± 13.81, female = 71.47 ± 11.93), were higher than the mean scores of male and female students exposed to CMI (male = 44.07 ± 10.69, female = 43.56 ± 8.16), respectively. Also the mean gain score of 45.50 and 41.31 for male and female students exposed to CAI respectively, this value was higher than the mean gain score of 22.36 and 19.00 for the male and female exposed to CMI.

Therefore, it could be inferred that male and female students exposed to CAI achieved differently higher than those exposed to CMI, though female students exposed to CAI had higher mean gain score than male counterpart. Also male students exposed to CAI achieved higher than male students exposed to CMI, female students exposed to CAI achieved higher than female students exposed to CMI.

Table 4

Male and Female Senior Secondary School Students Achievement in Cellular Respiration when Exposed to Computer-Assisted Instruction and Conventional Method of Instruction

Group	Gender	N	Pretest Mean ± SD	Posttest Mean ± SD	Mean Gain Score
CAI	Male	20	25.00 ± 12.38	65.50 ± 13.81	45.50
	Female	23	30.17 ± 10.11	71.48 ± 11.93	41.31
Control	Male	28	21.71 ± 9.21	44.07 ± 10.69	22.36
	Female	36	24.56 ± 8.61	43.56 ± 8.16	19.00

Hypothesis 2: There is no significant difference between the achievement of male and female Senior Secondary School students taught cellular respiration when exposed to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI).

Table 5 revealed that there was no significant difference in the achievement of male and female Senior Secondary School students taught cellular respiration

when exposed differently to CAI with $F_{(1, 40)} = 0.43$ $p>0.05$ and CMI with $F_{(1,61)} = 0.23$, when $p>0.05$, the hypothesis is therefore not rejected, which means that there was no significant difference in the achievement of male and female Senior Secondary School students taught cellular respiration when exposed to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI).

Furthermore, *t*-test statistical result in Table 6 shows that, there was significant difference in the achievement of the male students exposed to CAI and CMI, respectively with *t* value of 6.06, $p<0.05$, also there was significant difference in the achievement of the female students exposed to CAI and CMI, respectively with *t* value of 10.89, $p<0.05$

Table 5

ANCOVA Showing Difference in Achievement of Male and Female Senior Secondary School Students taught Cellular Respiration When Exposed to CAI and CMI

Treatments	Source	Type III sum of squares	df	Mean square	F- value	Sig.
CAI(EXPERIMENTAL)	Corrected model	3452.29[a]	2	1726.15	18.745	.000
	Intercept	12976.14	1	12976.14	140.94	.000
	Pretest	3069.96	1	3069.96	33.34	.000
	Gender	39.70	1	39.70	0.43	.52[NS]
	Error	3682.78	40	92.07		
	Total	210068.00	43			
	Corrected total	7135.07	42			
CMI(CONTROL)	Corrected model	240.41[a]	2	120.21	1.42	.25
	Intercept	12028.58	1	12028.58	141.74	.00
	Pretest	236.22	1	236.22	2.78	.01
	Gender	19.91	1	19.91	0.23	*.63[NS]
	Error	5176.53	61	84.86		
	Total	128092.00	64			
	Corrected total	5416.94	63			

NS denotes F is not significant at p value < 0.05

Table 6

The t-test analysis of the Difference in Achievement of Male and Female Senior Secondary School Students taught Cellular Respiration When Exposed to CAI and CMI

Gender	Group	N	$\bar{x}$±SD	Df	T	Sig
Male	CAI	20	65.50 ± 13.81	46	6.06	0.00
	CMI	28	44.07 ± 10.69			
Female	CAI	28	44.07 ± 10.69	62	10.69	0.00
	CMI	36	43.56 ± 8.16			

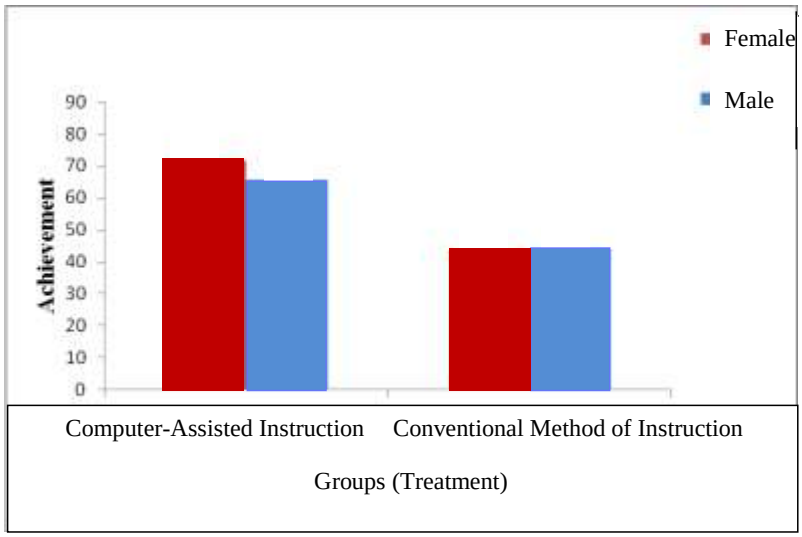


Figure 9. Bar chart showing mean achievement score of male and female Senior Secondary School students taught cellular respiration when exposed to CAI and CMI

Research Question 3: Is there any difference in the achievement of public and private Senior Secondary School students taught cellular respiration when exposed differently to CAI and CMI?

The mean scores (58.63 and 74.67) obtained for public and private school students, respectively taught cellular respiration when exposed to CAI were higher than the mean scores (42.89 and 44.93) obtained for the public and private school students, respectively taught cellular respiration using CMI as shown in Table 7, Table 7 also shows that public school students taught cellular respiration using CAI has a higher mean score of 58.63 ± 9.82 than public students of the control group with mean score of 42.89 ± 10.73, it could be deduced from the table that the private school students exposed to CAI has higher mean score of 74.67 ± 10.93 than the private school students of the control group with mean score of 44.93 ± 7.00. In addition, Table 8 reveals that students of public school exposed to CAI has mean score of 58.63 ± 9.82 as against the private school exposed to CMI with low mean score of 44.93± 7.00, while private school students exposed to CAI has mean score of 74.67±10.97 and public school students exposed to CMI has mean of 42.89 ± 10.73. The public and private school students exposed to CAI achieved differently higher.

Table 7

Description of Achievement of Public and Private Senior Secondary School Students taught Cellular Respiration When Exposed to Computer-Assisted Instruction and Conventional method of instruction

Groups	School Types	N	Pretest Mean ± SD	Posttest Mean ±SD	Mean Gain Score
CAI	Public	16	15.63±6.33	58.63±9.82	43.00
	Private	27	34.96±6.41	74.67±10.97	39.71
Control					
	Public	36	28.39±6.45	42.89±10.73	24.50
	Private	28	16.79±7.37	44.93±7.00	28.14

Hypothesis 3: There is no significant difference between the achievement of public and private Senior Secondary School students taught cellular respiration when exposed to Computer-Assisted Instruction (CAI) and Conventional Method of Instruction (CMI).

Table 8 revealed that, there were significant differences in the achievement of public and private Senior Secondary School students taught cellular respiration, exposed to CAI with $F_{(1, 40)} = 0.18$, $p < 0.05$ compared to the CMI at $F_{(1, 61)} = 7.11$ $p > 0.05$, since the p-value is less than 0.05 for the public and private school students taught with CAI, therefore the null hypothesis is rejected.

Table 9 also shows that, there were significant difference in the achievement of public school students exposed to CAI and private school students exposed to CMI with *t*-value of 5.38, $p<0.05$, In addition, there were significant difference in the achievement of private school students exposed to CAI and public school exposed to CMI with *t*-value of 11.54 $p<0.05$.

Table 8

ANCOVA showing Difference in Achievement of Public and Private Senior Secondary School Students taught Cellular Respiration When Exposed to Computer-Assisted Instruction and Conventional Method of Instruction

Treatments	Source	Type III sum of squares	Df	Mean square	F- value	Sig.
CAI	Corrected model	3428.84[a]	2	1714.42	18.50	.000
	Intercept	5799.94	1	5799.94	62.60	.000
	Pretest	843.52	1	843.52	9.10	.004
	School Types	16.24	1	16.24	.18	.001**
	Error	3706.24	40	92.66		
	Total	210068.00	43			
	Corrected total	7135.07	42			
TI(CONTROL)	Corrected model	762.72[a]	2	381.36	5.00	. 010
	Intercept	5672.43	1	5670.48	73.35	.000
	Pretest	697.19	1	697.19	9.14	. 004
	School Types	542.22	1	542.22	7.11	.06
	Error	4654.22	61	76.30		
	Total	128092.00	64			
	Corrected total	5146.94	63			

Table 9

t-test showing Difference in Achievement of Public and Private Senior Secondary School Students taught Cellular Respiration When Exposed to Computer-Assisted Instruction and Conventional Method of Instruction

Group	School type	N	Mean ± SD	Df	T	Sig
CAI	Public	16	58.63±9.82			
CMI	Private	28	44.73±7.00	42	5.38	0.00
CAI	Private	27	74.67±10.97			
CMI	Public	36	42.89±10.73	61	11.54	0.00

Figure 10 shows the mean score of students in public and private school exposed to CAI and CMI, the highest mean score was observed in the CAI private school students followed by the CAI public school students and the lowest mean were observed both in the public and private school students exposed to CMI.

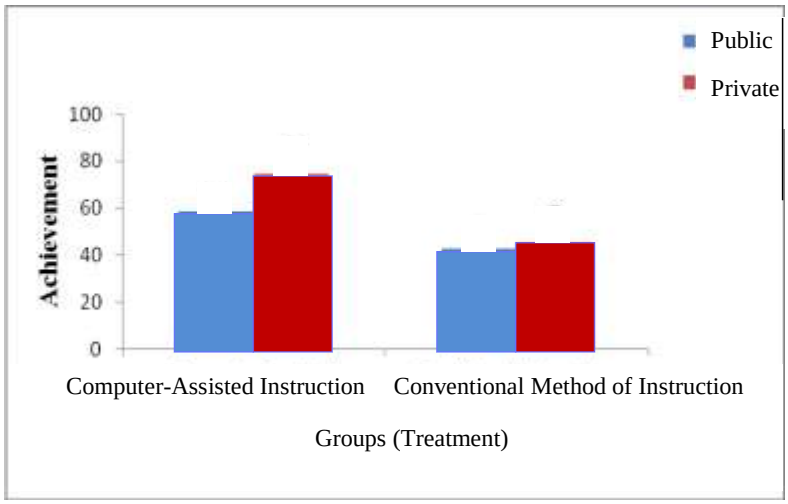


Figure 10. Mean score of students in public and private school exposed to CAI and CMI

Research Question 4: Is there any difference in the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI based on performance levels (high, medium and low score)?

Students with different performance levels achieved differently when exposed to Computer-Assisted Instruction. This is reflected in Table 10, in which the high performing students had the highest mean score of 88.00, followed by the medium 74.17 and the least mean score of 57.88 of the students termed the low scorer. Although, the mean score obtained by the low scorers have moved into the medium score level category while the high, medium and low scorer students exposed to CMI has mean score of 48.00, 44.34 and 41.33, respectively. These mean scores, all fell into low score level category, this implies that students exposed to CMI with different score levels do not achieved differently, in which the high and medium scorers have moved to the low scorer category.

Table 10

Description of Achievement of High, Medium and Low Performance Levels of Senior Secondary School Students taught Cellular Respiration When Exposed to Computer-Assisted Instruction and Conventional Method of Instruction

			Pretest		Mean Gain
Groups	Score levels	N	Mean±SD	Posttest ± S.D	Score
CAI	High	3	40.00±0.00	88.00 ± 2.00	48.00
	Medium	23	33.04±8.40	74.17 ± 10.84	41.13
	Low	17	18.47±9.07	57.88 ± 6.84	39.41
CMI	High	5	17.20±7.82	48.00 ± 10.86	30.80
	Medium	41	23.80±9.26	44.34 ± 8.93	20.54
	Low	18	23.89±8.27	41.33 ± 9.53	17.44

Hypothesis 4: There is no significant difference in the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI based on Performance levels (high, medium and low score).

The result of test of statistical difference in the achievement of high, medium and low scorer students is presented in Table 11. Table 11 reveals that $F_{(2, 39)} = 5.38$ at $p < 0.05$ for those students exposed to CAI since the p-value for the high, medium and low scorer students exposed to CAI is less than 0.05, the null hypothesis is therefore rejected which means that there were significant differences in the achievement of students with high, medium and low performance (score) levels when exposed to Computer-Assisted Instruction, although no significant

difference existed with the score levels of the students in the CMI group. This is shown in Table 11 where F $(_{2, 60})$ =1.74 at p > 0.05.

Table 11

ANCOVA Showing Difference in Achievement of Senior Secondary School Students taught Cellular Respiration when Exposed to Computer-Assisted Instruction and Conventional Method of Instruction Based on (Performnace) Score Levels (High, Medium and Low)

Treatments	Source	Type III sum of squares	Df	Mean square	F- value	Sig.
CAI	Corrected model	4315.77[a]	3	1438.59	19.90	.00
	Intercept	9770.27	1	9770.27	135.15	.00
	Pretest	519.77	1	519.77	7.19	.01
	Score Levels	903.77	2	451.59	6.25	.00**
	Error	2819.30	39	72.29		
	Total	210068.00	43			
	Corrected total	7135.07	42			
CMI(CONTROL)	Corrected model	506.01[a]	3	168.67	2.06	.12
	Intercept	12027.22	1	12027.22	146.94	.00
	Pretest	296.29	1	296.29	3.62	.06
	Score Levels	285.51	2	142.76	1.74	.18[NS]
	Error	4910.93	60	81.85		
	Total	128092.00	64			
	Corrected total	5146.94	63			

To ascertain where the significant difference in the group exposed to CAI, Scheffe Post Hoc was carried out and the output is shown in Table 12 which

reveals that the high scoring students achieved more than the medium and low scoring students with a mean score of 88.00 in subset 3 followed by the medium scoring students with a mean of 74.17 in subset 2 while the least is the low scoring students with mean score of 57.88 in subset 1. This implies that all the group benefitted from CAI most especially the low performing students that moved to the medium category, though, the high scoring students achieved more than the other two groups.

Table 12

Scheffe Post Hoc Showing where the Significant Difference for the Achievement of Students Exposed to Computer-Assisted Instruction

Score Level	N	Subset		
		1	2	3
Low	17	57.88		
Medium	23		74.17	
High	3			88.00
Sig.		1.00	1.00	1.00

Research Question 5: What is the interaction effect of treatment and gender on the achievement of Senior Secondary School students taught cellular respiration?

Table 13 shows that there were 20 males and 23 female students exposed to CAI, and 28 males and 36 female students exposed to CMI, it is also evident that mean scores of the students exposed to CAI was higher than the CMI; it is evident that male and female students exposed to CAI had higher mean scores than those of CMI. The highest mean score from the Table was 71.48 which were obtained by the female students exposed to CAI, this is followed by male in the same group with a mean score of 65.50.

Table 13

Interaction Effect of Treatment and Gender on the Achievement of Senior Secondary School Students taught Cellular Respiration.

Treatment	Gender	N	Mean ± S.D
Computer-Assisted Instruction	Male	20	65.50 ± 13.81
	Female	23	71.48 ± 11.93
Conventional Method of Instruction	Male	28	44.07 ± 10.69
	Female	36	43.56 ± 8.52

Hypothesis 5: There is no significant difference in the interaction effect of treatment and gender on the achievement of Senior Secondary School students taught cellular respiration.

Table 14 showed that the treatment had no interaction effect on gender, at $F_{(1, 102)} = 1.91$; $p>0.05$, hence, the null hypothesis not rejected. This show that, there were no significant differences in the interaction effect of treatment and

gender on Senior Secondary School student's achievement taught cellular respiration.

Table 14

ANCOVA Showing Difference in the Interaction Effect of Treatment and Gender on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.of F
Corrected Model	18890.11[a]	4	4722.53	50.02	.00
Intercept	25544.50	1	25544.50	270.58	.00
Pretest	2536.12	1	2536.12	26.86	.00
Treatment	12217.60	1	12217.60	129.42	.00
Gender	12.64	1	12.64	.134	.72
Treatment * Gender	179.86	1	179.86	1.91	.17[NS]
Error	9629.36	102	94.41		
Total	338160.00	107			
Corrected Total	28519.48	106			

This is further corroborated by a profile plot as shown in *figure* 11, which showed that the interaction that existed between male and female students taught cellular respiration using CAI was not significantly different from the interaction of male and female students taught using CMI, it is depicted also from the Table 13 that male (65.50) and female (71.48) students exposed to CAI both have high mean score while the male (28) and female (36) students exposed to CMI both have low mean score.

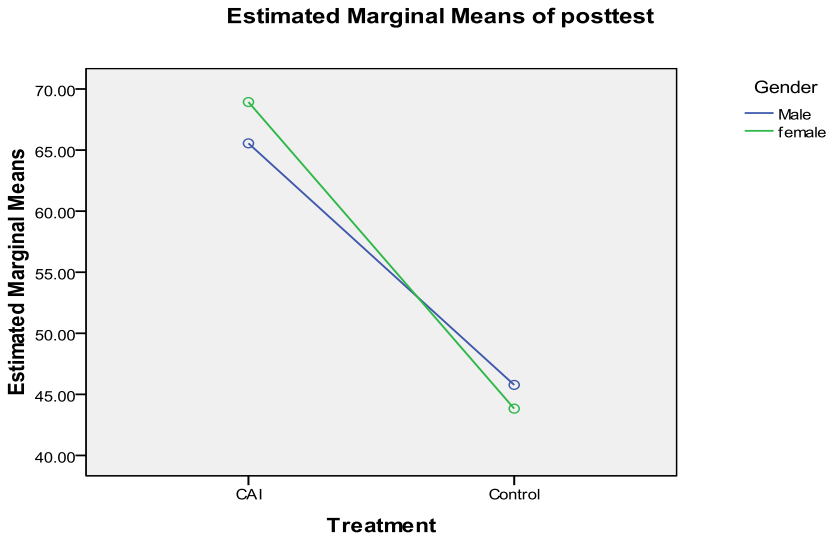


Figure 11. Plot of marginal means showing the interaction effect between treatment and gender

Research Question 6: What is the interaction effect of treatment and school types on the achievement of Senior Secondary School students taught cellular respiration?

On the interaction effect of treatment and school types on the achievement of Senior Secondary School students taught cellular respiration, Table 15 shows that the mean score of the students exposed to CAI was higher than that of CMI, it is evident that the public and private school students exposed to CAI had higher mean score than those of CMI. The highest mean score from the table is 74.67

which were obtained by the private school students exposed to CAI followed by the public school students exposed to CAI with a mean score of 58.63. The private and public school students were positively affected by their exposure to CAI than those exposed to CMI.

Table 15

Interaction Effect of Treatment and School Types on the Achievement of Senior Secondary School Students taught Cellular Respiration.

Treatment	School Types	N	Mean ± S.D
CAI	Public	16	58.63 ± 9.82
	Private	27	74.67 ± 10.93
Control	Public	36	42.89 ± 10.73
	Private	28	44.93 ± 7.00

Hypothesis 6: There is no significant difference in the interaction effect of treatment and school types on the achievement of Senior Secondary School students taught cellular respiration.

Table 16 showed that, there was no significant difference in the interaction effect between treatment and school type on the achievement of Senior Secondary School students exposed to CAI and CMI. This is because at $F_{(1, 102)} = 0.43$, $p>0.05$, hence the null hypothesis which states that there is no significant

difference in the interaction effect of treatment and school type on the achievement of Senior Secondary School students taught cellular respiration is not rejected.

Table 16

ANCOVA Showing the Interaction Effect of Treatment and School Types on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	20106.47[a]	4	5026.62	60.94	.00
Intercept	12841.28	1	12841.28	155.69	.00
Pretest	1488.16	1	1488.16	18.04	.00
Treatment	10607.58	1	10607.58	128.61	.00
School Types	1062.48	1	1062.48	12.88	.00
Treatment * SchoolTypes	35.19	1	35.19	.43	.52[NS]
Error	8413.01	102	82.48		
Total	338160.000	107			
Corrected Total	28519.477	106			

This is further corroborated by a profile plot as shown in *figure* 12, which shows that the interaction that existed between public and private school students taught cellular respiration using CAI was not significantly different from the interaction of public and private school students taught cellular respiration using CMI, Table 15 also shows that the student from public and private schools taught with CMI had low mean score of 43.44 and 44.93, respectively while those taught with CAI had a high mean score of 58.63 and 74.67, this conclude that the interaction that

existed between the achievement of public and private school students was due to the treatment they were exposed to.

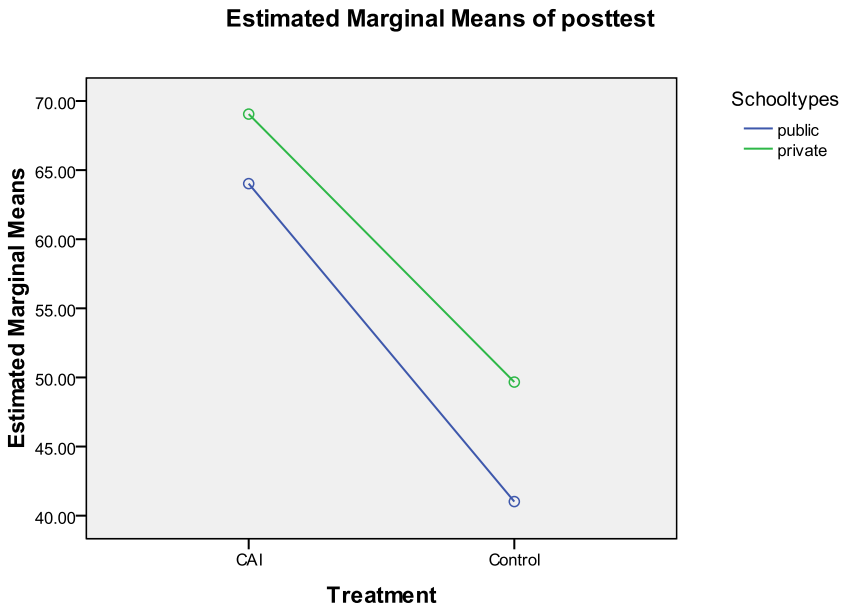


Figure 12. Plot of marginal means showing the interaction effect between treatment and school types

Research Question 7: What is the interaction effect of treatment and score levels on the achievement of Senior Secondary School students taught cellular respiration?

A comparison of the mean score of 41.33 ± 9.53, 44.34 ± 8.93 and 48.00 ± 10.87for the low, medium and high scoring students, respectively exposed to CMI and 57.88 ± 6.84, 44.34 ± 8.93 and 88.00 ± 2.00 for the low, medium and high scoring students exposed to CAI respectively as shown in Table 15 revealed that the high scoring students benefit most from the use of the two instructional strategies of the teaching – learning used in this study.

Table 17

Interaction Effect of Treatment and Score level on the Achievement of Senior Secondary School Students taught Cellular Respiration.

Treatment	Performance level	N	Mean ± S.D
Computer-	Low	17	57.88 ± 6.84
Assisted	Medium	23	74.17 ± 10.84
Instruction	High	3	88.00 ± 2.00
Conventional	Low	21	41.33 ± 9.53
Method of	Medium	28	44.34 ± 8.93
Instruction	High	5	48.00 ± 10.87

Hypothesis 7: There is no significant difference in the interaction effect of treatment and performance levels on the achievement of Senior Secondary School students taught cellular respiration.

Table 18 revealed that, there was significant difference in the interaction effect between treatment and performance level on the achievement of students exposed to CAI and CMI. This is because at $F_{(2, 101)} = 8.07$, $p<0.05$, hence the null hypothesis which states that there is no significant difference in the interaction effect of treatment and performance level on the achievement of Senior Secondary School students taught cellular respiration is hereby rejected.

Table 18

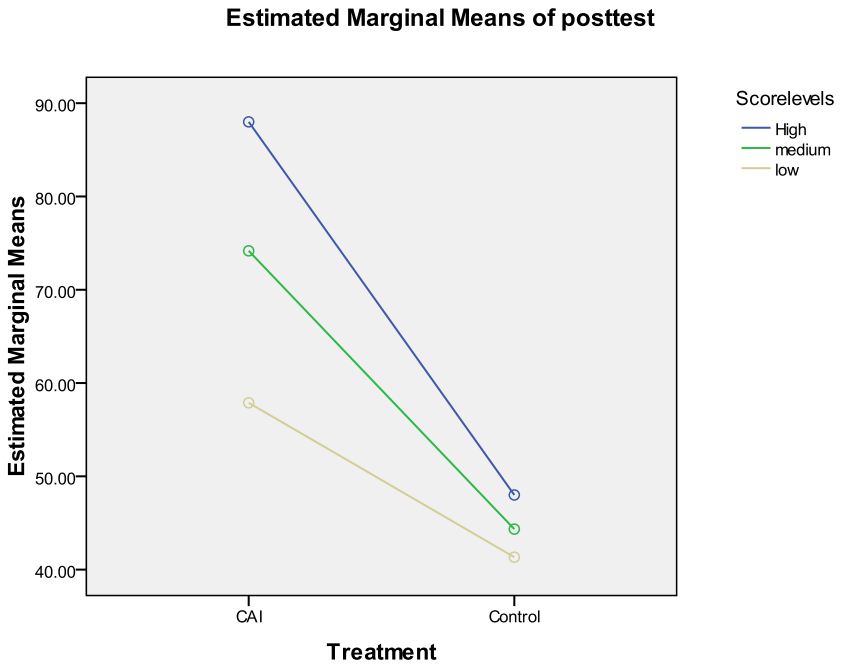
ANCOVA Showing the Interaction Effect of Treatment and Performance Level on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	19973.19[a]	5	3994.64	47.21	.00
Intercept	174858.86	1	174858.86	2066.48	.00
Treatment	10427.55	1	10427.55	123.23	.00
Score Levels	3100.70	2	1550.35	18.32	.00
Treatment * Score Levels	1364.83	2	682.42	8.07	.00**
Error	8546.29	101	84.62		
Total	338160.00	107			
Corrected Total	28519.48	106			

** denotes F is significant at p value < 0.05

The interaction effect between treatment and score level is also shown in *Figure* 13 which shows that there was significant difference in the interaction effect of treatment, it could be depicted from *Figure* 13 that the students exposed to CAI; the high scorer had the highest mean score of 88.00 followed by the medium scorer with a mean score of 74.17 and the low scorer with a mean score of

57.88 which differ from the CMI high scorer with mean score of 48,00, followed by medium scorer with mean score of 44.34 and the low scorer with mean score of 41.33, respectively for the CMI group only the low scorer group achieved within the range of their previous academic performance in biology.`



Covariates appearing in the model are evaluated at the following values: pretest = 25.10

Figure 13. Plot of marginal means showing the interaction effect between treatments and score level

Research Question 8: What is the interaction effect of gender and school types on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI?

On the interaction effect of gender and school types, Table 19 shows that the mean score of male students in the public and private school are 49.52 and 56.78 respectively while that of female for public and private school are 46.07 and 61.50 respectively, which implies that both male and female in public school had low mean scores (49.52 ad 46.07), respectively and high mean score for male and female in private school (56.78 and 61.50), respectively.

Table 19

Interaction Effect of Gender and School Types on the Achievement of Senior Secondary School Students taught Cellular Respiration when Exposed to CAI and CMI.

Gender	School Types	N	Mean ± S.D
Male	Public School	25	49.52 ± 13.97
	Private School	23	56.78 ± 17.52
Female	Public School	27	46.81 ± 11.37
	Private School	32	61.50 ± 17.54

Hypothesis 8: There is no significant difference in the interaction effect of gender and school types on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and TI.

Table 20 showed that there was significant difference in the interaction effect of male and female students achievement and school types since the value for $F_{(1,\ 102)} = 4.04$, $p<0.05$, the null hypothesis which states that there is no significant difference in the interaction effect of gender and school types on the achievement of Senior Secondary School students taught cellular respiration is rejected

Table 20

ANCOVA of the Interaction Effect of Gender and School Types on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	10133.10[a]	4	2533.28	14.05	.00
Intercept	17542.06	1	17542.06	97.32	.00
Pretest	5961.62	1	5961.63	33.07	.00
Gender	111.42	1	111.42	.62	.43
School types	2871.42	1	2871.42	15.93	.00
Gender * School types	727.83	1	727.83	4.04	.04**
Error	18386.38	102	180.26		
Total	338160.00	107			
Corrected Total	28519.48	106			

Figure 14 also reveals that significant difference existed between interaction effect of gender and school types with the mean score for male students in public school (49.52%) and private school (56.78%), while the mean score for female in public school (46.07%) and private school (61.50%), both the highest and lowest mean were found in the female students of both private and public schools

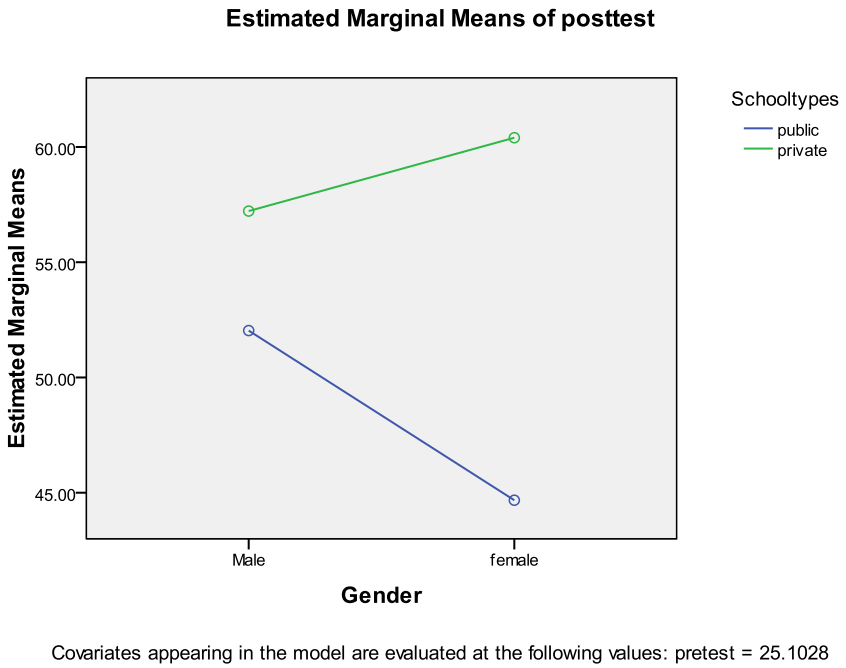


Figure 14. Plot of marginal means showing the interaction effect between gender and school types

Research Question 9: What is the interaction effect of gender and score levels on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and TI?

Table 21 revealed that the mean score of 47.67% and 51.18% was obtained for the low score male and female students, 55.71% and 54.56% for the medium scorer male and female and 63.00% for the high scorer male and female students, respectively. This implies that the effect of gender on students' achievement for the low, medium and high scoring students followed the same pattern.

Table 21

Interaction Effect of Gender and Score Level on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI.

Gender	Performance Level	N	Mean ± S.D
Male	Low	18	50.20 ± 13.99
	Medium	28	54.38 ± 16.59
	High	2	63.00 ± 32.53
Female	Low	17	49.68 ± 11.65
	Medium	36	56.18 ± 17.60
	High	6	63.00 ± 22.01

Hypothesis 9: There is no significant difference in the interaction effect of gender and score levels on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI.

Table 22 showed that there is no significant difference in the interaction effect of gender and score level since $F_{(2, 100)} = 0.18$ when $p>0.05$, the null hypothesis which states that there is no significant difference in the interaction effect of gender and score level on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI is therefore not rejected.

Table 22

ANCOVA Showing the Interaction Effect of Gender and Score Level on Achievement of Senior Secondary School Students taught Cellular Respiration when Exposed to CAI and CMI.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	7019.399[a]	6	1169.90	5.44	.00
Intercept	16960.30	1	16960.30	78.89	.00
Pretest	5425.00	1	5425.00	25.23	.00
Gender	24.96	1	24.96	.116	.73
Score Levels	585.44	2	292.72	1.36	.26
Gender * Score levels	77.22	2	38.61	.18	.84
Error	21500.08	100	215.00		
Total	338160.00	107			
Corrected Total	28519.48	106			

Figure 15 also reveals that the interaction between gender and score level in the achievement of student exposed to CAI and TI was seen within male and female students of low score level (47.67 and 51.18) and medium score level with mean score for male and female(55.71 and 54.56) respectively. There was a point of intersection for the female in the low scoring level and female in the medium scoring level.

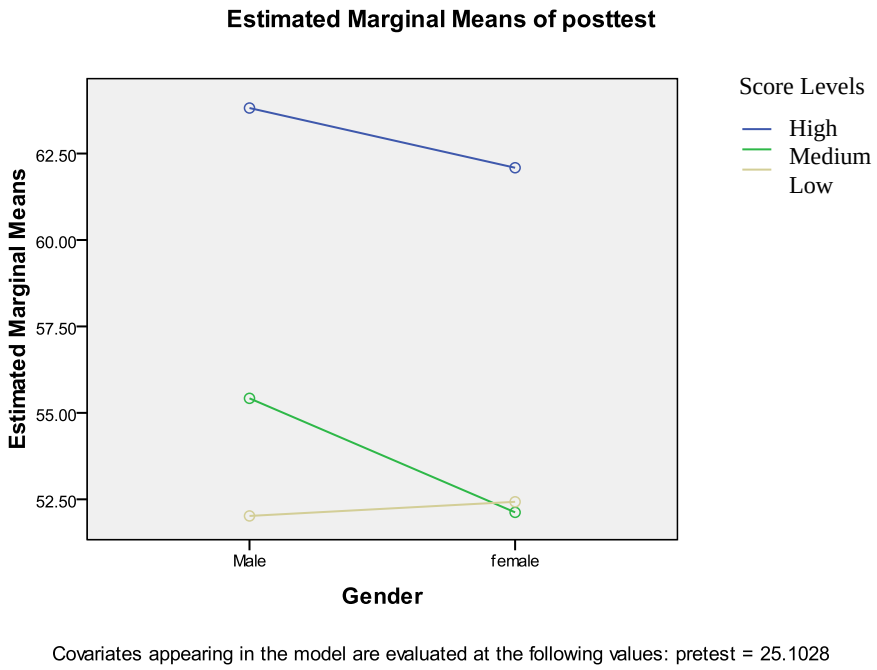


Figure 15. Plot of marginal means showing the interaction effect between gender and score levels

Research Question 10: What is the interaction effect of school type and score levels on the achievement of Senior Secondary School students in cellular respiration when exposed to CAI and CMI?

Table 23 reveals that the mean score of 48.78 and 50.50 was obtained for the low scoring public and private school students, 46.29 and 61.89 for the medium scorer public and private school student and 64.00 and 62.86 for the high scorer public and private students respectively. This implies that the effect of school types on students' achievement for the low and high scorer students follow the same pattern. High public school scorer achieved more with a mean of 64.00 followed by high private school scorer and then medium private school scorer and low private school scorer respectively.

Table 23

Interaction Effect of School Types and Score Level on the Achievement of Senior Secondary School Students taught Cellular Respiration when Exposed to CAI and CMI.

School Types	Score Levels	N	Mean ± S.D
Public	Low	23	48.78 ± 12.69
	Medium	28	46.29 ± 12.38
	High	1	64.00
Private	Low	13	50.50 ± 10.82
	Medium	35	61.89 ± 17.37
	High	5	62.86 ± 24.08

Hypothesis 10: There is no significant difference in the interaction effect of school types and score levels on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI.

Table 24 showed that, there were significant differences in the interaction effect of school types and score level since $F_{(2, 100)} = 3.28$, when $p<0.05$, the null hypothesis that state that there is no significant difference in the interaction effect of school types and score levels on the achievement of Senior Secondary School students taught cellular respiration when exposed to CAI and CMI is therefore rejected. The interaction effect is also shown in Figure 14

Table 24

ANCOVA Showing the Interaction Effect of School Types and Score Level on Achievement of Senior Secondary School Students taught Cellular Respiration when Exposed to CAI and TI.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	10703.10[a]	6	1783.85	10.01	.00
Intercept	14250.06	1	14250.06	79.98	.00
Pretest	5378.67	1	5378.67	30.19	.00
Schooltypes	232.72	1	232.72	1.31	.26
Scorelevels	319.95	2	159.98	.90	.41
Schooltypes * Scorelevels	1170.00	2	585.00	3.28	.04**
Error	17816.37	100	178.16		
Total	338160.00	107			
Corrected Total	28519.48	106			

** denotes F is significant at p value < 0.05

Figure 16 depicted that the interaction that existed between high scorer of public and private school with mean score of 64.00 and 62.86 was different from that which existed between medium scorer of the public and private school with mean score of 46.29 and 61.89, the medium scorer of the private school almost had a mean score obtained from the high scorer of the school, although the low scorer of public school (48.78) had a mean greater than the public school medium scorer (46.29).

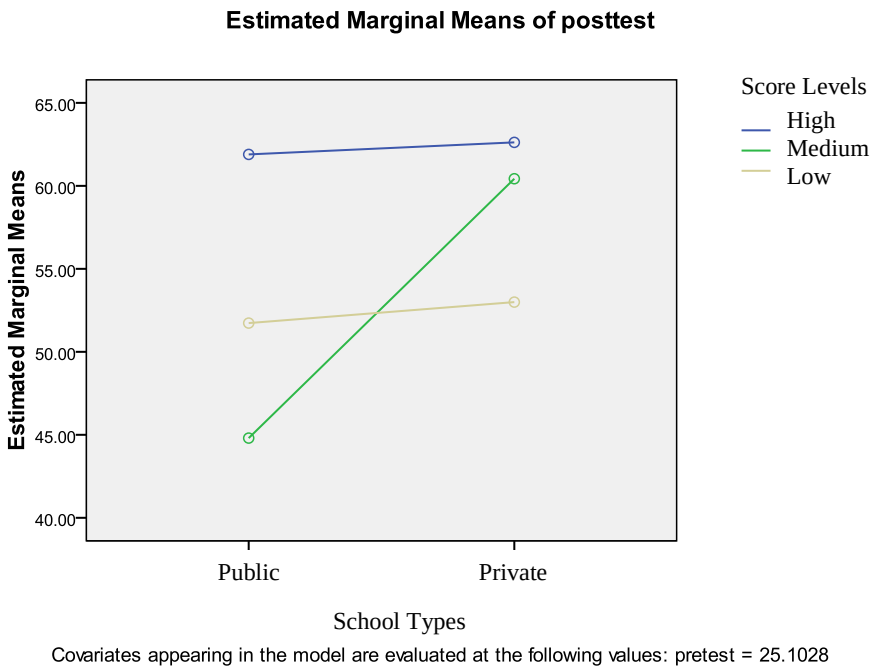


Figure 16. Plot of marginal means showing the interaction effect between school types and score levels

Research Question 11: What are the interaction effects of treatment, gender and school types on the achievement of Senior Secondary School students taught cellular respiration?

The male and female students exposed to CAI in the public school has mean of 58.00 and 59.67 and in private school had mean of 73.00 for the male and 75.64 for the female and the male and female exposed to TI in the public school had

mean of 44.87 and 42.19, respectively and the private school had 44.31 and 45.47 as shown in Table 25

Table 25

Interaction Effects of Treatment, Gender and School Types on the Achievement of Senior Secondary School Students taught Cellular Respiration.

Treatment	Gender	School Types	N	Mean ± S.D
CAI	Male	Public	10	58.00 ± 11.15
		Private	10	73.00 ± 12.37
	Female	Public	6	59.67 ± 7.94
		Private	17	75.65 ± 10.25
CMI (Control)	Male	Public	15	43.87 ± 12.99
		Private	13	44.31 ± 7.74
	Female	Public	21	42.19 ± 9.05
		Private	15	45.47 ± 6.52

Hypothesis 11: There is no significant difference in the interaction effects of treatment, gender and school types on the achievement of Senior Secondary School students taught cellular respiration.

Table 26 revealed that the value of $F_{(1, 98)} = 0.98$, $p>0.05$ therefore, the null hypothesis that states that there is no significant difference in the interaction effect of treatment, gender and school types on achievement Senior Secondary School student is not rejected.

Table 26

ANCOVA Showing The Interaction Effect of Treatment, Gender and School Types on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	20273.92[a]	8	2534.24	30.12	.00
Intercept	12018.92	1	12018.92	142.85	.00
Pretest	1567.13	1	1567.13	18.63	.00
Treatment	9603.33	1	9603.33	114.14	.00
Gender	.04	1	.04	.00	.98
School Types	891.80	1	891.80	10.60	.00
Treatment * Gender	54.63	1	54.63	.65	.42
Treatment * School Types	52.10	1	52.10	.62	.43
Gender * School Types	75.78	1	75.78	.90	.35
Treatment * Gender * School Types	.06	1	.06	.00	.98[NS]
Error	8245.56	98	84.14		
Total	338160.00	107			
Corrected Total	28519.48	106			

Research Question 12: What are the interaction effects of treatment, gender and score levels on the achievement of Senior Secondary School students taught cellular respiration?

The male and female students exposed to CAI among the high, medium and low scorer has the mean of 86.00 and 89.00 for the high, 72.40 and 75.35 for the medium and 55.56 and 60.50 for the low scorer, while the male and female students exposed to CMI among the high, medium and low scorer has mean of

40.00 and 50.00 for the high, 46.44 and 42.70 for the medium and 39.78 and 42.89 for the low scorer as shown in Table 27

Table 27

Interaction Effects of Treatment, Gender and Score levels on the achievement of Senior Secondary School students taught Cellular Respiration.

Treatment	Gender	Score Levels	N	Mean ± S.D
CAI	Male	High	1	86.00
		Medium	10	72.40 ± 13.02
		Low	9	55.56 ± 6.23
	Female	High	2	89.00 ± 1.41
		Medium	13	75.54 ± 9.13
		Low	8	60.50 ±6.91
CMI (Control)	Male	High	1	40.00
		Medium	18	46.44 ± 10.05
		Low	9	39.78 ± 11.64
	Female	High	4	50.00 ± 11.43
		Medium	23	42.70 ± 7.78
		Low	9	42.89 ± 7.22

Hypothesis 12: There is no significant difference in the interaction effect of treatment, gender and score levels on the achievement of Senior Secondary School students taught cellular respiration.

Table 28 reveals that the value of $F_{(2,94)} = 0.27$, $p>0.05$ therefore the null hypothesis that states that there is no significant difference in the interaction effect of treatment, gender and score level on the achievement of Senior Secondary School students taught cellular respiration is not rejected.

Table 28

ANCOVA Showing the Interaction Effect of Treatment, Gender and Score Levels on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	21063.38[a]	12	1755.28	22.13	.00
Intercept	22827.08	1	22827.08	287.78	.00
Pretest	659.51	1	659.51	8.32	.01
Treatment	6368.69	1	6368.69	80.29	.00
Gender	44.93	1	44.93	.57	.45
Score levels	1614.60	2	807.30	10.18	.00
Treatment * Gender	7.59	1	7.59	.10	.76
Treatment * Score levels	440.54	2	220.27	2.77	.07
Gender * Score levels	118.45	2	59.22	.75	.48
Treatment * Gender * Score levels	42.03	2	21.02	.27	.77[NS]
Error	7456.10	94	79.32		
Total	338160.00	107			
Corrected Total	28519.48	106			

Research Question 13: What are the interaction effects of treatment, school types and score levels on the achievement of Senior Secondary School students taught cellular respiration?

The public and private school students exposed to CAI among the high, medium and low scorer has mean score of 88.00 for the high scorer in private school and no high scorer in public school, while 66.00 and 75.40 for the medium scorer and 56.92 and 61.00 for the low scorer, in public and private school

respectively. The public and private school students exposed to TI among the high, medium and low scorer has mean of 64.00 and 44.00 for the high scorer, 43.92 and 45.00 for the medium scorer and 38.20 and 45.25 for the low scorer respectively as shown in Table 29

Table 29

Interaction Effects of Treatment, School Types and Score Levels on the Achievement of Senior Secondary School Students taught Cellular Respiration.

Treatment	School Types	Score Levels	N	Mean ± S.D
CAI	Public	Medium	3	66.00 ± 19.08
		Low	13	56.92 ± 6.56
	Private	High	3	88.00 ± 2.00
		Medium	20	75.40 ± 9.25
		Low	4	61.00 ± 7.75
Control	Public	High	1	64.00
		Medium	25	43.92 ± 10.12
		Low	10	38.20 ± 9.86
	Private	High	4	44.00 ± 7.12
		Medium	16	45.00 ± 6.93
		Low	8	45.25 ± 8.00

Hypothesis 13: There is no significant difference in the interaction effect of treatment, school types and score levels on the achievement of Senior Secondary School students taught cellular respiration.

Table 30 revealed that the value of $F_{(1,95)} = .63$, $p>0.05$ therefore, the null hypothesis that states that there is no significant difference in the interaction effect

of treatment, school types and score levels on the achievement of Senior Secondary School students taught cellular respiration is not rejected.

Table 30

ANCOVA Showing the Interaction Effect of Treatment, School Types and Score Levels on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	21741.24[a]	11	1976.48	27.70	.00
Intercept	13130.14	1	13130.14	184.03	.00
Pretest	934.43	1	934.43	13.10	.00
Treatment	7505.05	1	7505.05	105.19	.00
School Types	12.48	1	12.48	.18	.68
Score levels	1475.46	2	737.73	10.34	.00
Treatment * School Types	228.80	1	228.80	3.21	.08
Treatment * Score levels	433.72	2	216.86	3.04	.05
School Types * Score levels	394.06	2	197.03	2.76	.07
Treatment * School Types * Score Levels	44.78	1	44.77	.63	.43[NS]
Error	6778.24	95	71.35		
Total	338160.00	107			
Corrected Total	28519.48	106			

Research Question 14: What are the interaction effects of treatment, gender, school types and score levels on the achievement of Senior Secondary School students taught cellular respiration?

Table 31 shows the interaction among treatment, gender, school types and score levels, the Table 31 reveals that the achievement of students when administered the treatment depend on the level of other variables considered. It is evident that achievement of Senior Secondary School student taught cellular respiration varies based on gender, school types and score levels.

Table 31

Interaction Effects of Treatment, Gender, School Types and Score Levels on Achievement of Senior Secondary School Students taught Cellular Respiration

Treatment	Gender	Score Levels	School Types	N	Mean ± S.D
CAI	Male	High	Private	1	86.00
		Medium	Public	3	66.00 ± 19.08
			Private	7	75.14 ± 10.19
		Low	Public	7	54.57 ± 4.43
			Private	2	59.00 ± 12.73
	Female	High	Private	2	89.00 ± 1.41
		Medium	Private	13	75.54 ± 9.13
		Low	Public	6	59.67 ± 7.94
			Private	2	63.00 ± 1.41
		Medium	Public	3	66.00 ± 19.08
			Private	20	75.40 ± 9.25
		Low	Public	13	56.92 ± 6.56
			Private	4	61.00 ± 7.75
Control	Male	High	Private	1	40.00
		Medium	Public	11	47.27 ± 11.67
			Private	7	45.14 ± 7.47
		Low	Public	4	34.50 ± 13.20
			Private	5	44.00 ± 9.49
	Female	High	Public	1	64.00
			Private	3	45.33 ± 8.08
		Medium	Public	14	41.29 ± 8.21
			Private	9	44.89 ± 6.94
		Low	Public	6	40.67 ± 7.23
			Private	3	47.33 ± 5.77

Hypothesis 14: There are no significant differences in the interaction effects of treatment, gender, school types and score levels on the achievement of Senior Secondary School students taught cellular respiration.

Table 32 revealed that, there is no interaction effect of treatment, gender, school types and score levels on the achievement of Senior Secondary School students taught cellular respiration.

Table 32

ANCOVA Showing the Interaction Effect of Treatment, Gender, School Types and Score Levels on Achievement of Senior Secondary School Students taught Cellular Respiration

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	22241.68[a]	20	1112.08	15.24	.00
Intercept	11924.98	1	11924.98	163.36	.00
Pretest	973.79	1	973.79	13.34	.00
Treatment	5931.76	1	5931.76	81.26	.00
Gender	5.82	1	5.82	.08	.78
Score Levels	1230.47	2	615.23	8.43	.00
School Types	.54	1	.54	.01	.93
Treatment * Gender	.88	1	.88	.01	.91
Treatment * Score Levels	288.98	2	144.49	1.98	.14
Treatment * School Types	194.76	1	194.76	2.67	.11
Gender * Score Levels	153.34	2	76.67	1.05	.35
Gender * School Types	26.85	1	26.85	.37	.55
Score Levels * School Types	366.77	2	183.38	2.51	.09
Treatment * Gender * Score Levels	2.74	2	1.37	.02	.98
Treatment * Gender * School Types	15.37	1	15.37	.21	.65
Treatment * Score Levels * School Types	103.88	1	103.88	1.42	.24
Gender * Score Levels * School Types	97.44	1	97.44	1.34	.25[NS]
Treatment * Gender * Score Levels * School Types	.00	0	.	.	.
Error	6277.80	86	72.99		
Total	338160.00	107			
Corrected Total	28519.48	106			

Summary of Major Findings

The major findings of the study as obtained from the data analyzed are summarized as follow:

1. Senior Secondary School students exposed to CAI achieved significantly better than those exposed to CMI
2. There is no significant difference in the achievement of male and female students taught using CAI or CMI
3. There is a significant difference in the achievement of public and private school students exposed to CAI while there is no significant difference in the achievement of public and private school students exposed to CMI
4. There is a significant difference in the achievement of high, medium and low scoring students taught using CAI while there is no significant difference in the achievement of high, medium and low scoring students taught using CMI
5. There is no significant difference in the interaction effects of treatment and gender on the achievement of Senior Secondary School students taught cellular respiration.
6. There is no significant difference in the interaction effects of treatment and school types on the achievement of Senior Secondary School students taught cellular respiration.

7. There is a significant difference in the interaction effects of treatment and score levels on the achievement of Senior Secondary School students taught cellular respiration.
8. There is a significant difference in the interaction effects of gender and school type on the achievement of Senior Secondary School students taught cellular respiration.
9. There is no significant difference in the interaction effects of gender and score levels on the achievement of Senior Secondary School students taught cellular respiration.
10. There is no significant difference in the interaction effects of school types and score levels on the achievement of Senior Secondary School students taught cellular respiration.
11. There is no significant difference in the interaction effects among treatment, gender and school types on the achievement of Senior Secondary School students taught cellular respiration.
12. There is no significant difference in the interaction effects among treatment, gender and score levels on the achievement of Senior Secondary School students taught cellular respiration.
13. There is no significant difference in the interaction effects among treatment, school types and score levels on the achievement of Senior Secondary School students taught cellular respiration.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter focuses on the comprehensive discussion of findings, conclusions drawn from the findings and recommendation based on the major findings from the study. The discussion is based on the variables used in this study which includes instructional strategy {computer-assisted instruction (CAI) (experimental) and conventional method of instruction (TI) (control)}, school types, gender, students' score levels and student's achievement in cellular respiration.

Discussion

The present study investigated the effects of a computer-assisted instructional package on students' achievement in cellular respiration in Ibadan, Nigeria.

The findings for this study have been discussed under the following headings

1. Findings on the effects of instructional strategy on the achievement of Senior Secondary School students' taught cellular respiration.
2. Findings on the influence of gender on the achievement of Senior Secondary School students' taught cellular respiration.
3. Findings on the influence of school types on the achievement of Senior Secondary School students' taught cellular respiration.

4. Findings on the influence of score levels on the achievement of Senior Secondary School students' taught cellular respiration.
5. Findings on the interaction effects on the achievement of Senior Secondary School students' taught cellular respiration.

1. Findings on the Effects of Instructional Strategy on the Achievement of Senior Secondary School Students Taught Cellular Respiration.

Hypothesis one was to investigate the effects of instructional strategy in form of Computer-Assisted Instruction as experimental group and Conventional Method of Instruction as control group on the achievement of Senior Secondary School students' taught cellular respiration. The result of the Analysis of Covariance on the achievement of Senior Secondary School students exposed to Computer-Assisted Instructional via Computer-Assisted Instructional Package on cellular respiration and those taught with Conventional Method of Instruction indicated a significant difference in favour of students taught with CAI (experimental group). This implies that exposing students to CAI as an instructional strategy helps them to understand and comprehend cellular respiration easily more than those exposed to CMI. This positive result of CAI from the students may be associated with the general characteristics of CAI, such as: one-to-one interaction; self pacing; individual attention; self directed learning; great motivation and instantaneous response.

The finding is in agreement with the earlier findings of Ramanjeet, Sushama and Anil (2012), Yusuf and Afolabi (2010), Ali (2005), Gilani (2005), French and Russell (2001), Phillips and Moss (1993), Jegede, Okebukola and Ajewole (1992) whose studies were directly on Biology. Similarly, the findings agree with the studies of Alasoluyi (2015) in economics, Oyelekan and Olorundare (2009), Okoro and Etukudo (2001) in Chemistry, Kara and Kahraman (2008), Ogundoju, Bayo-Lebi and Asunbiaro (2014) on Physics, Pilli (2008), Fakomogbon, Adetayo, Oyebode and Eruwa (2014), Semra and Cenk (2012), Ash (2004), Udousoro (2000), in Mathematics, Atif (2014) in statistics, Onasanya, Daramola and Asuquo (2006) on Introductory Technology, Egunjobi (2002), in Geography, Ajelabi (1998) on Social Studies, Siskos, Melanie (2014) in language education, Antoniou, Papaioannou and Laparidis (2005) on Physical Education. Thus, it confirmed that CAI has been effective in enhancing student's academic achievement, not only in Biology but other subject than conventional method of instruction. The positive impact of CAI was also supported by findings of Karper, Robinson and Casado-kehoe (2005) on Couselling Education.

However, this finding contradicts the conclusion of Adeyemi (2012), Owusu, Monney, Appiah & Wilmot (2010) that students instructed by the conventional approach performed better than those instructed by the CAI.

2. **Findings on the Influence of Gender on the Achievement of Senior Secondary School Students Taught Cellular Respiration.**

The influence of gender on the achievement of Senior Secondary School students' taught cellular respiration with CAI and CMI was examined with hypothesis two. The result of Analysis of Co-variance revealed that there is no significant difference in the achievement of male and female Senior Secondary School students exposed to CAI, though the female students made a greater mean gain score than the male but the difference was not statistically significant enough to show that the difference was caused by the treatment of the study. The higher mean gain score achieved by the female students might be attributed to their curiosity and interest to break male monopolisation and dominances of computer gadgets. The findings showed that both genders had a higher achievement when taught with CAI. This implies that neither the male nor female students achieved differently from one another. These findings are in agreement with earlier findings of Ramanjeet, Sushama and Anil (2012), Yusuf and Afolabi (2010), Spencer (2004) and Jayemani (1991). Also, the findings agreed with the submission of Oludipe (2012) and Bello (1990) on gender and achievement in Basic Science and Biology. The findings support the findings of Fakomogbon, Adetayo, Oyebode and Enuwa (2014) on effect of computer assisted instructional package on the performance of students in Mathematics that male and female students performed equally well.

The findings also agreed with Ash (2004) conclusion on the effects of computer assisted instruction on middle school mathematics achievement. The

findings is also in favour of the conclusion of Achuonye (2011) that gender does not affect the use of computer in learning process, likewise of Anulobi (2009) in his study of fine arts with Video Compact Disc Instructional Package (VCDIP), found out that gender did not have any impact because both the boys and girls performed same. The findings established the findings of Bello and Abimbola (1997) who found out that gender was not a determining factor in concept mapping ability in evolution.

However, the findings contradict the findings of Achuonye and Olele (2009), which indicated male dominance in computer usage. Thus, it can be inferred from the findings that the use of Computer-Assisted Instruction enhances the achievement of both males and females Senior Secondary School students and CAI is not gender biased.

3. **Findings on the Influence of School Types on the Achievement of Senior Secondary School Students Taught Cellular Respiration.**

The result of Analysis of Co-variance on the achievement of public and private Senior Secondary School students' taught cellular respiration shows significance difference when exposed to CAI but no significance difference exist between the achievement of public and private Senior Secondary School students' taught cellular respiration using CMI. This implies that the positive impact of CAI is not limited to the students of private school alone, but both public and private school students achieved significantly when exposed to CAI. While the public and

private school students exposed to CMI do not show significant different in their level of knowledge derived. Public and private school students found CAI favourable more than CMI in terms of academic achivement.

This finding on public and private school students exposed to CAI is in agreement with Philias and Wanjobi (2011) who reiterated that type of schools has effect on the performance of students in mathematics. Effects of CAI has been found positive in the both school types, which mean that both students from the two school types found CAI effective in teaching – learning process. This finding on public and private school students exposed to CMI corroborates the submission of Alimi, Ehinola and Alabi (2012), and Yusuf and Afolabi (2010) that there is no significant difference in the academic achievement of students in public and private senior secondary. Keeves (1978) reiterated that type of school, classified as public or private did not make any difference in the determination of students' academic achievement.

Nevertheless, private school students achievement could be attributed to availability and utilization of computer facilities in their school, which has been incorporated into the students subject table unlike the public school that lack computer facilities or where available, it might have been burgle or students were hindered not to have full access to the computer system based on some factors.

4. **Findings on the Influence of Performance (Score) Levels on the Achievement of Senior Secondary School Students Taught Cellular Respiration.**

The result of Analysis of Co-variance on the achievement of high, medium and low scoring students of Senior Secondary School students' taught cellular respiration shows significant difference when exposed to CAI but no significant difference exist in the achievement of high, medium and low scoring students of Senior Secondary School taught cellular respiration using CMI. This implies that the high scoring students exposed to CAI achieved better than the other two groups (low and medium), although the mean score obtained by the low scoring students moved into the medium score levels category. The low scoring students found CAI more favourable than CMI, and benefited with an improvement result that translated them to medium scoring category.

However, Computer-Assisted Instruction had a greater effect on all the score levels. This finding could be attributed to high cognitive demand placed on students, curiosity, construction of independent knowledge learning with fun and other stimulating factors associated with the CAI package. This finding is in line with Adeoye (2015), Omiola, Enuwa, Awoyemi and Bada (2012), Olaniyan, Omosewo and Nwakwo (2015), Akanmu (2013), Gbigbadua, Abimbola, and Ahmed (2012), Abimbola and Aworanti (1997) who found that significant difference exist in score levels of the experimental group against control group.

However, the finding disagree with the studies of Abdulwahab (2014), Gbigbadura (2014) and Sunday (2014), that there is no influence of score levels on the achievement of students in chemistry, biology and mathematics, respectively.

6. Findings on the Interaction Effects on the Achievement of Senior Secondary School Students Taught Cellular Respiration.

The study determined the interaction effects of treatment and gender; interaction effect of treatment and school types; interaction effect of treatment and score levels; interaction effect of gender and school types; interaction effect of gender and score levels; interaction effect of school types and score levels; interaction effect of treatment, gender and school types; interaction effect of treatment, gender and score levels; interaction effect of treatment, school types and score levels on the achievement of Senior Secondary School students' taught cellular respiration.

Out of these interactions, treatment and score levels; gender and school types shows significance difference in their interaction effect. The implication of the significant interaction effect of treatment and score levels is that the types of treatments influence the score levels. It could be also inferred that the treatment influence the results obtained by the low, medium and high scoring students taught cellular respiration.

The significance difference in the interaction effect on gender and school types implies that gender influence the achievement of students in private school than public school. This also means that the achievement of the male differs from that of the female in both school types.

The findings agree with the submission of Adeoye (2015) who found that there is an interaction effect among group, gender and score levels on the achievement of students that learned biology using demo kit and those that learned without demo kit. Also Akanmu (2013) observed a significant interaction effect among the cognitive style, gender and score levels when students were taught mathematics using guided discovery learning method or conventional method.

Meanwhile, the findings disagreed with the submission of Abdulkadri (2011) who observed no significance interaction effects among groups, gender and score levels when Senior Secondary School students were taught biology using check sheet and those taught using conventional method of teaching,.

Conclusion

Over the years, performance in biology has been not encouraging. Osuafor and Okonkwo (2013) in their study, found that in 2002, 2003 and 2004 the percentages of candidates who passed West African Senior School Certificate Examinations (WASSCE) at credit level and above (grades 1-6) in biology were 30.3%, 42.1% and 30.2%, respectively. Also, WAEC Chief Examiners' Reports

(2013) contained that cellular respiration questions were not popular in theoretical section and not many candidates attempted it. In an attempt to solve and reduce the level of poor performance in biology, this study was conducted to find out the effect of computer-assisted instructional package on Senior Secondary School students achievement in cellular respiration in Ibadan, Nigeria.

The result of this study showed that those students exposed to Computer-Assisted Instruction achieved significantly higher than those taught with Conventional Method of Instruction. It was discovered that CAI enhanced the achievement of both students from public and private schools. There was a significant difference in the achievement of students with high, medium and low score levels when exposed to CAI. The CAI had a greater effect on students of all the score levels, it is also noticed that the high scoring students achieved more than the other two scoring groups, while the low scorers benefitted and moved into the medium scoring level based on the mean score obtained. The low scorers obtained a mean value that fall into the medium scoring level and this made the low scoring students to move into the medium category.

The result from this study has shown that female students had a greater mean gain score than male students but the difference was not statistically significant, whereas, both sexes had a higher achievement when taught with CAI. This implies that CAI is not gender selective; it enhanced the achievement of all students. From the results and findings obtained in this study, it can be concluded that for effective

teaching – learning process to take place, Senior Secondary School students may benefit a great deal from the use Computer-Assisted Instruction (CAI).

Recommendations

The following recommendations were made based on the findings of this study:

1. The use of CAI has been found to be an effective instructional strategy and therefore should be adopted for effective teaching-learning of science subjects, most especially biology at all levels of studies. Unlike Conventional Method of Instructions, CAI permits students to learn at their pace with full mastery of contents and knowledge. Evaluation and instant feedback results enable the students to measure their level of understanding of certain concepts in CAI. Also, multimedia contents of CAI increase the amusement and curiosity of the students to gain a longer period of academic focus and attention than that of Conventional Method of Instruction. Therefore, CAI needs to be incorporated into all teaching–learning processes in this nation, to compliment the various existing method of instructions delivery. Students should be continuously guided and monitored while using CAI to avoid distraction and other application that can distract the students while using CAI should be disabled for effective concentration on the real content.
2. Biology teachers need to equip themselves with ICT knowledge to adapt with present day teaching–learning classrooms challenges and update themselves through conferences, seminars, workshop and personal efforts that

will enhance their methods of instruction delivery and computer usage most especially on CAI. In-service training should be made available for teachers on utilization of computer programs, gadgets and facilities for an optimum output.

3. Now that computer application is very useful in all walks of life, Government should give priority to computer literacy and usage in the public secondary school, adequate funding should be made available by ministry of education to equip the schools with the necessary ICT facilities for the effective usage of computer-assisted instruction. Computer-assisted instructional packages for various subjects should be developed for use in both private and public school systems in Nigeria. Public Private Partnership should be encouraged by the government from various organizations for schools ICT empowerment and proper monitoring should be enforced to ensure the usability of ICT facilities and provision of electricity to where not available, to avoid of been put under lock and key by many public schools. In addition, adequate security should be provided in the public secondary school to protect computer facilities against been stolen.
4. Computer-assisted instructional packaged like the one designed for this study, should be made available for teachers and students usage in our secondary schools and replication of such package should be done in other difficult topics in biology to aid students comprehension.

Limitation of the Study

The study was faced with some challenges and limitations among which are:

1. Difficulty to finds schools that satisfied the criteria for sample selections which includes: functioning computer laboratories; computer literate students; co-educational school and good SSCE tracking results of five years.
2. Non-cooperation on the part of school's head and teachers.
3. Choking or congested school's subject table in most the private schools.
4. Lack of electricity power supply and unavailability generator in public school and where it was available huge amount of money was demanded instead of fuel.
5. The performance (score) levels of the students that participated in the study was derived from their school based terminal examinations results which was not standardized and equivalent. Therefore, the finding could not be generalized.

Suggestions for Further Studies

1. Influence of students' attitude or socio – economic factors and parental educational background on Computer-Assisted Instruction as an instructional strategy should be examined to further establish the significance of Computer-Assisted Instruction.

2. Study involving effects of Computer-Assisted Instruction on students' attitude and school location should be carried out to cater for greater generalization of the findings.
3. The evaluation of retention levels of the students may also be added as another variable in relation to the effects of Computer- Assisted Instruction on achievement of students' in biology or any other sciences.
4. Replication of this study should be carried out in other science subjects and different geographical locations.

Dissemination of Research Findings

The findings of this research study will be disseminated via: local journal, international journal, periodicals, newspapers, workshop, conferences and seminars.

Specifically, the researcher will publish articles that will contain the research findings in both local and international journal of good reputation to share the findings with fellow researchers and education stake holders.

Editorial column for science and education in national newspaper will be sought for, to share the findings with every Nigerians, and beyond.

Workshops for the secondary school teachers will be organized in collaboration with the state ministry of education to disseminate the research findings.

Conferences will be attended to get a platform for sharing the research findings. The researcher will organized a seminar at a local level, liaising with the department of science education of university of Ilorin or any other tertiary institution to share the findings of this research work with others.

BUDGET PROPOSAL				
DESCRIPTION OF ITEM	**EXPECTED FROM**			**TOTAL**
	SPONSOR	**STUDENT**	**OTHERS**	
1.0 Personnel Costs/Allowances		**₦**	`	**₦**
1.1 Research Assistants		5,000*4		20,000
1.2 Research Informants				
1.3 Technical Assistants		5,000*2		10,000
Subtotal (not > 20% of budget)				**30,000**
2.0 Equipment (List & Specify)				
2.1 Ear phone		120*100		12,000
2.2 Software (Programmers charges)		150,000		150,000
2.3				
Subtotal (not > 25% of budget)				**162,000**
3.0 supplies/ Consumables				
3.1Graphics design, typing, printing.		80,000		80,000
3.2 Internet browsing, downloading and other		200,000		200,000
3.3 Photocopy of materials		30,000		30,000
3.4				
3.5				
Sub total				**310,000**
4.0 Data collection & Analysis				
4.1 Incentives to the best students		10,000		10,000
4.2 Data analysis		30,000		30,000
4.3				

Sub total		**40,000**
5.0 Travels		
5.1 Transportation	50,000	50,000
5.2		
Sub total		**50,000**
6.0 Dissemination		
6.1 Journals	60,000	60,000
6.2 Seminar and Workshops	70,000	70,000
Sub total		**130,000**
7.0 Others/Miscellaneous (specify)		
7.1 Proposal preparation and presentation	35,000	35,000
7.2 Fuel for schools generators	40,000	40,000
7.3 Thesis preparation and binding	33,000	33,000
7.3 Others	30,000	30,000
Sub total		**138,000**
Grand Total		**860,000**

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APPENDICES 1

Achievement Test on Cellular Respiration (ATCR)

Instruction: Each question is followed by four options lettered A to D. Choose the correct option for each question. Good luck!!!!!!! **Time:** 40 minutes

1. In glycolysis, phosphorylation takes place in …… part of the cell. (a) mitochondria (b) cytoplasm (c) lysosome (d) vacuoles
2. Most of the energy in the cell is produced in the……..
   (a) mitochondria (b) lysosome (c) plastid (d) cytoplasm
3. In cellular respiration, energy is stored in the form of ……. (a) adenosine diphosphate (ADP) (b) adenosine monophosphate (AMP) (c) adenosine triphosphate (ATP) (d) electrical energy
4. In the anaerobic stage of respiration in plant, calculate the net ATP produced per glucose molecule (a)one (b) two (c) three (d) four
5. Which of the following are the final products of aerobic respiration (a) water, x carbondioxide and energy (b) pyruvic acid, carbondioxide and energy (c) glucose, energy and urea (d) lactic acid, water and carbohydrate
6. Which of the following is a product of brewing when yeast is used as a fermenting agent (a) nitrogen (b) malt (c) ethanol (d) sucrose
7. During anaerobic respiration in skeletal muscles, pyruvic acid is ,,,,,,,,,
   (a) reduced to lactic acid (b) oxidized to ethanol (c) oxidized to lactic acid (d) reduced to water
8. During prolonged exercise, glucose in the muscle is converted to
   (a) pyruvic acid (b) lactic acid (c) Co enzyme A (d) ethanol
9. What happen when a mammal respires anaerobically for a long period of time?
   (a) pyruvic acid is converted into Acetyl CoA (b) more energy is released from fats in the body (c) lactic acid accumulates in the muscles (d) the Kreb's cycle is fully completed
10. The role of ATP includes all the following activities except (a) provision of energy to do work in living organisms (b). transmission of nerve impulse (c) keeping the body warm in homoithermic animals (d) producing water during aerobic respiration
11. Yeast is added to the dough during the preparation of bread because it produces (a) ethanol (b) heat (c) carbon dioxide (d) carbohydrate
12. Respiration is an essential life process providing the living cells with
    (a) oxygen (b) sugars (c) energy (d) carbon dioxide
13. The overall reaction in glycolysis can be summarized best by which of the following equation.
    (a) $C_6 H_{12} O_6 \longrightarrow C_3 H_4 O_3 + 4H + ATP$

(b) $C_6H_{12}O_6 \longrightarrow 2C_3H_4O_3 + 4H + 2ATP$
(c) $C_6H_{12}O_6 \longrightarrow 2C_3H_4O_3 + 4H + ADP$
(d) $C_6H_{12}O_6 \longrightarrow 2C_3H_4O_3 + 4H + 2ADP$

14. Anaerobic respiration results in the production of (a) more energy than aerobic respiration (b) No energy (c) an equal amount of energy to aerobic respiration (d) less energy than aerobic respiration
15. The process of aerobic respiration requires (a) a food source, oxygen and blood supply (b) a food source, carbon dioxide and enzymes (c) oxygen, enzymes and sunlight (d) a food source, oxygen and enzymes
16. Production of lactic acid in living cells is caused by (a) sufficient oxygen to break down glucose (b) insufficient oxygen to break down glucose (c) sufficient carbon dioxide to break down glucose (d) insufficient carbon dioxide to break down glucose
17. In cellular respiration, energy is made available to organisms by (a) addition of a phosphate group to ADP (b) breaking off a phosphate group from ATP (c) adding a phosphate group to glucose (d) breaking off a hydrogen ion from reduced nicotinamide adenine dinucleotide
18. The process of anaerobic respiration of yeast in sugar solution is known as (a) alcoholic oxidation (b) alcoholic fermentation (c) tissue respiration (d) Alcohol production
19. In the absence of oxygen, the pyruvic acid produced during glycolysis is converted to Co_2 and (a) water (b) glycerol (c) ethanol (d) citric acid
20. Which of the following events does NOT occur during anaerobic respiration of glucose? (a) muscle cells produce lactic acid (b) carbon dioxide is produced (c) milk bacteria produce lactic acid (d) sufficient energy is not produced.
21. The equation that can be used to summarize the process of anaerobic breakdown of sugar is (a) $C_6H_{12}O_6 \rightarrow 2C_2H_2OH + 2CO_2$ (b) $6CO_2 + 6H_2O \rightarrow C_6H_2O_6 + 6O_2$ (c) $C_2H_{12}O_6 + 6O_2 \rightarrow 6O_2$ $6H_2O + H_2O$ + energy (d) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ + energy
22. Fatigue of leg muscles may occur after riding many kilometers on bicycle because of (a) Insufficent glucose (b) excess carbondioxide (c) excess protein (d) insufficient oxygen.
23. In the absence of oxygen, the pyruvic acid produced during glycolysis in plant cells is converted to CO_2 and (a) water (b) glycerol (c) ethanol (d) citric acid
24. The end product of glycolysis in plants and animals is (a) pyruvic acid (b) citric acid (c) aspartic acid (d) malic acid
25. Anaerobic respiration differs from aerobic respiration by the production of (a) less amount of energy and water (b) greater amount of energy and alcohol (c) less amount of energy and alcohol (d) greater amount of energy

26. Cellular respiration is important for the (a) release of energy for body use (b) absorption of oxygen into the alveoli (c) exhalation of carbon (iv) oxide from the lungs. (d) release of carbon (iv) oxide into the lungs
27. Calculate the number of ATP produced in citric acid cycle when a molecule of glucose is fully oxidized (a) 36 (b) 32 (c) 30 (d) 28
28. Each reduced *flavin adenine dinucleotide* ($FADH_2$) is equivalent to…….number of ATP (a) 2 (b) 3 (c) 4 (d) 1
29. Each reduced *nicotinamide adenine dinucleotide* (NADH) is equivalent to…….number of ATP (a) 1 (b) 2 (c) 3(d) 4
30. Which of the following stage in cellular respiration does $FADH_2$ comes up (a) glycolysis (b) citric acid cycle (c) anaerobic respiration (d) pyruvate formation
31. Anaerobic respiration processes take place in which of the following organisms (a) plants (b) plants and microorganisms (c) plants and animals (d) animals and microorganisms
32. The oxidative phosphorylation process of aerobic respiration takes place in the (a) a lysosome (b) ribosomes (c) mitochondria (d) cytoplasm
33. Anaerobic respiration of yeast in solution of sugar is known as…… (a) lactic acid reduction (b) alcoholic oxidation (c) alcoholic fermentation (d) lactic acid decomposition
34. Calculate the sum total of ATP molecules gained in glycolysis including the NADH is (a) 8 (b) 6 (c) 4 (d) 2
35. Calculate the total net gain of energy (ATP) per glucose molecule, when it is completely oxidized (a) 32 (b) 30 (c) 36 (d) 38
36. To neutralize the accumulation of lactic acid in the muscle of an athlete, the athlete must ……..(a)rest (b) eat (c) drink water (d)pant heavily
37. Glucose is phosphorylated to glucose-6-phosphate in the presence of ……. enzyme (a) phosphokinase (b) hexokinase (c) isomerase (d) dehydrogenase
38. Fructose-1,6-diphosphate is broken down into ……. number of triose phosphate molecule (a)1(b) 2(c) 3(d) 4
39. Phosphoenol Pyruvic acid is converted to Pyruvic acid under the influence of ……. enzyme (a) *enolase*(b) *pyruvate kinase* (c) *aldolase* (d) *hexokinase*
40. Fumarate is hydrolysed to malate in the presence of …… enzyme (a) *fumarose* (b) *fumarase* (c) *funman* (d) *fadloase*
41. What type of respiration is common among the following microorganisms: yeasts, bacteria, fungi (a) aerobic respiration (b) anaerobic respiration (c) buccal respiration (d) cutaneous respiration
42. Conversion of ATP into electric energy which forms electric current used for capturing prey take place in which of the following fish (a) electric ell (b) electric eel (c) electric bat (d) electric crab

43. Which of the following enzymes is needed for light in light- producing insects?
(a) *luciferase* (b) *luciase* (c) *luciose* (d) *lucikinase*
44. Which of the following animals is a light producing animal?
(a) fire flies (b) fire rat (c) fire bat (d) fire bird
45. The following are the similarities between aerobic and anaerobic respiration except (a) both occur in the cytoplasm of plant and animal cells (b) both involve the breakdown of simple sugar to Pyruvic acid (c) respiratory enzymes and co-enzymes are involved (d) both undergo complete oxidation of sugar.
46. Cellular respiration can be divided into …….. and ……. respiration (a) aerobic and glycolysis (b) anaerobic and fermentation (c) aerobic and anaerobic (d) Krebs cycle and glycolysis.
47. Which of the following type of cellular respiration produces high amount of ATP.
(a) anaerobic (b) Krebs cycle (c) aerobic (d) glycolysis.
48. Formulate a chemical equation of an anaerobic respiration in a sprinter.
A. $C_6H_{12}O_6 \longrightarrow 2CH_3COCOOH + 2H_2 + 2ATP$
B. $CH_3COCOOH \longrightarrow CH_3CHOHCOOH + 2NAD + 2ATP$
C. $CH_3COCOOH \longrightarrow C_2H_5OH + CO_2 + 2ATP + NAD^+$
D. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + ATP$
49. Bacteria, yeast, fungi, tapeworm and roundworms are categorize as organisms that respire
A. pyruvically B. aerosoilbically C. anaerobically D. fermentation
50. Predict the type of respiration a terrestrial tree growing in waterlogged soil will undergo while the water last. A. aerobic respiration B. anaerobic respiration C. fermentation respiration D. external respiration

Solution to the Achievement Test on Cellular Respiration (ATCR)

1. B
2. A
3. C
4. B
5. A
6. C
7. A
8. B
9. C
10. D
11. C
12. C
13. B
14. D
15. D
16. B
17. B
18. B
19. C
20. B

21.D

22.D

23.C

24.A

25.C

26.A

27.C

28.A

29.C

30.B

31.C

32.C

33.C

34.A

35.D

36.D

37.B

38.B

39.B

40.B

41.B

42.B

43.A

44.A

45.D

46.C

47.B

48.A

49.C

50.B

Appendices 2

Item Analysis Table of ATCR

Item number	Item difficulty index (p) $p = \frac{N_p}{N} \times 100$	Discrimination index (d) $d = \frac{U_p - L_p}{U}$
1	36	0.77
2	73	0.27
3	86	0.15*
4	75	0.08*
5	61	0.30
6	62	0.42
7	44	0.42
8	36	0.62
9	42	0.81
10	38	0.58
11	29	0.23

12	**43**	**0.38**
13	**59**	**0.30**
14	**67**	**0.04***
15	**51**	**0.50**
16	**52**	**0.62**
17	**53**	**0.50**
18	**60**	**0.50**
19	**22**	**-0.08****
20	**77**	**0.30**
21	**49**	**0.62**
22	**43**	**0.69**
23	**51**	**0.46**
24	**28**	**0.15***
25	**57**	**0.62**
26	**41**	**0.53**
27	**47**	**0.77**

28	**76**	**0.46**
29	**26**	**0.50**
30	**59**	**0.50**
31	**69**	**0.38**
32	**14**	**0.19***
33	**45**	**-0.04****
34	**23**	**0.04***
35	**22**	**0.42**
36	**53**	**0.50**
37	**34**	**0.26**
38	**65**	**0.58**
39	**32**	**0.46**
40	**49**	**0.69**
41	**24**	**0.38**
42	**21**	**0.35**
43	**41**	**0.19***

44	**44**	**0.38**
45	**44**	**0.53**
46	**53**	**0.62**
47	**67**	**0.35**
48	**35**	**0.42**
49	**79**	**0.46**
50	**24**	**0.38**
51	**73**	**0.07***
52	**23**	**0.31**
53	**18**	**0.15***
54	**53**	**0.46**
55	**43**	**0.38**

Note: ** show quiz items to be deleted while ***** show quiz items that will be revised or reconstructed.

Two items (-0.04 and -0.08) and other three items with very low discrimination index (0.04, 0.04 and 0.07) were deleted, while others were reconstructed to have a total fifty (50) quiz items.

Appendices 3

Science Education Dept.,
University of Ilorin,
Ilorin, Nigeria.
14th of July, 2015.

The principal,

Adesina College,

Akobo, Ibadan,

Oyo State.

Dear Sir,

PERMISSION TO CARRY OUT A RESEARCH STUDY IN YOUR SCHOOL

I ODEKUNLE, Olusegun Tayo, Ph. D. student of the above named institution, seeks for your consent and permission to carry out a research work on my study titled " The effects of a computer-assisted instructional package on students' academic achievement in cellular respiration in Ibadan, Nigeria".

Cellular respiration tutorial interactive package will be used as a computer instructional package. The purpose of the package is to make teaching-learning process of cellular respiration more interactive with immediate feedback assessments. This study will last for four weeks in your computer laboratory. Specifically, an intact class of SS1 students of science department with their biology teacher and IT manager will be needed in the course of the works.

I believe this study will promote a meaningful teaching – learning process to the students.

Looking forward for your favorable consideration. Thanks.

Odekunle O. T
Researcher Signature & Date

Principal Signature & Date

Appendices 4

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

FACULTY OF EDUCATION

DEPARTMENT OF SCIENCE EDUCATION

INFORMED CONSENT FORM

Dear Student,

Please be informed that you are selected to participate in a research study. Your consent is hereby required to take part in the study. Detail information about the research is provided below. Kindly endorse this consent form if you volunteer to participate in the study after reading about the research.

Purpose of the Research. The purpose of the research is to determine the effects of use of a computer-assisted instructional package on students' achievement in cellular respiration, as parts of efforts to promote meaningful learning in biology.

Procedure. Student participants will be required to attend series of class lessons on Cellular respiration, a major topic in the biology syllabus. The lessons will take place in their regular class or computer laboratory during the periods allocated to biology on the class timetable. A novel instructional strategies will be used to teach cellular respiration during the lesson. The lessons would last for four (4) weeks only.

Confidentiality. All information provided by you will be treated with utmost confidentiality and used for the purpose of the research only.

Risks. Lessons on cellular respiration will be taught in your regular classroom; hence, no risk is envisaged to your person during the research.

Benefit. The likely benefits to you include meaningful learning of cellular respiration and other related biology concepts in the biology syllabus. You therefore stand to obtain a good grade in biology in the West African Senior School Certificate Examination (WASSCE) and other public examinations required for admission into University.

Rights of Volunteers (Student Participants). Your participation in this research is voluntary; hence, if you decide not to take part or stop your participation in the research at any time, you will not lose anything. If you have any question about this research, you may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria or call the researcher on cell phone number 08169296070.

Student Respondent Agreement. I hereby voluntarily consent to participate in the research. I know that I may refuse to participate or stop my participation in the research at any time. Also, I understand that if I have any question about the research or my right as a student participant, I may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on the cell phone number 08169296070.

_____	_____	_____
Student Participant	Signature	Date
_____	_____	_____
Student's Parent/ Guardian	Signature	Date
_____	_____	_____
Researcher	Signature	Date