USING 5Es LEARNING-CYCLE INSTRUCTIONAL STRATEGY TO ENHANCE SCIENTIFIC REASONING ABILITY AND ACHIEVEMENTAMONG SECONDARY SCHOOL BIOLOGY STUDENTS IN MINNAEDUCATIONAL ZONE, NIGER STATE

BY

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A THESISSUBMITTED TO THE POSTGRATUATE SCHOOL FEDERAL UNIVERSITY OFTECHNOLOGY,MINNA, NIGERIA INPARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN EDUCATION (BIOLOGY)

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ABSTRACT

This study examined using 5Es learning cycle strategy to enhance scientific reasoning ability and achievement among secondary school Biology students in Minna educationalzone.This study was guided by six research questions and six research hypotheses tested at the 0.05 level of significance. It was a pre-testpost-test non-equivalent, non randomizedquasi-experimental design. Intact classes were employed for the study. The population was 58,303Biology students in 90 public senior secondary schools in Minna educationalzone for 2020/2021 academic session. Hence the target population for the study consisted of 19,520 SS II Biology students in Minna educational zone. The sampling technique adopted to select four co-educational public secondary schools in Minna was purposive sampling technique to allow the researcher to make her judgement and choice.Therefore the sample size for this study was made up of two hundred and seventy two (272)with male (120) and female (152) students from four (4) selected co-educational schools in Minna educational zone, Niger State. The sample size was guided by Central Limit Theory. The classroom Test of Scientific Reasoning Ability (ClaTeSRA) and Respiration Achievement Test (RAT) were used to collect data. Reliability coefficient of ClaTeSRA obtained was 0.86 and RAT was 0.81 using Pearson Product Moment Correlation. Research questions were answered with mean and standard deviation, while research hypotheses were tested with Z-test and ANCOVA at 0.05 level of significance. Findings revealed that 5Es learning-cycle strategy enhanced the students' scientific reasoning ability and achievement more than the conventional method. There was no statistical significant difference in the scientific reasoning ability of male and female secondary school Biology students as well as rural and urban students taught with 5E learning-cycle strategy. It was concluded from the study that 5Es learning-cycle instructional strategy has the potency to improve students' scientific reasoning ability and achievement. It was recommended among others that curriculum planners and education stakeholders should endeavour to organize workshops, seminar and symposia for science educators in general and Biology teachers in particulars so that they would be trained on how to use 5Es learning-cycle instructional strategy to enhance Biology students' scientific reasoning ability for better academic achievement.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

All over the globe, science is perceived as the central pillar on which a successful economy is built because it has made innovations came into limelight, and innovation is seen as the driving force of all economic growth. Science provides support in the development of any nation which is the reason it is regarded as a rock upon which any technological career is established. Scientific knowledge has made the world well structured with facilities all around making the world beautiful. The function of science in society is evident and obvious therefore the community has continued to place more emphasis on science and technology. As a result, humanity has gone all out to understand science to make survival easier and comfortable.Science as an area of knowledge gives theoretical explanations based on observation and experimentation about natural phenomena (Akande *et al.*, 2018). It deals with studying the natural environment through which people can develop both enquiry and disciplined logical power of thought. Science is making the world experiencing tremendous development socially and economically. Therefore, it is needless to stress the fact that science is the pillar of modern technology as there are several changes that have been recorded in the different sectors of the economy which have positive impacts on the standard of living.

Yakubu (2018), opined that, the improved standard of living of humanity is due to the knowledge of science that is applied in the day to day activities of the human race. Safo *et al*. (2013) opined that food, shelter, healthcare facilities and services, and clothing are all effects of science and technology. The emergence of science and technology worldwide today provides a means for swift and advance productivity in all aspects of human lives.According to Nweke *et al*. (2011), Nigerians' earnings have been boosted since the emergence of science and technology. It forms the basis for prolonged national development by reducing ignorance, illiteracy, poverty, and diseases. These have a more significant influence on all ramifications of life. The advancement and development of any country in the world technologically depend solely on scientific progress, a strong base of modern technology. This led the Federal Government of

Nigeria in the National Policy on Education (FRN, 2014), to emphasize the teaching of science at all levels of education to acquire scientific knowledge which is a strong foundation for science and technology.

Scientific knowledge obtained by students at both primary and secondary levels of education enables them to opt for courses like Medicine, Botany, Biochemistry, Zoology, and pharmacy. Yakubu (2018), concurred with the assertion when he penned that, science is the bedrock upon which virtually all technological breakthroughs are established. The place of science in the development and fulfillment of the needs and aspiration of any country rest on the success of its students in science related fields. Success in sciences like Biology and other science subjects has brought changes through innovations in telecommunications, transportation, medical health services, agro-allied industry and lot more due to success in the three natural sciences.

Science education is an important field of endeavor as it deals with teaching and learning of science to school children, college students, or adults within the general public who are not considered traditionally to be members of the scientific community. Science education concentrates on the teaching of science contents, science process, and method of teaching or addressing misconceptions held by learners regarding science content. Science education aims to increase the understanding of people in science and the construction of knowledge as well as to promote scientific literacy and responsible citizenship (Mbajiorgu, 2019). Science education has the potential for helping the development of the required abilities and understanding by focusing on developing powerful ideas of science and ideas about the nature of scientific activity and its applications. According to Jacob (2013), science education is very important to the development of any nation that is why every nation must take it very serious in all institutions of learning. Developed countries were able to achieve so much in science and technology because of science education. Science education comprises of the three science subjects: chemistry, physics and Biology which are combined with education. Biology education is very important to any growing economy like Nigeria. Many graduates of Biology education are self employed and employers of labour; many of them who owned schools do not need to buy chalk outside anymore and they can equally produce for other schools. Biology education trains Biology students on the concept of Biology taking into cognizance the three domains of learning (cognitive, affective and psychomotor), as well as training them on science methods and processes in order to build science process skills, investigative skills and reasoning skills.

Biology is one of the natural science disciplines taught at secondary school level in Nigeria; others are physics and chemistry. One of the core branches of natural science is the science that studies life (both the life around and within us), thus making it the most significant science area to human endeavor. The most liked and enjoyed of the three natural science disciplines amongst senior secondary school students in Nigeria is Biology (Jibril *et al*., 2015). Also, Biology is the most simpleto understand among the science subjects that is why it normally attracts the widest enrolment among Nigerian students (Adewale *et al*., 2016).

Biology is concerned with how the living world came into existence, its functions and the interdependent relationship between living organisms and their environment (Umar, 2011). Biology as a branch of science offers opportunities for students to promote learning awareness. It enhances the actualization of an individual's abilities and possibilities for;

1. Understanding scientific methods or processes which include observation, measuring, data collection, drawing accurate inference, and conclusion during experimentation.
2. Equipping individuals with the knowledge of vocational selection such as Medicine, Pharmacy, Nursing, microbiology and biochemistry (Akande *et al*., 2018).
3. Providing a benchmark for human medicine, biochemistry, dentistry, food production, biotechnology, microbiology, pharmacy, zoology and botany.
4. An individual to understand the basic principles of life as well as understand the proper functioning and working in their body system
5. Development of enquiring mind through making observations of nature and answering biological questions (Akande *et al.*, 2018).

Biology contains several topics taught in secondary school which are featured in both internal and external examinations.Cellular respirationis one of the topics in properties and functions of cell, and it is contained insenior secondary school Biology curriculum. It has contents such as aerobic and anaerobic respiration, krebs cycle and glycolysis. Questions drawn from this topic appeared often in both the West African Senior School Examinations (WASSCE) and the Senior School Certificate Examinations conducted by National Examination Council (NECO) for senior secondary school students. Biology is perceived to be a vital science subject, despite its importance, reports from research have it that there is a high rate of failure in the subject, especially in areas tagged as difficult topics (Ihejiamaizu *et al*., 2018)). The teaching and learning of science and Biology particularly has not been very successful over the last decade or more. The gradual depreciation in the quality of teaching and learning and failure rate in Biology,is characterized by the poor performance of students in Biology examination conducted by WAEC for period of six years (2013-2018), see Appendix A. According to WAEC chief examiners report (2019), students had issues with certain topics and performed poorly in them such as genetics and cellular respiration. WAEC chief examiner reported in 2018 that, the poor performance of students is attributed to the continuous use of conventional teaching methods by teachers. According to Samba, and Eriba, (2012), respiration has explicitly been identified as one of the concept that teachers perceived to be complicated. Therefore, contents relating to this concept are pointed out by teachers who teach them to be complicated. Aremu, and Sangodoyin (2010); Cimer (2011) also reported that respiration and photosynthesis, among other topics, are some sub-topicsperceived to be abstract and complex for students to understand. When a concept is noticed as challenging to teach, subject teachers tend to avoid introducing it. This automatically and continuously means that students will avoid answering questions from such concepts in the examinations because they lack understanding of such concepts and candidates will be recording a high rate of failure. One of the major factors contributing to the poor performance of students in Biology is instructional strategy (Yakubu, 2018).

Instructional strategy is a tactic that, teachers adopt in the classroom during the teaching and learning exerciseswhich is tailored to the needs of the students to help them achieve their learning goals. According to Yakubu (2018), Teaching Resources (2015), defined instructional strategy as a method used in teaching and learning processes that allows to activate students' curiosity about a topic, engage students in learning, and probe critical thinking skills to better understand the course content. The teaching method adopted by teachers in teaching a particular concept matters a lot. There are traditional teaching methods (such as lecture, discussion, role-play and so on) and innovative instructional strategies. The innovative instructional strategies are activity-based, and learners centered, when used effectively can improve teaching and learning of Biology concepts.

Among the creative instructional strategy is the learning-cycle. It allows students focus on certain activities and play effective students role, emphasizing that students are the producers of their knowledge. 5Es learning-cycle is a type of learning-cycle which when utilized in the classroom to teach can enhance the teaching of difficult conceptsin Biology (Ihejiamaizu *et al*., 2018). 5Es learning-cycle is the focus of this study.

The 5Es learning cycle was developed by Rodger Bybee for the Biological Science Curriculum Study (BSCS) to deliver meaningful inquiry experiences (Bybee, 2015). The 5Es model is a constructivist approach and allows educators to utilize a sequential series of steps in cycle to incorporate inquiry and enables students produce their knowledge and concept understanding within lessons. The 5Es cycle gets its name from initials of the words and number of phases. These are Engage, Explore, Explain, Elaborate, and Evaluate (Bybee, 2015). At the engagement phase, the teacher introduces task to the students, connections to past learning and experience can be involved. A demonstration of an event, presenting a phenomenon or problem or asking pointed questions can be used to focus the learners' attention on the tasks that will follow. The goal is to arose their interest and involvement. At the exploration stage, learners participate in activities that allow them to work with materials that give them a 'hand on' experience of the phenomena being observed. Simulations or models whose parameter can be manipulated by learners to build relevant experience of the phenomena can be provided. Questioning, sharing and communication with other learners should be focus at the explanation stage. The learner is encouraged to put observations, questions, hypotheses, and experiences into language from the previous stages. Communication between learners and learner groups can spur the process. The instructor may choose to introduce explanations, definitions, mediate discussions or simply facilitate by helping learners find the words needed. At the elaborate stage, students use the understanding gained in the previous stages; now, learners are encouraged to build and expand upon it. Inferences, deductions, and hypotheses can be applied to similar or real-world situations. Varied examples and applications of concepts learnt to strengthen mental models and provide further insight and understanding. Evaluation is ongoing and may occur at all stages to determine that learning objectives have been met and misconceptions avoided. Any number of rubrics, checklists, interviews, observation or other evaluation tools can be used. At this phase, the teacher poses varying questions to the learners that take them deeper into a concept. It provides an opportunity for students to demonstrate what they understand about scientific inquiry and how they can apply their knowledge. Thus, helps provide students with valuable, quality experiences. "creating teachable moment" becomes the goal of the teacher with this model and students are central to their own learning experiences within a carefully constructed learning progression in which students must adjust their understanding over time as they infer from their observations. 5Es learning-cycle strategy enables students to engage in cognitive and metacognitive activities which are the backbone of their logical thinking.

Different research works have been conducted on learning-cycle instructional strategy both outside and within the country. Still, few have been found researched on in Nigeria, particularly in Biology. Among studies found on learning cycle in Biology are those operated by Patrick and Urhievwejire (2012); Ajaja (2013); Babalola, *et al.* (2019); Ibrahim (2015): Sadi and Cakiroglu (2010). The above studies were conducted in Biology but not on using 5Es learning-cycle instructional strategy to enhance scientific reasoning ability and achievement among secondary school Biology students. Also, only few works have been found on how students in rural and urban areas were engaged on scientific reasoning ability. These were the gaps that were filled by this research study. To achieve the goal, the study examined using 5Es learning-cycle instructional strategy on the scientific reasoning ability and achievement among secondary school Biology students in Minna educational zone, Niger State.

Scientific reasoning which is an essential variable in science involves the application of logic principles to scientific methods – the formulation of hypotheses, the pursuit of explanation, the making of prediction, the analysis of data, the solution of the problem, the control of variables, the creation of experiment, the development of empirical law – all is in a logical way and in such a way to make sense (Wenning & Vierya, 2015). Scientific reasoning could involve making generalizations from specific information (inductive reasoning) or drawing specific conclusion from general principles or premises (deductive reasoning). As students are involved with 5Es learning-cycle strategy, they take active role in their education which probes analytical thinking in them which allows the students develop reasoning and problem solving skills involved in knowledge acquisition and knowledge change that results from the learning-cycle activities. Therefore, it is necessary that students of all educational level develop it as well as investigative skills necessary to manage daily life problems successfully and life-long learning skills which may have a long term impact on the academic achievement of students.

The academic achievement of students is a crucial aspect in the teaching and learning process. Students' achievements are measured by their performance in tests, assignments and examinations, which are summed up at the end of the term. Academic achievement is the degree of success students attain after being taught or passed through a learning process. According to Jimoh (2014), academic achievement is the level of success achieved by a student in school subjects. An instructional strategy is a crucial variable that influences students’ achievement. One of the classroom instructional strategies is the 5Eslearning cycle. It is used to indicate students’ level of success in a particular task they were previously exposed to and it can also be used as indices for determining students’ ability to undertake another task effectively. According to research report gender may be a determinant of students’ academic achievement and reasoning ability.

In a typical classroom that is co-educational where male and female co-exist and interact in the learning process, the existence of male and female is called gender. Gender is essential for students' scientific reasoning ability and achievement in science subjects in general and Biology in particularat the secondary school level. There are different findings concerning the influence of gender on scientific reasoning and achievement of science students. Some researchers think that, gender has no effect on scientific reasoning abilities and achievement. Others believe that, gender influences scientific reasoning and academic achievement. Piraksa *et al*., (2014) recorded that gender does not have any impact on students’ scientific reasoning abilities for each construct they used in the research. Similarly, Bada, and Dokubo (2011), had it that there is no significant difference in the performance of Male and female students in mathematics and science. In view of the above, this study worked on using 5Es learning cycle instructional strategy to enhance scientific reasoning ability and achievement among secondary school Biology students taking cognizance of Gender of students involved in the research. School location is another variable examined in the study.

School location is the exact place in the physical environment, when compared to other areas (rural or urban), where a school is sited (Madaki, 2021). In Nigeria, life and activities in rural area is the same, homogenous and less complex. The environment lacks basic infrastructures, the use of local dialect is promoted and the inhabitants have lesser opportunities. Schools in this area have inadequate facilities when compared with urban dwelling. Urban centers on the other hand have modern facilities, more opportunities and are highly favoured in many areas such as provision of library, increasing industrialization, health facilities, better educational facilities, good number of qualified teachers, good use of English language in schools (Alordiah *et al*., 2015). This will only mean that learning opportunities in schools located in rural and urban centers will not be the same, and consequently the development of scientific reasoning skills and achievement of students could differ. She added that, the medium used in teaching students in secondary schools is English language, and what obtains in rural settlement is their local language, therefore, building scientific reasoning ability, and achievement of students in rural and urban centerswill not be the same. According to Madaki (2021), research studies have shown positive influence on students learning outcome and achievement based on school location while others have shown negative influence of school location on scientific reasoning and achievement of students. Due to the inclusive submissions the present study equally examined the influence of school location on students reasoning ability and achievement using 5Es learning-cycle strategy.

1.2 Statement of the Research Problem

Secondary school Biology students ought to be exposed to the right learning experiences with modern and student-based instructional strategies, take more of an active role in their education, be independent strategic learners, curious about a topic and be engaged in a kind of learning situation that would probe logical thinking to scientific methods for the better understanding of course contents and for a better technological society. Research reports, have it that, students' performance in science-related subjects, Biology inclusive at Senior Secondary Certificate Examinations is a thing to worry about as the results are not consistent (Akande, 2018). The poor performance of students at both internal and external examinations in Nigeria and Niger State, in particular, is of great concern to Nigerians, Niger State government, parents and well-meaning Nigerlites and Nigerians. Teaching and learning of science in Nigeria secondary schools and Niger State in particular should be done in such a way that students are exposed to scientific processes in the laboratory with strategies that would promote or enhance students' thinking and reasoning abilities and achievement.

Unfortunately, achieving this goal has become a daunting task as most secondary school teachers use the conventional teaching methods to instruct students. According to WAEC Chief Examiners’ Report (2019), students performed poorly in certain topics such as genetics and cellular respiration. This he said is attributed to the continuous use of conventional teaching methods. Students that are supposed to be analytical, logical thinkers and explorers are subjected to only passive learning. It is a known fact from research that the continuous use of traditional teaching method makes students tolerant rather than active learners and as such affects theirs exploring capabilities and hence, affects their reasoning ability and achievement. For scientific reasoning ability and achievement to be enhanced a constructivist approach, which is inquiry-based strategy is required. In response to this problem, the researcher proposes using 5Es learning-cycle instructional strategy, an inquiry-based strategy, to train students to develop scientific reasoning and enhance achievement of students. The study is therefore aimed at using 5Es learning-cycle instructional strategy to enhance secondary school Biology students' scientific reasoning ability and achievement in Minna educational zone, Niger State.

1.3 Aim and Objectives of the Study

The study aimed at using 5Es learning-cycle instructional strategy to enhance scientific reasoning ability and achievement amongsecondaryschool Biology students in Minna educational zone, Niger State. Specifically, this study achieved six (6) objectives which were to determine;

1. the scientific reasoning ability of secondary school Biology students taught using 5Es learning-cycle strategy and the group taught with lecture method
2. the mean academic achievement of secondary school Biology students taught using 5Es learning-cycle strategy and the students taught respiration using lecture method
3. the scientific reasoning abilityof male and female secondary school Biology students taught Biology using 5Es learning-cycle strategy
4. gender academic achievement ofsecondary school Biology students taught respiration using 5Es learning-cycle strategy
5. the scientific reasoning ability of secondary school Biology students in rural and urban centers taught Biology using 5Es learning-cycle strategy and the students taught using lecture method
6. the academic achievement of secondary school Biology students based on school location taught respiration using 5Es learning-cycle instructional strategy and the students taught using lecture method.

1.4 Research Questions

The following research questions were raised that guided the study:

1. What is the significant difference in the mean reasoning ability scores of secondary school Biology students taught using 5Es learning-cycle instructional strategy and those taught using the lecture method?

2. What is the significant difference in the mean achievement scores of secondary school Biology students taught Biology concepts using 5Es learning-cycle and those taught with lecture method?
3. What is the significant difference in the mean scientific reasoning ability scores between male and female secondary school Biology students taught using 5Es learning-cycle instructional strategy?
4. What is the significant difference in the mean achievement scores between male and female secondary school Biology students taught Biology using 5Es learning-cycle Instructional strategy?
5. What is the significant difference in the mean scientific reasoning ability scores of secondary school Biology students in rural and urban centers taught using 5Es learning-cycle instructional strategy?
6. What is the significant difference in the mean achievement scores of secondary school Biology students based on school location taught Biology using 5Es learning-cycle instructional strategy?

1.5 Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significant.

HO_1: There is no significant difference in the mean scientific reasoning ability score between secondary school Biology students taught using 5Es learning-cycle and those taught with lecture method.

HO_2: There is no significant difference in the mean achievement score between secondary school Biology students taught with 5Es learning-cycle strategy and the group taught using lecture method.

HO3: There is no significant difference in the mean scientific reasoning ability score between male and female secondary school Biology students taught using 5Es learning-cycle instructional strategy

HO4: There is no significant difference in the mean achievement score between male and female secondary school Biology students taught using 5Eslearning-cycle instructional strategy.

HO5: There is no significant difference in the mean scientific reasoning ability score between secondary school Biology students in rural and urban center staught using 5Es learning-cycle instructional strategy.

HO6: There is no significant difference in the mean academic achievement score between secondary school Biology students in rural and urban centers taught using 5Es learning-cycle instructional strategy.

1.6 Scope of the Study

The study was carried out in Minna, the capital of Niger State, involving secondary schools Biology students. Niger State is located in the North Central geopolitical zone in Nigeria. The state lies on latitude 9^0 36' 54.86" and longitude 6^0 32'51.94'E; the state shares a country border with the Republic of Benin (West) and state borders within Nigeria. These include the Federal Capital Territory (FCT) on the South-East, Zamfara (North), Kebbi (North-West), Kwara (North-Central) and Kaduna (North-East).

The study was conducted in four co-educational public secondary schools in Minna educational zone, Niger State. The concept scope was respiration, the concept was chosen for the study because it is considered complicated and difficult to comprehend (Samba and Eriba, 2012), resulting in poor performance of students in both internal and external examinations. In WAEC Chief Examiners report (2019), respiration among other topics recorded high failure rate in WASSCE. Senior secondary two (SS II) students were involved in the study, because the concept was contained in SSII syllabus and senior secondary two students were not preparing for Senior Secondary Certificate Examination (SSCE) and (SS1) students were not stable at the time. The schools used for the study include Hill-Top Model School, Minna, Day Secondary School, Pyata, Government Science College, Chanchaga, and Day Secondary School, Garatu.The independent variables are 5Es learning-cycle and conventional instructional strategies. The dependent variables are scientific reasoning ability and achievement, while gender and school location are the moderating variables. The time scope was five (5) weeks

1.7 Significance of the Study

The outcome of this research study would be helpful to senior secondary Biology students, teachers, Ministry of education, curriculum planners, researchers and parents.

The findings of this study would benefit the students as 5Es learning-cycle encourages inquiry and it is activity-based, which would enable secondary school science students develop interest in science concepts and also broaden students' understanding of difficult and abstract concepts. This is important in teaching and learning of Biological concepts for better academic achievement and scientific processes. Hence their exposure to the strategy can enhance their scientific reasoning ability and achievement.

Exposure of Biology teachers to the findings of this study would provide useful insight that would help determine the appropriate instructional pedagogy that teachers would adopt if they want teaching and learning at this level of education to be meaningful. Biology teachers' exposure to the findings of this study would make them and other science teachers to be innovative in their teaching technique and provide clear awareness of 5Es learning-cycle instructional strategy and how to employ it in the teaching and learning of respiration and other difficult topics in Biology and science in general. This would be achieved through exposure to workshops, seminar, symposia and conferences.

It would benefit Ministry of Education, in the sense that it would enable them to be aware of the importance of innovative instructional strategies. This can be ascertained from the level of students' performance in both reasoning and achievement test when 5Es learning cycle is use to teach students. Therefore, it would sensitize the Ministry of Education to provide materials, equip laboratories and provide the appropriate learning environments for better performance by both teachers and students.

The findings would serve as a guide to curriculum planners and curriculum development bodies in Nigeria like NERDC to modify the curriculum to infuse and emphasize on the importance of scientific reasoning skills and innovative instructional strategies like 5Es learning-cycle in secondary school Biology curriculum to teach respiration and other difficult concepts in Biology. This would be achieved by exposing the teachers to the findings of this study either through conferences, seminar, and workshop or refresher programs.

It would alsohelp professional bodies such as Science Teachers Association of Nigeria (STAN), in collaboration with the Federal Ministry of Education, State Ministry of Education to organize conferences and workshop to teach Biology teachers on how to incorporate innovative strategies of instruction such as 5Es learning-cycle in the teaching of respiration and other difficult concepts in Biology using these findings as a guide.

The findings of the study would benefit researchers as it would serve as a reference point for further studies. Based on the suggestions made for further research, researchers can carry out similar study using other Biology concepts and subject areas. 5Es learning-cycle is an inquiry strategy and as such researchers could bring up ideas on how to use it on other variables.

Exposure of the findings to parents would enable them to be aware of the importance of 5Es learning-cycle to the performance of their wards, and can make submissions to the government through PTA meetings suggesting what government should do to bring about implementation of 5Es learning-cycle and other modern instructional strategies.

1.8 Operational Definition of Terms as used in the study

Instructional Strategy: this is a method a teacher employs to teach students skillfully to become independent, strategic learners, which could assist them in accomplishing tasks or goals.

Learning-Cycle: this is the constructed learning strategy that the researcher employs in guiding the students to learn by themselves.

5Es: These are the initials of words that begin with the letter E which constitutes the five phases adopted in the learning-cycle. They are engage, explore, explain, elaborate and evaluate.

Engage: this is the first E and first phase of the 5Es in the learning-cycle. It is known as “inquiry mind” where students are introduced to tasks.

Explore: It is the second E and second phase of the 5Es in the learning-cycle strategy. It is also known as “working with questions”.

Explain: This is the third E of the 5Es in the learning-cycle. It is known as communication of findings of scientific investigation.

Elaborate: The fourth E is elaborate. At the elaboration phase students extend what they have learnt on respiration to what obtains in real life

Evaluate: It is the fifth, and final E and phase of the 5Es. It is known as pulling it "AII Together," providing a snapshot of what the students understand

Scientific Inquiry: The process where students investigate the materials or lesson aids provided by the teacher to find answers to the questions or problems on respiration tabled before them

Scientific Reasoning: It means the ability of the Biology students to think very well andfind answers to the logical questions which involves scientific knowledge that is given to them. It is determined by classroom test of scientific reasoning ability.

Scientific Reasoning Skills: These are the various reasoning abilities (deductive and inductive) that the studentspossess or developed during the teaching and learning of respiration.

Achievement: This is the learning outcome of the students which is measured by respiration achievement test (RAT).

RAT: This is Respiration Achievement Test instrument, used to determine the achievement of students on respiration concept after treatment.

ClaTeSRA: Classroom Test of Scientific Reasoning Ability, Instrument on reasoning.

Gender: Thesex of the students, male or female.

School Location: This is the area in Minna educational zone (rural or urban) where the schools involved in the study are built.

Rural Area Schools: These are schools within the zone that are outside Minna town.

Urban Area Schools: These are schools in Minna town.

Deductive Reasoning: It is the logical thought ability that the Biology students developed when they answered questions correctly from general principles or when they are able to find answers or understand particular question asked.

Inductive Reasoning: This is the logical thought ability that the Biology students built when they employed specific principle to reach a general conclusion about a problem.

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE

2.1 Conceptual Framework

The relationship that exists between the three major variables in this study; the dependentVariables (scientific reasoning ability and achievement), the independent variables (5Es learning-cycle strategy and lecture method) and moderating variables (gender and school location) are established. The conceptual framework is illustrated in the conceptual map as shownin Figure 2.1.

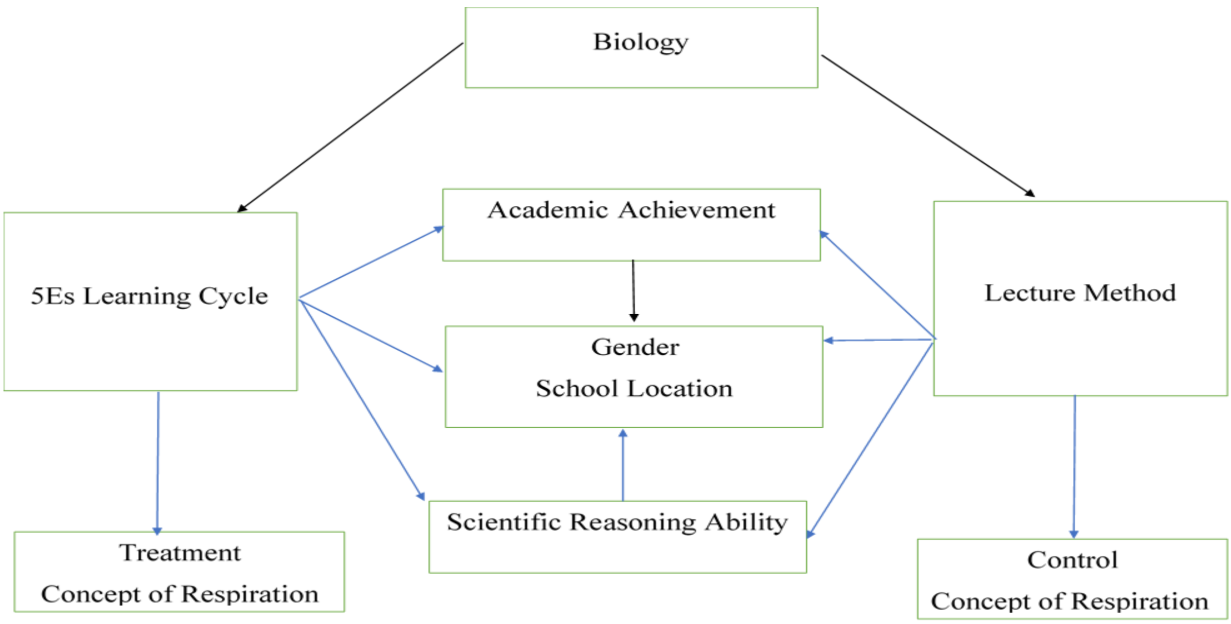

Figure 2.1: Conceptual Framework

The conceptual map in Figure 2.1 above shows Biology as the subject involved in the study, 5Es learning-cycle and lecture method as the teaching strategy and method respectively adopted in instructing the students.5Es learning-cycle strategy which is the treatment is adopted for teaching respiration to the experimental group while lecture method (conventional method) is adopted for instructing the control group. It has been generally adopted that scientific reasoning ability and achievement of students are improved by constructivist approach. The 5Es learning-cycle is a constructivist approach and it includes: engage, explore, explain, elaborate and evaluate. 5Es learning-cycle instructional strategy is an independent variable, and the study agrees that scientific reasoning ability and achievement could be enhanced by it.There is relationship that exists between the independent variables (5Es learning-cycle and lecture method), dependent variables (scientific reasoning ability and achievement) and moderating variables (gender and school location) as illustrated in the conceptual map in Figure 2.1. The moderating variables are believed to ignite the potency or capability of independent variable on the dependent variables.It means that gender and school location can determine how effective 5Es learning-cycle instructional strategy and lecture method are on scientific reasoning ability and achievement of students if the learning environment is conducive, if the Biology laboratories are well equipped as well as availability of good and qualified teachers in schools and lastly, if the moderating variables have the right attributes. There is an established relationship between the various components of the 5Es learning-cycle. The 5Es are administered in sequence accordingly from engage to evaluate. Engage which is the first E of the 5Escomes before explore, the second E, and through to the last E which is evaluate. The 5Es are linked and occur in phases (Bybee, 2015). As teaching and learning take place using this strategy, students are opportunedto make inquiry from materials and learning aids provided to construct their knowledge. Therefore, it promotes meaningful understanding of scientific concepts due to its activity-oriented nature. It promotes active and collaborative learning, develops critical thinking skills, problem-solving skills, scientific process skills, logical and reasoning skills in students (Febrianto *et al*., 2018). According to Mahmod (2017), the reasoning abilities developed by students correlate with achievement of content learning. Also, Piraksa *et al.* (2014), opined that understanding and achievement of students in science is determined by their scientific reasoning ability.

In a nutshell, it can be said that dependent variables (scientific reasoning and achievement) make up the outcome of independent variables, that is how well scientific reasoning ability is built and achievement made depend on 5Es learning-cycle instructional strategy and lecture method. However, the two variables are interdependent and correlate in such a way that it influences each other in its real life long learning processes.

2.1.1 The Concept of 5Es learning- cycle instructional strategy in education

Learning-cycle is a sequential instructional strategy that helps students to learn the content of the lesson meaningfully (Bybee, 2015). It promotes meaningful understanding of scientific concept in students due to its activity-oriented nature. It also explores and deepens that understanding in application to a new situation. 5Es learning-cycle is a type of learning-cycle used in teaching and learning of scientific concept. 5Es learning-cycle is a sequential learning experience that gives students the opportunity to construct their understanding over time. The cycle leads students through five phases of learning that are easily described using words that begin with the letter E: Engage, Explore, Explain, Extend and Evaluate (Babalola *et al.*, 2019). The illustration of how the five Es are implemented across the lessons is described in the following phases shown in Figure 2.2.

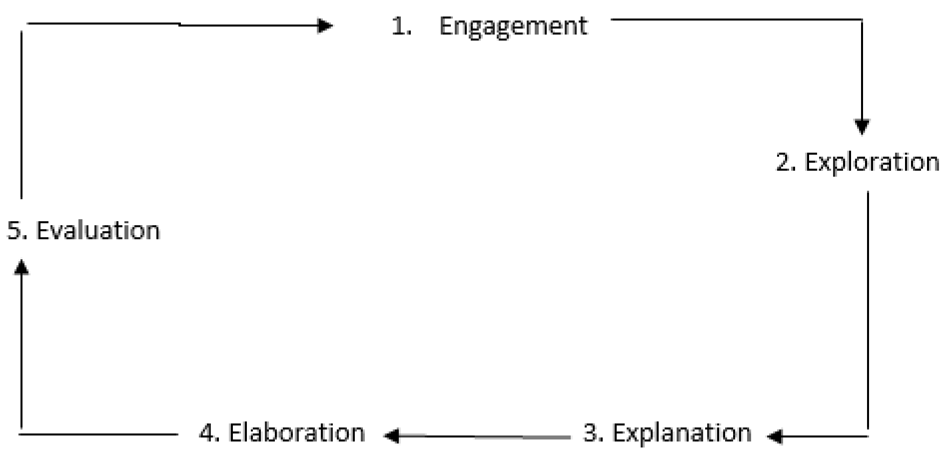

Figure 2.2: The phases of 5Es learning-cycle

Engagement phase:

The engagement phase is characterized by the introduction of a task to the students. Students come to learning situations with prior knowledge. The engage lesson provides the opportunity for teachers to find out what students already know or think they know about the topic and concepts to be covered by asking them invocating questions. The engage phase, tagged inquiry minds, is designed to pique students' curiosity and generate interest, determine students' current understanding about scientific inquiry, invite students to raise their own questions about the process of scientific inquiry, encourage students to compare their ideas with those of others, and enable teachers to assess what students do or do not understand about the stated outcomes of the lesson.

Exploration phase:

At the exploration phase (phase 2) tagged working with questions, students investigate the nature of scientifically testable questions, probably by conducting activities that enable them manipulate the teaching aids or work with materials that will guide their understanding of the content of instructions. Student engages in short readings and generates their own set of testable questions. This lesson provides a common set of experience within which students can begin to construct their understanding. Students interact with materials and ideas through classroom and small-group discussion.

Explanation phase:

At the explanation phase (phase 3) tagged conducting scientific investigation, teachers interpret the activities of the previous phases, it provides opportunity for students to connect their previous experiences with current learning and to make conceptual sense of the main ideas. This stage allows for the introduction of formal language, scientific terms, and content information that might make students' previous experiences easier to describe. Students are guided to communicate their discoveries or findings.

Extension or Elaborate phase:

At the extension or elaboration phase, the knowledge or experiences, gained by learners are extended to real situation. Teacher introduces new information that extends what the learners have learnt during their activities. Students make conceptual connections between new and former experience, connect ideas, solve problems, and apply their understanding to a new situation.

Evaluation phase:

The evaluation phase (phase 5) tagged pulling it 'All Together', is the final phase of the instructional cycle, but it only provides a “snapshot” of what the students understand and how far they have come from where they began. At this phase, teacher poses varying questions to the learners that take them deeper into a concept. This phase provides an opportunity for students to demonstrate what they understand about scientific inquiry and how well they can apply their knowledge to carry out their own scientific investigation and to evaluate an investigation carried out by a classmate. It also assesses the student's progress by comparing their current understanding with their prior knowledge. The focus of this study is to enhance secondary school students Biology reasoning ability and achievement with 5Es learning cycle strategy in Minna educational zone of Niger State.

2.1.2 Origin of 5Eslearning-cycle instruction model

The origin of 5Es learning-cycle instructional model has its foundation on several instructional models, particularly those that influenced the development of the 5Es instructional model. The historical models include those developed by Johann Herbart, in 1901 (which is concerned with students' interest and conceptual understanding) (Herbart, 1901) and John Dewey (which is based on experience and indispensable traits of reflective thinking: preparation, presentation, generalization and application) (Dewey, 1966), as well as to a greater extent, the philosophical and psychological model presented by Atkin and Karplus (1962) as cited in (Bybee *et al*., 2006).

The Atkin-Karplus Learning Cycle was developed as early as 1962 by two American citizens, one an educationist by name Myron J. Atkin and the other a theoretical physicist, Robert Karplus. Myron developed an effective learning cycle for the Science Curriculum Improvement Study (SCIS). This learning model consists of three phases, 'Exploration', 'Terminology' and 'concept application, which could also be referred to as 'Exploration', 'Invention', and 'Discovery' (Mulder, 2019). He added that the learning cycle made students started having interest in subjects, began asking questions, and found out that they needed to look carefully at their own insights.In the late 1950's the theoretical physicist, Robert Karplus, who was at the university of California, had interest in science education. The interest he had made him explored children's thinking and their explanations on natural phenomena. By 1961, Karplus started joining the work of Jean Piaget, on developmental psychology to the design of instructional materials and science teaching. In the same year Myron J. Atkin, at lllionois University collaborated on a model with Karplus because he shared Karplus's ideas about teaching science to young children. The model they collaborated on was of guided discovery in instructional materials. The Aktin-Karplus model forms the basis of the 5Es instructional model (Mulder, 2019).

The 5Es learning cycle was developed by Rodger Bybee originally for the Biological Science Curriculum Study (BSCS) science learning in the year 1987 during a retreat in Colorado that was part of the curriculum development of BSCS science for life and living (Bybee *et al.*, 2006; Mulder, 2019). Karplus and Atkin learning cycle developed for the (SCIS) form the rock upon which the BSCS 5E learning cycle was built. The research conducted by National Research Council reported that how people learn, supports the design and sequence of the BSCS 5Es learning cycle model. For a long time now, since the late 1980's BSCS has used the 5Es learning cycle model greatly in curriculum materials development as well as in professional development experiences. The BSCS 5Es learning cycle phases include; Engagement, Exploration, Explanation, Elaboration and Evaluation (Bybee, 2015). From the brief history above it can be deduced that the three middle elements of 5Es learning cycle are fundamentally equivalent to the three phases of the SCIS learning cycle.

Table 2.1 Comparison of the Phases of the SCIS and BSCS 5E learning

SCIS Model	BSCS 5E Learning Cycle
	Engagement (New phase)
Exploration	Exploration (Adapted from SCIS)
Invention (Term Introduction)	Explanation (Adapted from SCIS)
Discovery (Concept Application	Elaboration (Adapted from SCIS)
	Evaluation (New phase)

According to Bybee (2015), the 5Es learning cycle Model is still an effective method for teachers to design science lessons aimed at meaningful understanding and active construction of knowledge. In addition to the exploration, concept or term introduction and concept application phases of SCIS learning cycle, Robert Bybee added two additional phases as shown in Table 2.1 above, which are the engage and evaluate. Therefore, the 5Es learning cycle model has five phases: Engage, Explore, Explain, Elaborate and Evaluate. The three phases of the SCIS learning cycle (Exploration phase, concept introduction phase and concept Application phase) align with explore, explain, and elaborate phases of the 5Es learning cycle model respectively.

In 5Es learning-cycle the initial engage phase is a new phase during which teachers assess students for their prior knowledge and generate students' interest concerning the topic at hand. In the second phase (explore), teachers ask provoking questions which encourage students to get involved in various hands-on/ minds-on activities to find answers to questions. The phase is aligned to the exploration phase of the SCIS learning cycle when students are encouraged to explore. In the third phase (explain), teachers encourage students to explain the concept and relate it to the big ideas they learnt from the results of their investigations and together with the teacher, provide the necessary explanation regarding the topic. This phase is similar to the concept introduction phase of the SCIS learning cycle where students are provided with opportunity to explain their ideas. The elaborate phase is aligned to concept application in which learners extend the knowledge or experiences gained to real life situation. The evaluation phase is a new phase and learners progress is assessed. In the evaluation phase, learners understanding is determined by comparing it with their prior knowledge.

2.1.3 5Es learning- cycle instructional strategy as a scientific inquiry tool

A very familiar tool in science education that enhances critical and logicalthinkingwhen a question or phenomenon is investigated is the scientific inquiry. Scientific inquiry is defined as an educational tool which enhances critical thinking by investigating a question or problem (Dodge, 2017). It involves seeking information or knowledge by questioning. Jean Piaget ideas are related to the concept of inquiry. He brought to light that sequence by which children, inside of them revise their thinking about how the world works are through what they observe and experience. From his study of children and how they viewed the world, he guessed that children gradual increase of knowledge is built over a period of time and adaptation allows children to put in practice what they have observed to expected challenges. The backbone that supports the idea of constructing knowledge and building understanding from experience and written thought in science education is the idea of John Dewey (Bybee, 2015). Knowledge can be constructed, and experience built when students are engaged in inquiry learning using 5Es learning cycle strategy. Dewey felt certain in connecting students hypotheses, subsequent experiences, and conclusions through reflection and realized that the experiences acquired by students in the classroom is paramount and needed to provide privileges for students skills development they will need for their future lives endeavors and problem solving making students to become more engaged or involved in their learning which gives them the opportunity to better develop a growing sense of inquiry learning-based experience, logical and critical thinking skills.

Logical and critical thinking is essential in science learning, and for inquiry learning-based experiences to be provided for students. A scientist Rodger bybee, developed the 5Es learning model which is made of Dewey instructional model and Atkin and Karplus learning cycle (Bybee, 2015 & Sickel, 2015). The 5Es learning cycle model letsteachersinstruct students in a cyclical order to include inquiry in the learning processes. In the 5Es learning cycle the students engage, explore, explain, elaborate and are then evaluated. This promotes valuable and quality experiences that Dewey described it as valuable tool. Also teachable moment for teacher is experienced and students are central to their own learning experiences as learning continues from one step to the next changing their understanding over time. Students have the opportunity to reflect on their previously held misconception or assumptions. It allows students to experience failure and learn from their mistakes, a skill that is important not only in sciences, but other field as well, making students to revise on their thinking to understand phenomenon better, and experience individual conceptual change. Cooperative and collaborative learning is equally promoted with this strategy which is an inquiry-based-learning tool.

Inquiry-based-learning using 5Es learning cycle instructional strategy help to create a classroom culture that permit questioning (Dodge, 2017). It provides a useful and a valuable tool to build questioning skill by asking thoughtful questions, observing phenomena and then connecting it to their knowledge of the world, understanding how the world works and build the critical thinking skill needed to take decision and analyze problems. The experience is beneficial to the students, the school community and teachers as well in developing ability which provide meaningful educational experience that prepares them for the real world.Some of the scientific enquiry skills identified by the National Research Council that science students are expected to build up include the following; (1) identifying questions, problems and concepts that guide scientific investigation (2) Designing and conducting scientific investigations (3) Using technology and mathematics (statistics) to improve investigations and communications, (4) Formulating and revising scientific explanations and models using logic and evidence (5) Recognizing and analyzing alternative explanations and models, (6) Communicating and defending a scientific argument, (7) Understanding how these inquiry skills inform our understanding of the nature of science (Dodge, 2017). In spite of the numerous inquiry skills mentioned by National Research Council (NRC) they have the same idea and students learning opportunities that rely on using questions during their process of inquiry, making inquiry to also mean questioning phenomenon and revising pre-existing thought to include newly integrated knowledge. Therefore, for guided inquiryto be implemented properly, 5Es learning cycle instructional model should be utilized (Bybee, 2015).

Guided inquiry gives students opportunity to tackle a question posed, and students are opportune to communicate and interpret results, which enables them to grow and increase in knowledge within the classroom. When students are not guided and are left to inquire especially in areas where they have little background knowledge, they may perceive the wrong idea about a concept (Dodge, 2017).The belief of a teacher in perceiving and teaching can structured how curriculum is delivered (Sickel, 2015). In most cases, experiences, individual encounter and beliefs about best practices show how a teacher sees their role in their classroom when they are engaged in inquiry-based instruction from being the center of attention to a guide and facilitator of learning (Lebak & Tinsley, 2010). For this transformation to be attainable in the classroom culture, it is paramount for teachers to practice cooperation and collaboration with both students and colleagues alike. Therefore, there will be paradigm shift from teacher-centered to students-centered as learning progresses. The growth a teacher required is concurrent to the implementation of the new methodology of teaching. Teachers engaged in inquiry are in turn likely to engage their students in inquiry as well.

2.1.4 Teaching respiration in senior secondary school biology with 5Es learning-cycle instructional strategy

Respiration is a topic in cell, specifically in properties and functions of cell. It is contained in secondary school Biology curriculum. its contents include aerobic and anaerobic respiration, glycolysis and krebscycle. According to Sarojini (2018), respiration is not considered as respiratory system, from the definition of respiration it occurs in the mitochondria of living cells. Mitochondria are organelles not organs therefore it is misleading to discuss respiration in respiratory system. Respiratory system on the other hand involves all the organs that are concerned with breathing and gaseous exchange. Respiration which is a broad term is sequence of processes leading to the release of energy in living cells which is stored as Adenosinetriphosphate (ATP). When oxygen inhaled gets to the body cells it acts on energy-rich food substances, breaks them down and release energy as ATP. This process is known as cellular respiration and it takes place via the krebs cycle. Respiration can be taught using learner-centered teaching strategy such as 5Es learning-cycle instructional strategy.

5Es learning-cycle instructional strategy is an important tactic in teaching respiration in Biology. It provides opportunity for students to go through certain phases in order of learning to construct their knowledge and understanding of the concept of respiration, and the development of scientific reasoning ability necessary to take decision. In 5Es learning-cycle instructional strategy students engage in certain tasks, explore materials to find answers to problems, explain their findings, extend their findings to real life situations and are then evaluated. In learning respiration with 5Es learning-cycle strategy, students are given tasks relating to respiration concept at the engagement phase. This is to enable them connect their prior knowledge to the current experience.The teacher may coin questions from topics such as gaseous exchange process which the students often carryout, characteristics of livingthings, digestion and other topics that have link to respiration. This will help arouse their curiosity and interest in the lesson. At the next phase which is the exploration phase, students are made to work on questions raised on respiration concept. Students may be asked to define, classify, explain, deduce, analyze, calculate, observe, investigate, predict and describe. Students are required to find answers to the questions by carrying out activities that allow them work with materials provided for the lesson through small groups, this will enable them build the desired experience, construct their knowledge and understanding of respiration and as well develop scientific reasoning skills.

The students' findings are communicated to learners or learnersgroup at the explanation phase. The teacher may explain further or help the learners find the right words or vocabulary needed to explain certain concepts of respiration. At the elaborate phase students extend what they have learnt and understood during their activities to real-world situations such as recognizing activities in their locality in which anaerobic respiration is involved like during vigorous exercise, and identify industries where citric acid like the one obtained from krebs cycle in respiration is applied to make things like cosmetics, ink and drugs. The evaluation phase is the final phase, and it gives a snapshot of what the students understood on respiration. The teacher could also assess how well they have built scientific reasoning ability.Teacher may ask questions like (1) define respiration (2) Choose the item that is different in the table. (3) Enumerate products of glycolysis in descending order.

2.1.5 5Es learning-cycle instructional strategy and scientific reasoning ability and achievement in biology

For a long time, it has been challenging teaching science subjects in Nigerian schools. Despite the fact that most students attend science classes, many still find it difficult to acquire and improve upon the required science knowledge and skills. Therefore, recognizing the functions and significance of science in the society may be a difficult task. Ibrahim (2015), penned that teachers shy away from teaching methods full of effective activities that will enhance scientific reasoning abilities in preference for methods that are easy and most times inadequate and inappropriate. Therefore, teacher education programme needs to be improved qualitatively. One of the best ways adapted to change this trend, is the design of several learning techniques to ensure that students appreciate and understand the relevance of science in the society. One of such techniques is the 5Es learning-cycle.

5Es learning-cycle as a learning technique increases conceptual understanding and learning motivation in Biology (Febrianto*et al*., 2018). As Biology students carry out investigation on concepts of respiration, it gives them room to comprehend content of instruction, no matter how difficult they appear to be. Samba, and Eriba (2012), are of the view that respiration is identified as one of the difficult concepts as determined by teachers, the result of which the writers stressed that topics related to this concept are found to be difficult by even the teachers who teach them. Ihejiamaizu *et al*.(2018), stated clearly that, when a certain concept appeared to be difficult to teach, subject teachers have a tendency to shy away from that concept. This invariably means that students lack understanding of such concept. Therefore, 5Es learning cycle strategy, a constructivist oriented teaching is the answer as it enables Biology students to be involved in inquiry employing critical thinking and scientific reasoning thereby increasing conceptual understanding and learning motivation.

Mahardika, and Indrawati (2017), who carried out lesson in physics on vehicular concept discovered that, 5Es learning cycle strategy has the potential for developing conceptual understanding. The conceptual understanding included in the cognitive process consists of: to interpret, to point out, to classify, to summarize, to conclude, to compare and to explain (Hutahaean *et al*., 2017). All of these cognitive process skills are enhanced during Biology lessons when a constructivist approach is adopted as discovered by Febrianto *et al*. (2018). These researchers opined that, 5Es learning cycle strategy develops logical and critical thinking skills. These skills can be seen from the ability of conceptual understanding and problem-solving among students. The ability of a student in problem-solving is rooted on the ability to reason, interpret, to classify, to summarize, to explain, to conclude and the understanding of a concept. (Hartono, 2013), is of the view that Scientific reasoning ability of interpreting representations of science (such as images, equations, mathematical, and graphs), communication skills, science process skills, ability to solve problem can all be enhanced using 5Es learning strategy. The researcher added that many students learn Biology and have misconceptions about the lesson, even though before they start to learn it. Students should be able to both learn and apply the concept of Biology in their daily lives. Conceptual knowledge is a critical point for the generation and choosing of appropriate procedures in solving problems (Kola, 2017). 5Es learning-cycle strategy is an appropriate technique for solving problems.

5Es learning cycle promotes active, collaborative, inquiry-based learning in Biology. Students are involved in more than listening skills, analyzing and evaluating evidence, experience and discussing, and talking to their peers about their own understanding.

Students work collaboratively with others to solve problems and plan investigations. It is discovered that Biology students learn better when they work with others in a collaborative environment than when they are alone in an environment where there is competition. Collaborative learning is yielded toward scientific inquiry when the students are active and students succeed in making their own discoveries. In addition, Biology students ask questions, they also observe, analyze, explain, draw conclusions and ask new questions. Inquiry-based experiences could be through direct experimentation and explanations through critical and logical thinking. Therefore, Biology teachersshould make sure students are used to logical and critical thinking and scientific reasoning by enabling them to seek explanations through performing experiment in order to find solutions to the problems, and to make inquiries about issues to be discussed in the next lesson to understand the concept (Hartono, 2013).

According to Ibrahim (2015), who carried out research in Biology on genetics using 5Es teaching strategy discovered that, when students make inquiries or investigations it enables them to be in charge of their learning and be actively involved. 5Es learning-cycle is an inquiry-based, constructivist-oriented teaching of science by actively engaging students in authentic and practical investigations that give room for the development of more realistic ideas about scientific study. It also offers a learner-centered environment which is more motivating. 5Es learning-cycle has importance in science process which cannot be overemphasized and thus, the National Research Council created the standards around a central theme, 'Science standards for all students'. This theme emphasizes the importance of inquiry in the science process, permitting students to describe objects and happenings, ask questions, construct explanation, test those explanations against current scientific knowledge and pass across their knowledge to others (Opara, 2011).In teaching science and Biology with 5Es learning cycle, the assumptions of people around the globe are considered, and logical and scientific reasoning ability are fostered. With 5Es learning cycle teacher acts as catalyst rather than dispensers of information. They make students attempt problems, issues and questions and then give them some sort of encouragement for inquiry into the nature of the problems and guidance for seeking solutions. Teacher helps students pose problems, investigate, and clarify positions and concision. 5Es learning cycle promotes and gives room for inquiry and the value and attitude that are needed toan inquiring mind including process skills, (observation, collection and organization of data, identification and controlling variables, formulating and testing hypothesis and explanations, inferring), active, autonomous learning, tolerance of ambiguity, logical thinking, persistence, verbal expressiveness (Ibrahim, 2015).

2.1.6 Scientific reasoning ability and secondary school students' achievement

Having citizens who are able to better the society technologically is paramount. Educators' most important goal should be to produce students who not only pass their examinations but are able to reason scientifically and think critically, foster content knowledge in order to raise or create ideas that will take the world to the next level of advancement. According to Ahmad, et al (2020), every year Pakistani education system produces secondary school students that pass SSCE with good grades but when they face a reasoning and application-based test like any entry test they perform poorly. Scientific reasoning ability is critical to allow students of Science, Technology, Engineering, and Mathematics (STEM) to be able to successfully take on open-ended real-world tasks in careers later in life (Febrianto *et al.*, 2018). Secondary school students need to be trained in the aspect of scientific reasoning so that they would be used to logical and critical thinking, which will enable them to perfect their thinking and reasoning skills (There is a popular saying that practice makes perfect). Students' scientific reasoning skills can be done through training and can be transferred (Kambeyo, 2017). The general reasoning skills may include abilities to systematically explore a problem, to formulate and test hypotheses, to manipulate and isolate variables and to observe and evaluate the consequences. The training in scientific reasoning skills may also have a long term impact on students' academic achievement (Febrianto *et al*., 2018). The same author opined that the STEM education community thinks that transferable general abilities are also as important and necessary for students to learn as in the STEM content knowledge.

According to Kulasegaram and Rangachari (2018), it is necessary for expansion of the learning objectives that relate to course and discipline- specific concepts. Accentuating the expansion of learners reasoning skills and the accomplishment of procedural information is a suitable way for the existing advancement of students reasoning abilities. Achievement in learning is progress of individual as an outcome of supportive collaboration. It consists of the development that empowers the students to work in a good way in his environment, improve and adapt behaviors that enable him to have healthy relationships and achieve personal success, (Darling-Hammond *et al.*, 2019). In formal education settings, teaching and learning emphasize on training of content knowledge and it is expected that constant and laborious content learning will help to develop students' general reasoning abilities. However, there are accepted research evidences that prove that this relationship exists (Mahmood, 2017). Mostly work in education researches also proved the relationship of students learning of content knowledge in a good way and conducive environment to achieving personal success, and research on students general scientific reasoning abilities have been attaining fame in recent years.According to Ahmed *et al.* (2020), scientific reasoning of children is understudy from previous number of years and scientific reasoning involves the various collections of cognitive activities such as conceptual understanding as well as inquiry skills. Scientific reasoning is type of higher order thinking skill it is relevant to the abilities like identification, analysis, creativity, logical thinking and solving problems (Novia & Riandi, 2017).

The development of scientific reasoning through collaboration among person' internal factors such as metacognitive and cognitive development, and contextual ability are cultural factors (Tajudin & Chinnapan, 2017). Scientific reasoning is needed in processing information and drawing conclusions and these conclusions are more than the direct experiences andit is necessary to manage daily life problems successfully (Han, 2013). So there is an advancement of new dynamic development in instructional methods and materials that increase students' scientific abilities. Scientific reasoning needs to be developed during teaching and learning in science classrooms and it affects achievement and cognitive factors (Zlatkin *et al.,* 2015). In the 21st century students required to develop scientific reasoning for endurance in all disciplines of learning to lead a successful life (Khoirina *& Cari,* 2018). Many assessment studies have proposed a positive correlation between measures of students' abilities in scientific reasoning and their achievement of content learning (Mahmood, 2017; Kambeyo, 2018). Assessment of scientific reasoning ability may be different from the assessment of learning of content knowledge, however, there is correlationship between the two. Student needs to have a better reasoning ability to have better understanding of content knowledge.It is not possible to have anitem for assessment of scientific reasoning which has no demand for knowledge (Adey & Csapo, 2012).

Scientific reasoning helps the people to have knowledge and deals with the changes in the society. Attainment of scientific literacy has an anticipation of all science education curriculum (Wang *et al.*, 2014). Several studies proposed that scientific reasoning is an essential part of scientific knowledge, similarly, in Thailand, a normal vision of literacy is of an individual: that is indulgent of information and comprehends the connection between science, societal norms and surroundings and in capable to engage himself in intellectual method and reasoning to investigate knowledge. Scientific literacy must improve from the base of pyramid that has three sides (Lee & Butler, 2019). If students have a command on reasoning, they can draw conclusions from a scientific problem (Ahmad, 2020), which invariably means that scientific reasoning can boost the cognitive or intellectual ability of science students to play out, and also, enables Biology students to think, create ideas, create products and increase their understanding of concepts of Biology from scientific investigation.

Scientific reasoning allows for the application of principles of logic to science process. Scientific reasoning ability influences the ability of Biology students to interpret, classify, explain, deduce, make hypothesis, summarize and make conclusions about scientific concepts (Wenning & Vierya, 2015). This promotes the deep understanding of content of instruction, and increases the required science knowledge and achievement. Biology students seek explanations in a logical way through indulging in science processes to make inquiry in order to find answers to problems raised, in doing that, their inquiry skills, reasoning skills, both deductive and inductive reasoning skills, investigative skills and problem solving skills are enhanced, which will have positive influence in understanding course contents.

2.1.7 Gender and scientific reasoning and academic achievement in biology

Gender is perceived by many science education researchers to be an important factor in science education. It is the sex of individuals or the reproductive attribute of students which is categorized into male and female. The oxford dictionary of English defines gender as the fact of being a male or female. Akande *et al.* (2018), defined gender as the economic, social, political and cultural attributes and opportunities associated with being a male or female. The concept has attracted much attention of researchers, scientists and psychologists to write several literatures on various facets like gender and workrole, gender and social role as well as gender and academic achievement. In most societies, men and women differ in many areas such as the way they reason and the activities they indulge in. Due to the reasoning ability of humanity, most societies consider women the weaker sex and are given less demanding chores to handle while men are allocated with what are regarded as complex and difficult tasks, and as a result, women as a group have less access to resources, opportunities and decision-making than men (Akande, et al, 2018). Women should be given opportunity to participate in economical, social, political and cultural activities, as well as educational decision-making processes as some women are endowed with high reasoning abilities, intelligence and wit which need to be tapped to foster students‘performance in science learning especially with the increasing emphasis on ways to boost manpower for technological development.

The population of females in science and technology fields should be increased in order to have more “hands-on” and “minds-on” in the field of science and technology to meet the need and aspiration of the 21st century. Although many science educators are of the view that, gender has the tendency to influence scientific reasoning ability and academic achievement of students in Biology, Piraksa *et al.* (2014), opined that as science literacy is currently considered the central goal for development in the 21st century citizen, scientific reasoning ability is determined as an important factor for students understanding, achievement and attitude towards science in general and Biology specifically which is influenced by gender. Gender has great effect on how well a student develops scientific reasoning skills which influences students understanding of course contents and achievement in Biology (Hotulainen et al., 2014). However, some education researchers are of the opinion that gender has no influence on students' scientific reasoning ability and school achievement rather other factors are responsible such as subject characteristics, both cognitive potentials and non-cognitive characteristics, classroom practices and contextual variables (Hotulainen *et al*., 2014).

According to Piraksa *et al*. (2014), scientific literacy as an instructional goal, and which involves all the factors listed by Hotulainen *et al*. (2014) typically includes students‘understanding of the nature of science and scientific reasoning. Scientific reasoning enables both male and female students to think, draw conclusion from principles and evidence to understanding of concepts in Biology. Scientific reasoning plays important role in the process of conceptual change as Biology students indulge in problem-solving processes that involves critical thinking in relation to scientific and procedural knowledge. Biology students' ability to reason scientifically is a reflection of their ability to think and to apply the principles of logic in biological processes. This will enable the students to be able to carryout investigation in respiration which includes designing experiments, analyzing scientific evidence, combining, evaluating the results in scrutiny, and understanding complex concepts in respiration. The ability to carryout biological processes and to understand concepts in Biology and respiration in particular is consequent in conceptual change and students‘achievement.

Achievement is an important variable in science education, and this depends on instructional pedagogy in science classroom and not gender as penned by Hotulainen *et al*. (2014). There is a critical area in students that needs improvement, which includes students ‘scientific reasoning ability and achievement, by both male and female students, because students of average and lower reasoning abilities struggle in solving problems that depend on conceptual understanding and may depend more readily on memorization of simple procedures to solve problems. Therefore, 5Es learning-cycle model is an effective strategy in developing scientific reasoning ability and problem solving ability in bothmale and female Biology students in order to do away with memorization (rote learning) and promote understanding of content of instruction.

2.1.8 School location, scientific reasoning ability and achievement in biology

School is one of the social institutions that is responsible for the development and training of the mind and skills of man. It is also for the preparation of man for challenges and responsibilities in the society at large. School is paramount to the government, individuals and educational administrators, that is why, it is built in different locations to be accessible to all. School location refers to the particular place in relation to other areas in the physical environment (rural or urban) where the school is sited (Madaki, 2021). School location plays important role in school experience and it may be a determinant of students' reasoning ability and achievement. According to Alordiah *et al.* (2015), an urban school has an environment-based activities peculiar to its environment that are different from a rural location. The urban areas are characterized by increasing industrialization, availability of modern infrastructures or resources, library, opportunities, good environment, quality and good number of teachers, and good use of English language in schools, therefore, it is expectedthat, students that attend schools in urban area experience better learning process and good learning outcome. In a similar way, a school located in the rural area, will have all the physical and demographic characteristics of a rural environment such as lack of infrastructures, use of local dialect, aging population and agrarian orientation, therefore, students attending schools in rural area are expected to face challenges of proper skill development and higher povertythanstudents attending schools located in urban areas.

Some researchers that worked on school location reported that, urban students performed better than rural students in all form of achievement test while others discovered that students in both urban and rural areas performed in a similar manner (Alordiah *et al*., 2015). The researcher added that in Nigerian schools, the lingual Franca is English language, which is not widely spoken in rural schools. What obtains in most cases is the native language of that settlement, this can go a long way in affecting how well the students will develop scientific reasoning skills and learning outcome in Biology since teaching and learning as well as assessment of students is done in English language. Science students generally and Biology students in partucular need to posses sound reasoning ability to be able to understand biological concepts. Reasoning affects science students' capacity to learn concepts in science, since English language is a barrier for effective communication in rural schools the chances of developing scientific reasoning ability is very slim, furthermore, the researcher argued, emphasizing the development of students' reasoning abilities and achievement of procedural or operative knowledge to be the only appropriate reaction to the current exponential increase of knowledge. A central purpose of education is thus, to provide the conditions which will foster the development of students' reasoning abilities, which is lacking in rural schools making the development of scientific reasoning ability a problem thus affecting students' understanding of respiration concept and achievement. Scientific reasoning ability is therefore a variable of critical importance to those students who seek to become professional scientists (Ezechi, 2017).

2.2 Theoretical Framework

2.2.1 Constructivism (Piaget, 1980)

Constructivism is one of much heralded of paradigm shift from teacher-centered to student-centered approach. Constructivist theory is of the view that teacher's role in learning should be a trainer, facilitator of learning processes and creator of educational environment. This is to enable the learners to construct their knowledge by themselves when they interact directly with the learning and when they use all the previously experiences to be at the centre of the learning process (Ihejiamaizu *et al.,* 2018). Constructivist theory makes it possible to have a deep understanding of the science concepts, in constructivist approach learners construct their knowledge by making connection with what they already know and with the new concepts through what they experience daily. According to Abu-Safar (2014), learner involvement in learning is characterized by activity, positive innovation leading to discovery of knowledge, understanding of oneself through discussion with others.

Jean Piaget (1896-1980) a Swiss psychologist is an advocate of constructivist theory. In his research, he worked on the development of intelligence in children, this cognitive development theory emphasis factors within the learners and not within the learning environment. In his work, he identifies four stages of mental growth in the children and each stage with a new intellectual abilities demonstrated, from his observation of children, Piaget understood that children were creating ideas that can make them think logically about abstract relationships and concepts, they were not limited to receiving knowledge from parents or teachers: they actively constructed their own knowledge. Piaget work is the bedrock on which constructivist theory stands. The implication to the study is that as students carry out study on cellular respiration using 5Es learning-cycle strategy, it enables Biology students to be actively and cognitively (mentally) involved in their learning and curious about the topic. As they manipulate materials provided to seek answers to the questions raised on respiration they build scientific reasoning skills and construct their knowledge over time through sequential series of steps. Constructivists believe that knowledge is constructed and learning occurs when children create products and are more likely to be engaged in learning when these products are personally relevant and meaningful (Zhou & Brown, 2017). 5Es learning cycle instructional strategy is students-centered strategy of learning which make learning of respiration more concrete, understandable and meaningful because real experiences are formed and given priority. Students become more active, creative and can understand and apply the principles of logic.

2.2.2 Behaviorism theory (Skinner, B.F. 1943)

Behaviorism is primarily concerned with observation and measurable aspects of human behavior rather than thought or emotions. Behaviorism learning theory gives importance to changes in behavior of the learner as a result of stimulus directed towards the learner and does not explain abnormal behavior in terms of brain or its inner workings (Zhou & Brown, 2017). A learner displays or chooses one response instead of another due to prior conditioning and psychological drives existing at the moment of the action. Behaviorist theory is of the view that all behavior is learned habits, and attempts to account for how these habits are formed. Behaviorist also hold that all behaviors can also be unlearned (unacceptable), and replaced by new behaviors (acceptable) such as rewarded response.

Skinner, B.F. (1904-1990) developed Operant Conditioning from Watson basic stimulus response model. His model was based on the premise that satisfying responses are conditioned, while unsatisfying ones are not. Operant conditioning is the rewarding of part of a desired behavior or a random act that approached it (Zhou & Brown, 2017).

Through Skinners research on animals, he concluded that bothanimals, Monkey in particular and human would repeat response that lead to favorable outcomes, and suppressed those that produced unfavorable results. This means that the more satisfying the outcome of a particular result, the better that action is understood and learned.

Implication for this study for experimental Biology on cellular respiration using 5Es learning strategy in particular is that, the more students experiment on cellular respiration using 5Es, the more the students repeat the act involving 5Es strategy and the better the process and reasoning skills are acquired by the students as well as their achievement enhanced.

5Es learning cycle is behavior modification strategy that elicits better classroom performance from reluctant students. They bring about increase desired outcome and reinforcement of behavior through students' participation in group work and in class discussion, thereby making the reasoning and achievement of new knowledge better than the conventional method of learning.

2.2.3 Theory of Multiple Intelligence (Gardner, Howard 1993)

Howard Gardner's theory of multiple intelligence utilizes aspects of cognitive and developmental psychology, anthropology and sociology to explain the human intellect. He suggests that the human organism has seven distinct units of intellectual functioning. He labelled these units, intelligences, each with its own observable and measurable abilities (Gardner, 1993). The Gardner hypothesis of intelligence is examined within the context of g, and Gardner's Ml Theory is compared to the work of cognitive style theory. This report concludes that Ml theory did not discover new "intelligences", but rather, put forth a reframing of what others have defined as cognitive styles.

The concept of multiple intelligences is a theory proposed by Harvard psychologist Howard Gardner. When you hear the word intelligence, the concept of IQ testing may immediately come to mind. Intelligence is often defined as our intellectual potential; something we are born with, something that can be measured, and a capacity that is difficult to change. In recent years, however, other views of intelligence have emerged, including Gardner's suggestion that, multiple different types of intelligence may exist.

The theory of multiple intelligence suggests that traditional psychometric views of intelligence are too limited. Gardner first outlined his theory in his book “Frames of Mind”: The Theory of Multiple Intelligences, where he suggested that all people have different kinds of "intelligences." Gardner proposed that there are eight intelligences; visual-spatial, verbal-linguistic, musical-rhythmic, logical-mathematics, interpersonal, intrapersonal, naturalistic and bodily-kinethetic, and has suggested the possible addition of the ninth known as "existentialist intelligence." According to Gardner an intelligence encompasses the ability to create and solve problems, create products or provide services that are valued within a culture or society.

While a person might be particularly strong in a specific area, such as musical intelligence, he or she most likely possesses a range of abilities. For example, an individual might be strong in verbal, musical, and naturalistic intelligence. Science students might be good in certain skills and abilities such as analyzing, applying, knowledge, observing, explaining and concluding.

Although Gardner’s intelligence theory was not originally designed for use in a classroom application, it has been widely embraced by educators and enjoyed numerous adaptations in a variety of educational settings. Teachers have always known that students had different strengths and weaknesses in the classroom, hence, 5Es learning-cycle instructional strategy strengthens the weaknesses of students in learning process for better understanding of course contents and development of reasoning abilities. Gardner’s research was able to articulate and provide direction as to how to improve a student's ability in any given intelligence. Accommodating this theory in this study, students" intelligences come to play. As students are involved with 5Es learning-cycle strategy, they classify, explain, deduce, make conclusion, interpret and induced. A student may be good with a skill and poor with another due to the different kinds of intelligences. With the adoption of 5Es learning strategy, the weaknesses of the Biology students are strengthened and articulated, and the weak abilities are improved.

In conclusion, three theories that supported this study have been examined, however, the most relevant theory that this work is based upon is constructivism theory, which is of the view that teachers are facilitators of learning processes, and students are allowed to create ideas and construct their knowledge by themselves.

2.3 Empirical Studies

2.3.1 5Eslearning-cycle instructional strategy and achievement

Babalola*et al.* (2019), examined the effects of 5E learning cycle and concept-mapping strategies on secondary school students' achievement in ecology in Kwara State of Nigeria. It was a quasi-experimental research design. The population for the study was all SS II students offering biology in Ilorin. Three co-educational public secondary schools were selected using purposive sampling techniques. A class was assigned to a particular strategy. Two experimental and one control groups were involved. 5E learning cycle had 85 students, concept-mapping had 71 students and control group had 73 students making a total of 229 students that participated. Researcher designed instrument called Ecology Achievement Test (EAT), which was used for data collection for both the treatment groups and control group. Reliability of EAT was 0.78 using Pearson Product Moment Correlation. The researchers used mean to answer the question and ANCOVA to test the hypotheses at 0.05 level of significant. Findings revealed that 5E learning cycle instructional strategy had the highest achievement followed by concept-mapping strategies and conventional method. The study concluded that 5E learning cycle strategy can improve students' achievement in ecology. It was recommended that workshop and seminar be organized by curriculum planner and education stakeholder for Biology teachers on how to use learning cycle to promote meaningful learning of difficult topics and better academic achievements.

There are conflicts of knowledge in thestudy of Babalola et al. and this study, SS II alone formed the entire population, and the guideline for choosing the sample size was equally omitted, number of research questions and research hypotheses were absent in the work. Another gap figured out is on recommendation, there was no recommendation made for the students on how to utilize 5Es learning-cycle to promote their learning since the strategy is a learner-centered strategy. The gaps identified above were filled in this study.In this study 5Es learning-cycle instructional strategy was also used. While their study determined the effects of 5Es learning-cycle instructional strategy on the achievement of students only, this study involved using 5Es learning-cycle strategy to experimental research design, SS11 intact classes, co-educational public schools, purposive sampling techniques and t-test for testing the research hypotheses. The differences are found in the number of independent variables, sample size, topic treated and number of depended variables.

Ibrahim (2015), investigated the impact of 5E teaching cycle on attitude, retention and performance in genetics among pre-NCE Biology students with varied abilities, North West Zone, Nigeria. The population of the study was 2231, pre- NCE Biology students made up of 1168 males and 1063 females. Two schools were selected from the eleven coeducational colleges of education that made of the population of the study using simple random sampling technique by balloting method. Fifty-five (55) pre-NCE Biology students ((38 males and 17 females) were selected from each school as guided by central limit theory. Equal numbers of subjects were selected for each group resulting to a total of one hundred and ten (110) students as sample size. The design for the study was quasi-experimental and control group design involving pretest posttest and post-posttest. Pretest was administered to both groups and subjects were assigned to sub-groups according to their ability level (high, average and low) by stratifying sampling technique after the pretest. Scores range from 60-100 (high ability level), 40-59 (Average ability level) and 0-39 (low ability level). Two instruments were used for the research study, Genetic Academic Performance Test (GAPT) with reliability coefficient of 0.79 and Students Attitude Genetics Questionnaire (SAGQ) with reliability of 0.82 were used for data collection. The researcher used mean score, Two Way Analysis of Variance (ANOVA) and Kruscal Wall is test statistics to answers research questions and test hypotheses at p-value less or equal to 0.05 level of significant. The findings of the study showed that pre-NCE Biology students exposed to 5E teaching cycle in the teaching and learning of genetics concepts in all the ability levels had higher mean performance scores and retain more than those in the control group exposed to lecture method of instruction. On the issue of gender differences, the study revealed that male and female in all ability groups exposed to 5E teaching cycle performed equally well and had also no difference in their retention abilities. It was recommended that teaching of Biology especially genetics should be conducted using 5E teaching cycle as it enhances meaningful learning, better retention of knowledge.

The study did not reveal the number of research questions and hypotheses used. His study implemented the use of 5E teaching cycle which is similar with this study. Similarities observed in both studies are not much. However, both studies used the same research design (Quasi-experimental). There were conflicts in knowledge as lots of differences were observed in both studies, the number of dependent variables, school age, institution, sample size and its selection, number of schools used, what type of sampling technique is used, number of subjects per class, topic taught and the number of moderating variables were not the same. Varied ability level was also considered in his study and not considered in this study rather school location was used.

Cardak *et al*. (2008), investigated the effect of 5E learning cycle on 6th grade students' achievement during the circulatory system unit while the experimental group and the control group were the same at first, after implementation, there was an important difference in favour of experimental group.There were conflicts in knowledge between the two studies, the researchers failed to include the number of research questions, research hypotheses, sampling technique, sample size, research design, population distribution, reliability coefficient, instrument for data collection and information on validity, making the work cadaverous. The findings of the result on the test scores were not revealed as well as the recommendations were not made. Both studies implemented the same teaching strategy and the results obtained were in favour of students in the experimental groups. Same subject, (Biology) was equally applicable in both research studies, but the topic taught was different.

Ndidio (2007), investigated the effect of constructivist instructional model on senior secondary school students' achievement in Biology using 5E learning cycle. The study adopted a quasi-experimental design of non-equivalent control group involving two groups.Three schools were chosen for the study in which two co-educational boys and one girl\schools were used. For each school 30 students were selected in the study, one group was assigned experimental group and the other control group.In the study, experimental groups were taught genetic using constructivist instructional approach, the control group was taught using lecture method. The study is too brief and skeletal in the sense that relevant information are missing. The findings of the results and other vital points were not relayed. In an experimental research of this nature, the number of research questions, hypotheses, guideline for the choice of sample size to show if the sample size reflects the population, are important aspect to be mentioned but were not indicated, the population, method of data analysis, reliability coefficient, instrument for collecting data and sampling technique to show it appropriateness to the design, all of these were absent in the study which became gaps that were filled in this study. However, in both studies the results obtained showed that the treatments were significantly more effective than lecture method.

Balci *et al*. (2006), carried out study to investigate the effect of the 5E learning cycle model conceptual change text and traditional instructions on eighth grade students understanding of photosynthesis and respiration in plant 101 8^{th} grade students. Three intact classes of the same school were used in their study.

A lot of critical points were swept under the carpet in the study making the work very skeletal. The research questions, research hypotheses, sampling technique, sample size, population distribution, method used in the data analysis, reliability, validity and instrument for data collection were breach and defects noticed in the study which this study filled. In addition, this study implemented the use of 5Es learning-cycle strategy to enhance scientific reasoning ability of secondary school Biology students as well as their achievement on respiration concept. Four intact classes from different schools were involved, taking cognizance of school location. There were three groups in theirstudy. Two of the groups were assigned as experimental groups in one of which 5E learning cycle model was used and in the other experimental group conceptual change text instruction was used. The third group was defined as control group in which the traditionally designed instruction was used. In this study two groups were involved (a school in the rural area and a school in the urban center make up a group, for both experimental and control groups). 5Es learning-cycle instructional strategy was administered on a group which is the experimental group and the control group in which the lecture teaching method was used. The results of both studies showed that the groups instructed with 5Es learning-cycle instructional strategy were favored over other strategies and groups.

2.3.2 5Es learning-cycle instructional strategy and scientific reasoning ability and achievement in science

Ahmad *et al.* (2020), carried out a study to find out the relationship between the scientific reasoning ability and the achievement marks of SSC science graduates. All SSC science graduates enrolled in intermediate 1st year class in any public or private college of Punjab were the population. 1620 students from four districts were conveniently selected. The suitable test "Lawson reasoning ability test" was adapted with permission to make it bilingual and pilot testing brought Cronbach α value 0.914. Test was administered to 1620 students of both public and private colleges whereas returned rate was 93.7%. Results calculated through descriptive statistics and Pearson Correlation was "no significant relationship between reasoning ability test scores and the SSC marks". It was recommended that assessment agencies i.e. Board of intermediate and Secondary education may include the items of higher order thinking in assessment. From the study, the total population figure of students in Punjab colleges was not given, also it was revealed that 1620 students from public and private colleges formed the sample size but the researchers did not specify the number of students from public colleges as well as private colleges. The number of test items used for the study was not stated, the number of research questions, research hypotheses were swept under the carpet.

Their study and this study emphasized on scientific reasoning ability and achievement. While their work is concerned with the relationship that exist between scientific reasoning ability and achievement of science graduates of college, this study looked at using a teaching strategy (5Es learning-cycle) to enhance scientific reasoning ability and achievement of secondary school students. The research designs and sampling techniques were different, both private and public colleges were involved in their work while in this study only public secondary schools were used. The result of their findings revealed that there is no significant relationship between reasoning ability test scores and achievement marks while in this study there is significant difference in the scientific reasoning ability and achievement test scores in favour of the experimental group when taught with 5Es learning-cycle instructional strategy.

Anwar and Zein (2019), analyzed scientific reasoning skills of Biology prospective teachers.The participants were the Biology education students that took plant anatomy course (n=139) at a university in Sumatera, Indonesia. Data of scientific reasoning skills were collected using instrument CTSR test. The data were processed by calculating score for each indicator. The scores of Scientific Reasoning Skills (SRS) were 0 to 12 which divided in 3 categories: (1) concrete; (2) transitional and (3) formal reasoning. Results of this research show that students' scientific reasoning skills in Biology education are: 52.5% students have a concrete; 32.4% a transition and 15.1% at formal reasoning. Based on data of this study, it is suggested that students' scientific reasoning skills at formal levels was very low. To increase scientific reasoning skills of the students, it needed revision on instructional strategies for plant anatomy course. A critical variable observed to be missing in the study is independent variable. A research of this nature without an independent variable is like mammalian flesh without a skeleton.The researchers only emphasized on the instrument on Scientific Reasoning

Ability and the scores obtained for each indicator, they did not mention if it was an experimental or survey research study (research design). In addition,the number of research questions, research hypotheses,population,theory that supports the choice of sample size, validity, reliability and method of data analysis were not captured making the content of the work thin.

One similarity noticed in both studies is the fact that, they both examined the scientific reasoning ability of Biology students, although the students were not in the same academic level. Biology prospective teachers (Biology education students) were the participants in their study while secondary school students were the subjects in this study. From the results obtained 52.5% score was realized from the three (3) different categories of scientific reasoning skills with twelve (12) questions administered on the students while in this study 68.34% with mean gain of 45.14 was realized from two (2) major categories or dimensions (deductive and inductive reasoning) with twenty five (25) questions administered on the students.The difference in the percentage score could simply be as a result of the utilization of 5Es learning-cycle teaching strategy used in this study which they failed to adopt in their study.

Nevin, (2017), investigated the effect of 5E learning Model on Academic Achievement, Attitude and Science Process Skills: Meta-analysis Study. For this purpose, all the Master's, doctoral theses and articles in Turkish and English languages which were carried out in Turkey between 2006 and 2016 and which are suitable for the research problem have been scanned and included in the scope of the study. In order to limit studies and conduct meta-analysis in this context, studies had to be planned with semi-experimental design with experimental and control groups; there had to be quantitative data such as mean, standard deviation, and sample size and they had to be applied only in science courses. The data obtained from the articles and theses were meta-analyzed and it was determined that the 5E learning model had an effect on the students' academic achievement, attitude towards science and science process skills. In this context, studies should be conducted in order to limit the studies and to perform the meta-analysis, in which semi-experimental design with experimental and control groups is planned, t-test is applied only in science courses. By analyzing the data obtained from the articles and theses, a general evaluation was made about the effect of the 5E learning model on academic achievement, attitude toward science and science process skills. As a result of the study, the effect of the method applied for each dependent variable was found to favor the experimental group. Conclusion has it that since this teaching model is effective it can be emphasized more in the curriculum. Alsometa-analysis studies that investigate with which course content and at which level of learning the applications prepared according to the 5E learning model are more effective can be performed.

The gap noticed in the study were total population and sample size which were not given in figure in the study, the number of research questions and research hypotheses used to guide the study were not indicated. Furthermore, the guideline for choosing the sample size, instrument for collecting data and reliability were not stated in the work.However, both studies adopted same teaching strategy (5Es learning-cycle), and the results obtained were in favor of the treatment strategy. The differences observed in both studies are the academic level of the subjects, while the participants in his work were post-graduate science and English language students of ten years range, secondary school students of aparticular academic session participated in this study. The research design, dependent and moderating variables were different as well. Mixed research design, and three dependent variables were adopted in his work while in this study experimental research design only was utilized, and two dependent and two moderating variables. Nelvin did not take gender and school location into cognizance unlike this study.

2.3.3 Gender and students' academic achievement

Owoeye, and Agabaje (2016), conducted a study on the attitude of students and gender as correlate of students' academic performance in Biology in senior secondary school. The study employed a descriptive survey research design. The population of the study was all government senior secondary school two (SS II) students in Ikere Local Government of Ekiti State. The technique employed for the study was simple random sampling technique which was used to select a total of one hundred and eighty (180) Biology students, ninety five males (95) and eighty five females (85) from six (6) government secondary schools in the local government area. The instrument used were Biology attitudinal scale (BAS) and Gender and academic performance in Biology (GAPB).The instruments were validated and found appropriate for the study, a reliability test was also conducted. Pearson Product Moment Correlation (PPMC) was used to analyze the hypotheses formulated for the study. The results findings revealed that there was no significant relationship in students' gender and academic performance in Biology. It was recommended that science educators (Biology Educators should discourage gender disparity in the teaching and learning of Biology. From the study, the total population of the participants was not mentioned. Actually the sample size was given but the guideline for the choice of the sample size was not stated in the work. The number of research questions, research hypotheses and validity wereomitted. The reliability coefficient was not stated but the researcher only made mention of a reliability test been conducted causing a gap in the work.

There are similarities that exist between the study and this study such as same academic level, same subject (Biology), both studies involved public schools, same sampling technique, same analytical tool were used to obtain the reliability coefficient. However, there is difference in the research design, while their study employed descriptive survey research design, this study employed quasi-experimental research design. Both research findings revealed the same thing, gender has no effect on students' academic performance or achievement.

Mangut, and Solomon (2015), investigated the effect of mastery learning approach (MLA) on the performance of boys and girls in public primary schools in basic science and technology in Jos metropolis Nigeria. Four research questions and four hypotheses were asked and formulated respectively. Non-equivalent pretest and posttest control group of quasi-experimental design was used. A sample of 175 pupils in primary six (92 boys and 83 girls), from two pilot science primary schools out of the population of 1,049 pupils from six pilot science primary schools in Jos Metropolis. Validated instrument for data collection was the Basic Science and Technology Performance Test (BSTPT), with a reliability value of 0.84 using Cronbach Alpha Coefficient. Research questions were answered with mean and percentages, while t-test was used in analyzing the hypotheses at 0.05 level of significant. Results showed that gender had no influence on the performance of pupils in basic science and technology and also showed that Mastery Learning Approach improved the performance of boys and girls in basic science and technology in the experimental group than those of the control group. The findings further revealed that there was no significant difference between boys and girls performance both of them improved equally in mastery learning approach. This implies boys and girls performance improved equally in BSTPT. The results showed that teaching method has great influence on the performance of pupils than gender influence, since the performance of both boys and girls in the experimental and control groups did not show any remarkable differences. It was recommended that teachers should integrate MLA in their classroom day to day teaching and learning process.

The study conducted by Solomon and Mangut captured a lot of critical information, however, sampling technique adopted in the study and the guideline for choice of the sample size were swept under the carpet and became a gap left in the work. The pupils were important factor in the study and no recommendation was made on the pupil that would improve their performance as far as mastery learning approach is concerned. Achievement is ascertained when students are able to understand and master concepts. These researchers carriedout investigation to determine the effect of mastery learning approach of boys and girls on students' performance in public primary schools in basic science and technology.The difference found in their work and this study is the instructional method, while they employed mastery learning approach, this study adopted inquiry learning method. Other differences observed were the academic level of the participants, number of research questions and hypotheses. Both studies adopted quasi-experimental research design, t-test for testing the hypotheses, and gender was used as a moderating variable. The results of both studies showed that gender had no influence on the performance of students and pupils. Also, both instructional strategies used improved the performance of boys and girls in both subjects

Jimoh *et al.* (2014), examined the effect of jigsaw cooperative learning strategy and gender on academic achievement of students' in cost accounting in colleges of education in Ogun State. The study adopted a 2x2 factorial design comprising of two groups (control and experimental) in their intact classes. Two research questions and three hypotheses, tested at 0.05 level of significant were formulated to guide the study. The study population comprised 405 final year cost accounting students drawn from two colleges of education in Ogun State. Cost accounting achievement test (CAAT) is the instrument used for data collection. The CAAT and the lesson plans for both control and experimental groups were all validated by three experts. The reliability coefficient of the instrument was computed using Cronbach alpha and was found to be 0.97. Mean was used to answer the research questions while Analysis of Covariance (ANCOVA) was employed to test the hypotheses. The results showed that cooperative learning method is more effective than the traditional lecture in the teaching of cost accounting. The study also revealed that gender did not contribute significantly to varying students' achievement scores. The study recommends the adoption of jigsaw cooperative learning strategy in teaching cost accounting among other courses in colleges of education. In the study the population was mentioned but the sample size was not stated.

In their research study, one dependent and twoindependent variables were used, JIGSAW instructional strategy was adopted. In this study 5Es learning-cycle instructional strategy was adopted. JIGSAW and 5Es strategy maybe different in terms of implementation but are similar as they are both cooperative and student-centered strategies. In addition, gender is adopted as independent variable in their study while it is used as a moderating variable in this study. Other differences found in the studies are the academic level of the participants, subject, analytical tool used in computing the reliability coefficient. Both studies adopted same analytical tool in answering the research questions and testing the hypotheses. Results of both studies revealed that the instructional strategies adopted in instructingstudents in experimental groups showed to be more effective than the conventional method, and that gender did not have effect on students' achievement.

Aniodoh, and Egbo (2013), conducted a study on the effect of gender on students' achievement in chemistry using inquiry role instructional model, quasi-experimental research design was used for the study. The study involved all senior secondary school two (SSII) chemistry students in government single sex schools in Enugu educational zone in the 2010/2011 session comprising seven hundred and ninety-seven (797) students in number. Simple random sampling technique was used to select two males and two female's schools from the government single sex schools in Enugu educational zone. The sample size was one hundred and fortyone (141) senior secondary school two chemistry students (SSII). The instrument for the study was Chemistry Achievement Test (CAT). Analysis of Covariance (ANCOVA) was used to test the hypotheses at alpha level of 0.05. The findings of the study revealed that female students performed better than their male counterparts. It was recommended based on the findings that chemistry teachers should be encouraged to use inquiry role instructional model because it could increase students' achievement in chemistry. Some critical content that were supposed to be captured in the work are missing- guideline for choice of sample size, number of research questions and corresponding hypotheses were not mentioned. The reliability, validity and method of data analysis were equally not captured and created a gap in the work.

The research work is similar to this study based on the fact that they both adopted the same research design, and adopted student-centered inquiry instructional model, same academic level and class, same sampling technique, same number of school, achievement test was involved in both studies. Results from theirstudy revealed that female students are better than their male counterpart in terms of performance while in this study there is no significance difference in the performance of male and female students.

Udosoro (2011), researched on the effect of gender and mathematics ability on academic performance of students in chemistry. The researcher employed a survey design, the population of the study comprised of all selected secondary schools in Uyo metropolis in Akwa Ibom State. Simple random sample technique was used for the study, the sample size was one hundred (100) senior secondary school one (SSI) chemistry students drawn from intact classes in two senior secondary schools in Uyo metropolis. The instruments used for the study were chemistry achievement test (CAT) and Mathematics ability test (MAT). The instrument was validated by two science educators and three chemistry teachers, face and content validity was used for the validation. A reliability coefficient of 0.75 was obtained. Data collected were analyzed using independent t-test statistics tool. Based on the findings of the study it was indicated that gender did not have any significant effect on the academic performance of students in chemistry also students with high students' mathematics ability performed significantly better than those with low mathematics ability in chemistry. It was recommended that both male and female chemistry students should be encouraged to excel in their study and science students who choose chemistry as a core subject should be made to understand the importance and relationship between mathematics and chemistry and should hence be serious in both subjects. The work in the study became limited as the total population figure was not mentioned even the guideline for choice of sample size was not stated as well as the number of research questions and research hypotheses.

The research studies have certain things in common, they both adopted same sampling technique (purposive), same school type, intact classes were used in both studies, and they both observed achievement test and ability test. The noticeable difference between the two works are the difference in number of schools involved in the study, number of schools involved in the study, the research design and statistical analytical tool. In his work he used two schools while in this work four schools were involved.He employed a survey experimental design and independent t-test statistical tool to run the analysis which shows that it was limited in terms of sample size while in this study experimental research design and t-test were used. Both studies showed that gender has no significant effect on students' academic achievement and ability rather the performance is based on internal factor that is students' ability level.

2.3.4 Gender and scientific reasoning ability

Tajudin and Chinnappan (2017), carried out the study on the role of reasoning in mathematical performance as a continuing topic of interest for researchers in mathematics education. True-experiment method was used for the study. This present study explored the link between scientific reasoning skills and mathematics performance as measured by students" responses to a series of problems. T-test was used as analytical tool for the study. Results indicated the existence of a moderate positive correlation between the two variables. All participating students exhibited low level of scientific reasoning. Despite this, students in the high-achievement group performed significantly better than their peers in the low-achievement group in the mathematics test. The results suggest there was significant differences in mean overall mathematics score between High and Low-Achievement group in scientific reasoning group. It was also revealed that there was no significant difference in the overall mathematics scores between boys and girls ($t(349) = 16.789$, $p < 0.05$). In conclusion the low levels of SRS as exhibited particularly by the students in the Low-Achievement group can be attributed to a number of factors. Firstly, it is possible that students were not given explicit instructions about reasoning and the role of reasoning in solving complex mathematical problems. Also teachers may not understand the nature of deep reasoning and its role in helping students to solve non-routine mathematical problem solving. Based on the above assumptions, the study concluded that teachers" professional programme in Malaysia must provide explicit instruction in reasoning skills.

The work of Tajudin and Chinnappan is just too flimsy to contend with, from the way the work was presented, the result was followed immediately after the research topic without making proper digestion of the work- the number of research questions and research hypotheses, instrument, method of data collection, reliability, population and sample size were not captured. In addition, result revealed that all participating students exhibited low level of scientific reasoning. The reason for this kind of result is not far fetch, the researchers expected the students to have performed excellently well when they were tried on the link between scientific reasoning skills and mathematics performance when subjected to series of problems. The students were not trained on how to exhibit reasoning ability, scientific reasoning skills do not just appear, students must be trained before it can manifest. This is a gap that this research work filled.Students were trained on how to enhance reasoning ability with 5Es learning-cycle and students taught with this strategy had better results.

The researchers investigated the correlation between scientific reasoning ability of students and performance in mathematics as measured by responses of students to series of problems. While their study explored the link between the two variables, this study was concerned with using a student-centered and inquiry strategy to enhance scientific reasoning ability and achievement of students. In a nutshell, both studies have certain things in common and differ from each other as well. Both studies explored reasoning ability and performance of science students, which are important variables in science disciplines. 5Es learning-cycle instructional strategy was examined in this study and was not considered in their study. Results from both studies showed that there is no significant difference in students'scientific reasoning scores based on gender. From conclusion made in their study the low level of scientific reasoning skills in the low-achievement group could be attributed to series of factors one of which is the non utilization of 5E learning-cycle instructional strategy.

Chakkrapan *et al*. (2013), examined the effect of gender on students' scientific reasoning ability in a context of Thailand. A total of 400 Grade 11 students from four co-educational schools in Northeastern region of Thailand participated in the study. The widely used and pre-validated Lawson Classroom Test of Scientific Reasoning (LCTSR) Lawson (2004) was administered to investigate students' scientific reasoning ability in six constructs namely (i) Conservation of Mass and Volume (CMV), (ii) Proportional Thinking (PPT), (iii) Control of Variables (CV), (iv) Probabilistic Thinking (PBT), (v) Correlational Thinking (CT), and (vi) Hypothetical-deductive Reasoning (HDR). The results indicated that the gender does not significantly impact on students' scientific reasoning ability for each construct. In addition, the lowest mean score for the students' scientific reasoning ability were HDR, CV, PPT, respectively, for both genders. The finding of this indicated that there is critical area for improvement of students' scientific reasoning ability. This also implied that instructional pedagogy in science classroom should be more emphasized on the way of teaching that (i) how to reason casually based on hypothesis generation (ii) how to design well fair science experiment, and (iii) how to determine correlation and conversation between target variables, in order to enhance the development of students' scientific reasoning ability.

Critical ingredients that make a work valid and well structured were not captured in the research work, the researchers failed to state the number of research questions with corresponding research hypotheses as well as the reliability coefficient. Sampling technique, sample size, the method used to analyze data collected from the field and how the instrument was validity were not mentioned in the study. The study tested students on only six constructs and left other important reasoning skills out making the work not buoyant enough.

The study carriedout by these researchers did not differ to a great extent from this study. In this study instructional pedagogy was laid more emphasis on as a tool used in enhancing students'scientific reasoning ability and achievement than their study which stressed on gender as an independent variable. Their test instrument on reasoning investigated students'scientific reasoning ability in six constructs while this study investigated two major dimensions (deductive and inductive reasoning) which encompass all other constructs. Seventeen reasoning skills were investigated in this study which shows that their instrument was limited. Similarities shared is in the type of test instrument adopted, the widely used and pre-validated Lawson Classroom Test of Scientific Reasoning (LCTSR) was administered on the students which is similar to the Classroom Test of Scientific Reasoning by Wenning and Vierya (2015) where the test instrument of this study was coined and adapted from. Results from both studies revealed that gender doesnot impact on students'scientific reasoning ability for each construct.

Patrick, and Urhievwejire (2012), carried out study on effects of learning cycle as an instructional strategy on biology and chemistry students' achievement. To guide this study, six research hypotheses were stated and tested at 0.05 level of significant. The design of this study was 2x2x3x6 Pre-test Post-test non-equivalent control group quasi experimental design. These included two instructional groups (experimental and control groups), sex (male and female), repeated testing (Pre, Post and follow-up tests), and six weeks of experience. The samples of the study included six senior secondary schools, 112 science students, and 12 biology and chemistry teachers. The instruments used for this study were: teacher's questionnaire on knowledge and use of learning cycle

(KULC); and Biology and Chemistry Achievement Test (BCAT). The data collected were analyzed with simple percentage, Analysis of Covariance (ANCOVA) and student t-test statistics. The major findings of the study included that only 30.43% and 26.31% of Biology and Chemistry teachers have the knowledge that learning cycle is an instructional method; all the Biology and Chemistry teachers sampled have never used learning cycle as an instructional method; learning cycle had a significant effect on students achievement Biology and Chemistry; students taught with learning cycle significantly achieved better in Biology/Chemistry Post-test than those taught with lecture method; the posttest scores of students in the learning cycle group increased over the period of experience; non-significant difference in Posttest scores between males and females taught with learning cycle; non-significant interaction effect between method and sex on achievement; and a significant higher retention of biology and chemistry knowledge by students taught with learning cycle than those taught with lecture method. It was concluded that the method seems an appropriate instructional model that could be used to solve the problems of science teaching and learning since it facilitates learning, retention and its effectiveness not being limited by sex.

Some critical and important part of the methodology were not included in the work causing conflict in knowledge with this study, the total population of the study was not indicated, guideline for choice of sample size, number of items on the test instrument, reliability coefficient, validity and sampling technique were not captured in the work. The researchers did notmake any form of recommendation in the work. Learning-cycle is an inquiry and student-centered instructional strategy, these researchers carriedout study on this strategy to determine its effect on students’ achievement which is similar to this study. Other similarities include use of quasi-experimental research design, same instructional groups, same number of research hypotheses, same academic level. In their study Biology and Chemistry teachers were part of the participants served questionnaires. While their study adopted mixed research design this study adopted a single type of research design. Results from both studies revealedthat learning-cycle instructional strategy had significant effect the academic achievement of students than the lecture teaching method. There was no significant difference in posttest scores between male and female taught with learning-cycle strategy.

2.3.5 School location and scientific reasoning ability

Ezechi (2017), carried out a study on school location influence on reasoning patterns and achievement of Nigerian students in genetics and evolution. It was argued that the reasoning pattern employed by students could be influenced by their school location. The research design used in the study was an ex-post facto research design. The study was guided by two research questions and one hypothesis. Multi stage sampling technique was used to select 352 students (178 urban and 174 rural) from four co-educational schools in Agbani education zone of Enugu State, Nigeria. Two instrumssents, Students' Reasoning in Explanation of Biological Phenomena (SREBP) and Genetics and Evolution Achievement Test (GEAT) were used to collect data. Data were analyzed using percentage and chi-square. Students in urban schools exhibited more scientific reasoning than their rural counterpart. In the research, the researcher did not include the total population used in the study as well as the reliability coefficient and validitywas omitted. The number of items on the test instrument was not captured.

From the research empirical put forward above, it is obvious that three variables investigated in the study are present in the present study: school location, reasoning and achievement. While school location is present as an independent variable in the study it was used as a moderating variable in this study. Reasoning and achievement are used as dependent variables in both studies. Therefore, variables are flexible. There was difference in the topics taught to students, the research design, sampling techniques, as well as tools used for running analysis were different also. However, both studies had same number of schools used for the study and same subject (Biology). The research findings on school location were the same. Both studies revealed that students in urban schools performed better in scientific reasoning ability test than their rural counterpart,although in this study school location had no significant difference in students'scientific reasoning ability and achievement.

Olawale (2017), investigated the effect of 5Es learning-cycle instructional strategy on academic achievement and retention of secondary school biology students' in Ogun State. True experiment design was used for the study. 256 Biology students was randomly selected for the study, in the three senatorial zone in Ogun State. Analysis of Covariance (ANCOVA) was used in analyzing the data. The result showed that significant difference does not exists in the achievement of rural and urban biology students when taught using 5Es learning-cycle instructional strategy. Also, there was a significant difference in the mean retention scores between male and female students taught using 5Es learning-cycle instructional strategy. In the study conducted by Olawale the total population was not indicated, the guideline for the choice of sample size as well as the number of test item was not captured. The number of research questions and research hypotheses, reliability, method used for data collection were not indicated in the work. No form of recommendation was made.

The research work is similar to this study based on the fact that both studies adopted the same instructional strategy, one of the dependent variable (achievement) and two moderating variables (school location and gender) are the same. The students that participated in the study were randomly selected, thus true experimental design was used in the study, while quasi-experimental research design was used in the presentstudy because an intact class was used and revealed that there is no significant difference in the achievement of rural and urban schools taught with 5E learning-cycle in terms of gender for both studies, while in both studies, male and female mean achievement were different. One major gap and difference in the studies was scientific reasoning ability. Scientific reasoning ability was not investigated in his study while it was investigated in this study.

2.4 Summary of Literature Reviewed

The reviewed literatures conceptualized concept of 5Es learning-cycle instructional strategy, origin of 5Es learning-cycle instructional strategy, 5Es learning-cycle instructional strategy as a scientific inquiry tool, teaching respiration in senior secondary school Biology with 5Es learning-cycle instructional strategy, 5Es learning-cycle instructional strategy and scientific reasoning ability and achievement, scientific reasoning ability and secondary school achievement, gender and scientific reasoning and achievement in Biology, school location and scientific reasoning ability and achievement in Biology.

The different theories relevant to this study are Constructivism, Behaviorismtheory and Gardner’s theory of multiple intelligence,the empirical studies are on effects of 5Es learning cycle instructional strategy on students' achievement, 5Es learning-cycle instructional strategy and scientific reasoning ability and achievement, gender and students' academic achievement, gender and scientific reasoning ability. The studies on achievement, scientific reasoning ability, gender and school location in different subjects indicated that 5Es learning-cycle instructional strategy, generally speaking, was more effective than the conventional method. The present study was under taken to investigate if 5Es learning cycle instructional strategy would enhance scientific reasoning and achievement of secondary school Biology students taught respiration using 5Es learning-cycle instructional strategy in Minna educational zone, Niger State. The results revealed that 5Es learning-cycle instructional strategy is a reliable tactic to help students develop scientific reasoning ability and enhance achievement of students. The need for this became imperative and variable such as achievement, scientific reasoning ability, gender and school location were incorporated as the variables in the study.

From the literatures reviewed, different research works have been conducted on learning cycle strategy both within and outside the country, scientific reasoning ability and achievement.All along, the literatures reviewed centered on certain areas, a lot of conflicts in knowledge were observed and gaps filled. The scientific reasoning ability of rural and urban students was not looked at as well as deductive and inductive reasoning. From the reviewed literaturesonly few of the research studies were conducted in Biology, however, not on using 5Es learning cycle instructional strategy to enhance scientific reasoning ability and achievement among secondary school Biology students in Minna academic zone, Niger State. None of these have been found in Nigeria and Niger State in particular. This is the gap the researcher filled in this study.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

The study adopted quasi-experimental of non-equivalent pre-test post-test Control group design. The design was adopted because it was impractical to run a true experiment, random pre-selection of students to treatment and control groups was not possiblehence the researcher used an intact class only from each sampled school.

The independent variables were 5Es learning-cycle strategy and lecture method. School location (rural and urban), two groups of gender (male and female) were investigated in this study as moderating variables (2x2x2). The dependent variables are scientific reasoning ability and achievement. Experimental and control groups were subjected to pre-test and post-test before and after treatment respectively. The design layout is as shown below in Table 3.1

Table 3.1 Research Design Layout

Group	Pre-test	Treatment	Post-test
E	O1	X	O2
	P1	X	P2
C	O1	-	O2
	P1		P2

Key:

E: Experimental group.

C: Control group.

X: Treatment for Experimental group(5Es learning cycle instructional strategy)

-: No treatment for Control group(Conventional Instructional Strategy)

O1: Pre-test on achievement for Experimental and Control groups

O2: Post-test on achievement for Experimental and Control groups

P1: pre-test on scientific reasoning for Experimental and Control groups

P2: post-test on scientific reasoning ability for Experimental and Control groups

3.2 Population of the Study

The population for the study comprised the entire Biology students of 2020/2021 session in Minna educational zone, Niger State. The target population was made up of all the senior secondary school two students offering Biology. There were (58,303,) students and 90 public senior secondary schools in Minna educational zone (see appendix C) for the table containing senior secondary schools and population of the study.

3.3 Sample and Sampling Techniques

The sample size for this study was made up of two hundred and seventytwo (272) with male (120) and female (152) students from four (4) selected co-educational schools in Minna educational zone, Niger State.The sample size is supported by Central Limit Theory by Pierre-Simon Laplace (1810), whose guideline explains that in an experimental research, sample size of 30 (n=30) is okay no matter the shape of the population distribution. The target population for the study consisted of 19,520 SS II Biology students in Minna educational zone. A purposive sampling technique was used to select the four schools. The number of Biology teachers, location and years of establishment of school, number of Biology students and workforce, gender composition was considered for schools' selection. Then, a simple random sampling technique was used to assign the four schools selected to experimental and control groups (a rural school and an urban school make up a group respectively) to avoid biasness in sampling location. See details in table 3.2 below. Lessons were taught by the research assistants trained for the purpose.

Table 3.2 Distribution of sample size by school, location and Gender

Groups	School	Location	Male	Female	Total
E	Government Science College, Chanchaga.	Urban	26	52	78
	Day Secondary School, Garatu	Rural	41	21	62
C	Hill Top Model School, Minna.	Urban	32	42	74
	Day Secondary School, Pyata	Rural	21	37	58
Total			120	152	272

Source: Field Work (2022).

The table shows the distribution of the sampled schools by location, size and gender. The schools are several kilometres from one another and therefore distance did not interfere in the result findings. The concept used for the study was taught to the students upon resumption in order to prevent interference, therefore, the students lacked knowledge of the concept before they were taught.

3.4 Instruments for Data Collection

3.4.1 Development of the instrument

The instruments developed for data collection in this study were grouped into two: Treatment and Test Instruments.

(1) Treatment instruments/Lesson plans;

Treatment instruments are 5Es learning-cycle instructional strategy and lecture method, 5Es learning-cycle instruction format was used to prepare the lesson plans for the experimental group and the lecture method lesson plans were used on the control group.The lessons were taught to the students in the sampled schools based on the time allocated for Biology in the school timetable.

(2) Test instruments

The research test instruments were of two types, reasoning test instrument referred to as Classroom Test of Scientific Reasoning Ability (ClaTeSRA) and achievement test instrument known as Respiration Achievement Test (RAT). Both instruments were multiple-choice test items used for Pre-tests and Post-tests. Pre-tests were reshuffled before it was administered on the students for post-test. Pre-tests were used to determine the entry-level of the students in the sampled schools. Post-tests were used to collect data for students' scientific reasoning ability and achievement. Both instruments contained two major sections, A and B. Section A dealt with demographic data of the students such as the name of school, school location, class, age and sex. Section B contained multiple-choice objective questions with four options (A-D).

(a) Classroom test of scientific reasoning ability (ClaTeSRA)

Questions for ClaTeSRA were adapted from Wenning, and Vierya (2015), Scientific Reasoning Test and modified to suit Secondary School Certificate Examination (SSCE) standard. ClaTeSRA is made up of two sections, A and B. Section A provide room for demographic data of the students and section B consisted of 25 multiple-choice objective questions with four options (A-D), 21 of the questions were deductive reasoning and four (4) were inductive reasoning with varying reasoning skills embedded in the questions (see appendix H for specification). ClaTeSRA was administered during pre-test and post-test.

(b) Respiration achievement test (RAT)

The questions for this test instrument were adapted from WAEC past questions. Section B contained 50 multiple-choice objective items with four options (A-D) as well, the correct option is circled. Blooms taxonomy was implemented for the development of the test instrument (see appendix K) for specification and appendix L for difficulty level of the test questions. RAT was administered during pre-test and post-test, questions for post-test were reshuffled.

3.4.2 Scoring of the test instruments

In order for students to be awarded a mark they were required to indicate the correct answers by circling on the correct letter (A-D) that corresponds to the right option for each item. The instruments were administered on the whole groups as pre-test and post-test. 'I' mark was awarded for each correct answer and '0' for each wrong answer, and the total scores were converted to 100%.

3.5 Validity of the Research Instruments

The instruments were validated by three experts, one from science education department, one from Industrial and Technology Education (ITE) department, both ofFederal University of Technology, Minna and the third expert was a teacher from Model Science College, Tudun Fulani. They looked atface and content validity on the

Respiration Achievement Test (RAT) and Classroom Test of Scientific Reasoning Ability (ClaTeSRA).

3.6 Reliability of the Research Instruments

To determine the reliability of the research instruments, pilot test was conducted at Government Army Day Secondary School Minna (GADSS) using test-retest method. The test was administered on 30 SS II students randomly selected for the pilot study, GADSS Minna is situated within the population but outside the sampled schools for the study. The result obtained from trial testing conducted was used to determining the reliability coefficient of test instruments. The following reliability coefficients were obtained using Pearson Product Moment Correlation **(**PPMC**),** RespirationAchievement Test (RAT) was 0.81 and Classroom Test on Scientific Reasoning Ability (ClaTeSRA) was 0.86, respectively. The rationale for the pilot testing was to enable the researcher determined the level of consistency of the test instruments.

3.7 Method of Data Collection

The researcher collected an introductory letter from the Department of Science Education, Federal University of Technology Minna. The researcher sought permission to conduct the study in the sampled schools by presenting the introductory letter to the principals of the selected schools for consideration. With permission, the researcher made some forms of familiarity and arrangement with the Biology teachers (research assistants) of the selected schools. A total of 5 weeks was used for data collection.

(a) Orientation and pre-tests; before the treatments were administered on the participating students in both experimental and control groups, orientation and pre-test were administered to both groups the first week before the commencement of the teaching activities.ClaTeSRA was administered first before RAT instrument. The instruments were used to determine the students’ prerequisite knowledge on the concept of respiration and scientific reasoning ability.

(b) Treatment adopted for the study; After pre-test for both instruments had been decided teaching activities with the treatments took centre stage, aerobic and anaerobic respiration were taught the second week, glycolysis was treated third week and krebs' cycle wastaught fourth week. The research assistants for the experimental group were trained on how to employ the strategy before teaching. The researcher gave the Biology teachers copies of the lesson plan, and the researcher guided the teachers on how to employ the strategy during the training sessions. This helped to assess the method of teaching as well as to ensure compliance to the instruction. Teaching activities lasted for three weeks and

(c) post-tests; post-testswereadministered on all the groups at the end of the lessons precisely on the fifth week. The post-tests and pre-tests were the same in terms of questions. Questionswere reshuffled before it was administered for the post-test.

3.8 Method of Data Analysis

Data on RAT and ClaTeSRA collected from the study were analysed using descriptive and inferential statistics. The research questions were answered with mean and standard deviation, pretest results were analysed with ANOVA while the hypotheses were tested with ANCOVA and Z-test at 0.05 level of significant. In summary, ANOVA is used to find out their entry behaviour and equivalent level of the groups by comparing the means of the groups as one independent variable is involved. ANCOVA is used to test hypothesis when the means of the groups are non-equivalent in order for controlling the effects of continuous covariates, while Z-tests are used for comparing means or proportions when the population standard deviation is known and the sample size is large. All theses tests are relevant in hypothesis testing and data analysis.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Answering Research Questions

The data collected for the purpose of this study were analyzed based on the research questions and hypotheses formulated.

Research Question One: What is the mean difference in the scores of secondary school Biology students' scientific reasoning ability test when taught with 5Es learning-cycle instructional strategy and those taught using the conventional method?

Table 4.1: Mean and Standard Deviation of Pretest and Posttest Scores on Scientific Reasoning Ability of Experimental and Control Group

Variable	N	Pretest		Posttest		Mean Gain	Mean Gain Diff.
		$\bar{x}$	SD	$\bar{x}$	SD		
Experimental Group	140	23.20	8.074	68.34	7.985	45.14	28.13
Control Group	132	24.08	7.594	41.09	7.757	17.01	

Table 4.1 shows the mean and standard deviation scores of experimental group and control group in pretest and posttest of scientific reasoning ability test. The result revealed that mean and standard deviation scores of the pretest and posttest experimental group are $\bar{x}$=23.20, SD = 8.074 and $\bar{x}$= 68.34, SD = 7.985.34 respectively. This gives a mean gain of 45.14 in favour of the posttest. On the other hand, the mean and standard deviation of the pretest and posttest of the control group are $\bar{x}$ = 24.08, SD = 7.594 and $\bar{x}$ =41.09, SD = 7.757 respectively and gives a mean score of 17.01 in favour of the posttest. The difference in mean gain is 28.13.The result also revealed that experimental group taught with 5Es learning cycle strategy had the higher mean gain of 45.14, and therefore performed higher than control group. The SD in pretest and

posttest of both experimental and control groups indicate that the responses of students are clustered around the mean.

Research Question Two: What is the mean difference in the achievement scores of secondary school Biology students taught respiration concept with 5Es learning-cycle and conventional instructional strategies?

Table 4.2: Mean and Standard Deviation of Pretest and Posttest Achievement Scores of Experimental and Control Group

Variable	N	Pretest		Posttest		Mean Gain	Mean Gain Diff.
		$\bar{x}$	SD	$\bar{x}$	SD		
Experimental Group	140	24.59	5.064	67.59	6.590	53.00	29.71
Control Group	132	16.74	5.320	40.03	5.957	23.29	

Table 4.2 shows the mean and standard deviation of the mean achievement scores of experimental group and control group in pretest and posttest. The result revealed that mean and standard deviation scores of the pretest and posttest experimental group are $\bar{x}$ =24.59, SD = 5.064 and $\bar{x}$ = 67.59, SD = 6.590 respectively. This gives a mean gain of 53.00 in favour of the posttest. On the other hand, the mean and standard deviation of the pretest and posttest of the control group are $\bar{x}$ = 16.74, SD = 5.320 and $\bar{x}$ =40.03, SD = 5.957 respectively and gives a mean score of 23.29 in favour of the posttest. The difference in the mean gain is 29.71.The result also revealed that experimental group taught with 5Es learning cycle strategy had the highest mean gain of 53.00, therefore the students in the experimental group outperformed students in the control group. The SD in the posttest of both groups indicate that the level of dispersion of the students' achievement is not far from the actual mean.

Research Question Three: What is the difference in the scientific reasoning ability test scores of male and female secondary school Biology students taught with 5Es learning-cycle instructional strategy?

Table 4.3: Mean and standard deviation of pretest and posttest scores based on gender on scientific reasoning ability test taught with 5Es learning-cycle instructional strategy

Group	N	Pretest		Posttest		Mean Gain	Mean Gain Diff.
		$\bar{x}$	SD	$\bar{x}$	SD		
Male	67	23.88	7.563	68.39	6.708	44.53	
Female	73	22.58	8.521	68.30	9.047	45.72	1.19

Table 4.3 shows the mean and standard deviation of the pretest and posttest scores of male and female experimental group on scientific reasoning ability test taught using 5Es learning-cycle instructional strategy. From the result, it can be seen that mean scores of the pretest and posttest of male are $\bar{x}$ =23.88, SD = 7.563 and $\bar{x}$ = 68.39, SD =6.708. The mean gain is 44.53 in favour of male posttest score. Similarly, the mean and standard deviation of pretest and posttest score of female are $\bar{x}$ = 22.58, SD = 8.521 and $\bar{x}$ = 68.30, SD = 9.047.47, the mean gain is 45.72 in favour of the female posttest score. Also the result reveals the difference of 1.19 in the posttest mean gain scores of male and female in favour of the female. The SD of pretests and posttests in both experimental and control groups indicate that the response of the students clustered around the mean.

Research Question Four: What is the difference in the achievement test scores of male and female secondary school Biology students taught with 5Es learning-cycle Instructional strategy?

Table 4.4: The mean and standard deviation of pretest and posttest scores of male and female achievement testof Experimental Group

Group	N	Pretest		Posttest		Mean Gain	Mean
		$\bar{x}$	SD	$\bar{x}$	SD		Gain Diff.
Male	67	14.72	5.424	68.72	5.160	54.00	1.92
Female	73	14.47	4.744	66.55	7.559	52.08	

Table 4.4 shows the mean and standard deviation of the pretest and posttest scores of male and female experimental groupachievement test taught with 5Es learning-cycle Instructional strategy. From the result, it can be seen that mean score of the pretest and posttest score of the male are $\bar{x}$ =14.72, SD = 5.424 and $\bar{x}$ = 68.72, SD =5.160. The mean gain is 54.00 in favour of the male posttest achievement test score. Similarly, the mean and standard deviation of pretest and posttest score of female are $\bar{x}$ = 14.47, SD = 4.744 and x = 66.55, SD = 7.559, the mean gain is 52.08 in favour of the female posttest score. Also the result reveals the difference of 1.92 of mean gain in the posttest in favour of the male.The SD in male and female posttest achievement scores is low, which means that students responses in the test are not far from the mean. This implies that both male and female students' in the experimental group tend to improve on their knowledge of respiration at the same level.

Research Question Five: What is the difference in the scientific reasoning ability test of secondary school Biology students based on school locationtaught with 5Es learning-cycle instructional strategy?

Table 4.5: The mean and standard deviation onscientific reasoning ability test of Experimental Group based on school location.

Group	N	Pretest		Posttest		Mean Gain	Mean Gain Diff.
		$\bar{x}$	SD	$\bar{x}$	SD		
Urban	78	22.97	8.77	69.28	5.72	46.31	2.63
Rural	62	23.48	7.15	67.16	10.07	43.68	

Table 4.5 shows the mean and standard deviation of scientific reasoning ability test of secondary school Biology students based on school location taught with 5Es learning-cycle instructional strategy. The result revealed the mean and standard deviation responses of urban schools pretest $\bar{x}$ = 22.97, SD= 8.77, posttest $\bar{x}$ = 69.28, SD = 5.72 mean gain is $\bar{x}$ = 46.31 respectively. On the other hand, rural schools pretest $\bar{x}$ = 23.48, SD= 7.15, posttest $\bar{x}$ = 67.16, SD = 10.07 mean gain is $\bar{x}$ = 43.68 respectively. The difference in posttest mean gain is 2.62.The results also revealed that urban school had the highest mean of 46.31 compared to rural school. From the SD in the table it indicates that the level of dispersion of the students' response is not far from the mean.

Research Question Six: What is the difference in the mean achievement test scores of secondary school Biology students based on school location taught respiration concept with 5Es learning cycle instructional strategy?

Table 4.6: The mean and standard deviationonachievement test scores of Experimental Group based on school location

Group	N	Pretest		Posttest		Mean Gain	Mean Gain Diff.
		$\bar{x}$	SD	$\bar{x}$	SD		
Urban	78	12.82	4.36	67.18	7.11	54.36	3.07
Rural	62	16.81	5.03	68.10	5.87	51.29	

Table 4.6 shows the mean and standard deviation of achievement scores of secondary school Biology students based on school location taught respiration concept with 5Es learning cycle. The result revealed the mean and standard deviation responses of urban schools pretest $\bar{X}$ = 12.82, SD= 4.36, posttest $\bar{X}$ = 67.18.05, SD = 7.11 mean gain is $\bar{X}$ = 54.35 respectively. Similarly, rural schools pretest $\bar{X}$ = 16.81, SD= 5.03, posttest $\bar{X}$ = 68.10, SD = 5.87 mean gain is $\bar{X}$ = 51.29 respectively. The difference in the posttest mean gain is 3.06.The results also revealed urban school had the highest achievement mean of 54.36 compare to rural school.The SD in urban and rural student posttest achievement scores is low, which means that students responses in the test are not far from the mean. This implies that both urban and rural students in the experimental group tend to improve on their knowledge of respiration at the same level.

4.2 Testing Research Hypotheses

The result on Analysis of Variance (ANOVA) on the pretest result of scientific reseaoning revealed that there was no significant difference in the mean score of experimental and control groups. This implies they are equivalent while the pre-test result on the academic achievement test revealed that there was significant difference in the mean achievement score of experimental and control groups. This implies that they are non-equivalent hence ANCOVA was used to test the direction of the significance and to control the covariate effects (See Appendix Q, Page 173).

Hypothesis One: There is no significant difference in the scientific reasoning ability test scores of secondary school Biology students taught with 5Es learning-cycle and conventional instructional method.

Table 4.7: Z-test posttest scores on scientific reasoning ability of experimental and control groups

Participants	N	$\overline{X}$	SD	t-cal	Df	p-value
Experimental Group	140	68.34	7.98	28.52	270	0.00
Control Group	132	41.09	7.75			

Table 4.7 shows the mean scores for scientific reasoning ability test scores of secondary school Biology students taught respiration using 5Es learning-cycle strategy and those taught withlecture method. Experimental Group test scores X = 68.34, SD= 7.98 and the mean for control group X=41.09, SD = 7.75. The table shows that t-cal 28.52, df = 270, with p = 0.00. Since p<0.05, hypothesis two is hereby rejected on the basis thatthere was statistically significant difference in the mean scores of Experimental and Control Groups in favour of experimental group.

Hypothesis Two: There is no significant difference in the mean academic achievement test scores of secondary school Biology students taught with 5Es learning-cycle and conventional instructional strategies.

Table 4.8 ANCOVA Posttest Achievement Scores of Experimental and Control Groups Using the Pretest as Covariate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	51587.914[a]	2	25793.957	649.453	.000
Intercept	77172.711	1	77172.711	1943.093	.000
PRETEST	.132	1	.132	.003	.954
GROUP	49472.064	1	49472.064	1245.632	.000
Error	10683.718	269	39.716		
Total	861700.000	272			
Corrected Total	62271.632	271			

Table 4.8 shows the ANCOVA Posttest Scores of experimental and control groups taught with 5Es learning-cycle strategy and lecture method respectively. An

examination of Table 4.1b with F (1, 271) = 1245.632, p = 0.000, the results of the analysis indicates that this hypothesis is rejected on the basis that the p value is less than 0.05 and the main effect (treatment) was significant. The results revealed that the 5Es learning-cycle produced a significant effect on the posttest achievement scores of students when covariate effect (pretest) was controlled. The result indicates that the treatment, 5Es learning-cycle accounted for the difference in the posttest achievement scores of the students. This implies that a significant difference exists between the two groups in favour of the experimental group.

Hypothesis Three: There is no significant difference in the mean scientific reasoning ability test scores between male and female secondary school Biology students taught with 5Es learning-cycle strategy.

Table 4.9: Z-test analysis of male and female students scores on scientific reasoning ability in experimental group

Participants	N	$\overline{X}$	SD	t-cal	Df	p-value
Male	67	68.39	6.70	0.95	138	0.34
Female	73	68.30	9.04			

Table 4.9 shows the analysis ofmean score for male and femalestudentstaught Biology using 5Es learning-cycle strategy. The mean for maleX= 68.39, SD = 6.70 and the mean for female students X=68.30, SD = 9.04. The table shows that t-cal = 0.95, Df = 138, with p=0.34. Since p >0.05, hypothesis three is hereby retained on the basis that the p value is greater than 0.05 and there was no statistically significant difference in the scientific reasoning ability test scores between male and female secondary school Biology students taught using 5Es learning-cycle strategy.

Hypothesis Four: There is no significant difference in the mean achievement scores between male and female secondary school Biology students taught using 5Es learning-cycle strategy.

Table 4.10: Z-test analysis of male and female students scores in experimental group on achievement.

Participants	N	$\bar{X}$	SD	t-cal	Df	p-value
Male	67	68.72	5.16	1.96	138	0.05
Female	73	66.55	7.55			

Table 4.10showsmean scores for male and female senior secondary school Biology students' achievement scores when taught respiration using 5Es learning-cycle strategies. X = 68.72, SD = 5.16 and the mean for female students X=66.55. The table show that t-cal = 1.96, df = 138, with p=0.05. Since p=0.05, hypothesis four is hereby retained, therefore, there was no significant difference between male and female senior secondary school Biology students' mean achievement scores when taught respiration using 5Es learning-cycle strategy.

Hypothesis Five: There is no significant difference in the mean scientific reasoning ability score between rural and urban secondary school Biology students taught using 5Es learning-cycle instructional strategy.

Table 4.11: Z-test analysis of rural and urban students' scores onmeanscientific reasoning ability of experimental group

Participants	N	$\bar{X}$	SD	t-cal	Df	p-value
Urban	78	69.28	5.72	1.56	138	0.11
Rural	62	67.16	10.07			

Table 4.11 shows the mean scoresonscientific reasoning ability test of secondary school Biology students based on school location when taught using 5Es learning-cycle.Urban schools X=69.28, SD = 5.72 and the mean for rural schools X=67.16, SD=10.07, t-cal= 24.99, df = 138, with p=0.11. Since p>0.05, hypothesis five is hereby retained on the

basis that there was no statistically significant difference in the scientific reasoning ability of rural and urban secondary school Biology students.

Hypothesis Six: There is no significant difference in the mean academic achievement scores of rural and urban secondary school Biology students taught using 5Es learning-cycle strategy.

Table 4.12: Z-test analysis of rural and urban students' scores on achievement taught Biology using 5Es Learning-Cycle

Participants	N	$\bar{X}$	SD	t-cal	df	p-value
Urban	78	67.18	7.11	0.81	138	0.41
Rural	62	68.10	5.87			

Table 4.12 shows the mean scores on achievement for secondary school Biology students based on school location when taught respiration using 5Es learning-cycle. Urban schools X=67.18, SD = 7.11 and the mean for rural schools X=68.10, Sd=5.87, t-cal = 0.81, df = 138, with p=0.41. Since p>0.05, hypothesis six is hereby retained on the basis that there was no significant difference in the academic achievement of secondary school Biology students based on school location when taught respiration using 5Es learning-cycle strategy.

4.3 Major Findings of the Study

(1) There was statistically significant difference in the scientific reasoning ability test scores of secondary school Biology students taught with 5Es learning-cycle and lecture instructional method

(2) There was statistically significant difference in the mean academic achievement test scores of secondary school Biology students taught respiration using 5Es learning-cycle and lecture instructional method

(3) There was no statistically significant difference in the scientific reasoning ability test scores of male and female senior secondary school Biology students taught with 5Es learning-cycle strategy.

(4) There was no statistically significant difference between male and female senior secondary school Biology students' mean achievement scores taught respiration with 5Es learning-cycle strategy.

(5) There was no statistically significant difference in the scientific reasoning ability test of secondary school Biology students based on school location taught with 5Es learning-cycle strategy.

(6) There was no statistically significant difference in the academic achievement of secondary school Biology students based on school location taught respiration with 5Es learning-cycle strategy.

4.4 Discussion of the Findings

The finding of this study revealed that there was statistically significant difference in the scientific reasoning ability test scores of secondary school Biology students taught with 5Es learning-cycle strategy and lecture method in favour of those exposed to 5Es instructional strategy. This is in support of the findings of Babalola, Jibril and Isaac (2019), who examined the effects of 5E learning cycle and concept-mapping strategies on secondary school students' achievement in ecology. It was revealed that 5E learning cycle instructional strategy had the highest achievement followed by concept-mapping strategies and conventional method. It also concurs with the study of Nevin (2017) who investigated theeffect of 5e learning model on academic achievement, attitude and science process skills: meta-analysis study. The findings revealed that as a result of the study, the effect of the method applied for each dependent variable was found to favor the experimental group.

The analysis also indicates that there was statistically significant difference in the mean academic achievement test scores of secondary school Biology students taught respiration with 5Es learning-cycle strategy and lecture instructional method.This is in agreement with the study of Ibrahim (2015) that investigated the impact of 5E teaching cycle on attitude, retention and performance in genetics among pre-NCE Biology students with varied abilities. The findings of the study showed that pre-NCE Biology students exposed to 5E teaching cycle in the teaching and learning of genetics concepts in all the ability levels had higher mean performance scores and retain more than those in the control group exposed to lecture method of instruction. This also agreed with the findings of Balci*etal.* (2006) who carried out study to investigate the effect of the 5E learning cycle model conceptual change text and traditional instructions on eighth grade students understanding of photosynthesis and respiration in plant. The results showed that there was a significant difference between experimental and control group in favour of experimental group with respect to student's understanding of photosynthesis and respiration in plant.

Furthermore, the finding also showed that there was no statistically significant difference in the scientific reasoning ability test scores of male and female senior secondary school Biology students taught with 5Es learning-cycle strategy. This is in support of the findings ofPatrick and Urhievwejire (2012) who carried out study on effects of learning cycle as an instructional strategy on biology and chemistry students' achievement. Results of the findings revealed no significant difference in the posttest scores between males and females taught with learning cycle. Also in line with the findings of Jimoh*et al.* (2014), who examined the effect of jigsaw cooperative learning strategy and gender on academic achievement of students' in cost accounting in colleges of education in Ogun State. The results showed that gender did not contribute significantly to varying students' achievement scores.

In addition, it was also observed that no statistically significant difference occurred between male and female secondary school Biology students' mean achievement scores taught respirations with5Es learning-cycle strategy. This concurs with the study of Ibrahim (2015) who investigated the impact of 5E teaching cycle on attitude, retention and performance in genetics among pre-NCE Biology students with varied abilities. The study revealed that male and female in all ability groups exposed to 5E teaching cycle performed equally well and had also no difference in their performance and retention abilities. Also in support of the findings of Mangut, and Solomon,(2015), who investigated the effect of mastery learning approach (MLA) on the performance of boys and girls in public primary schools in basic science and technology. The findings revealed that there was no significant difference between boys and girls performance both of them improved equally in mastery learning approach.

Further finding revealed that there was no statistically significant difference in the scientific reasoning ability test of secondary school Biology students based on school location when taught respiration with 5Es learning-cycle. This is contrary to the study ofEzechi, (2017), who carried out study on school location influence on reasoning patterns and achievement of Nigerian students in genetics and evolution. It was revealed that students in urban schools exhibited more scientific reasoning than their rural counterpart.

There was no statistically significant difference in the academic achievement of secondary school Biology students based on school location taught respiration with 5Es learning-cycle. This is in support of the findings ofOlawale, (2017), who carried out study on 5Es learning-cycle instructional strategy on academic achievement and retention of secondary school Biology students. The result showed that significant difference does not exist in the academic achievement of rural and urban Biology students taught with 5Es learning-cycle instructional strategy.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the findings of this study, it could be deduced that Biology students in experimental group had higherscientific reasoning ability scores in posttest when taught using 5Es learning-cycle strategyinMinna educational zone. The use of 5Es learning-cycle was found to be effective for teaching and learning of Biology. 5Es learning-cycle instructional strategy had positive effect on students' achievement more than lecture method. 5Es learning-cycle strategy proved to bridge the gender gap by given equal opportunity for male and female Biology students to enhance their reasoning ability.

The 5Es learning-cyclestrategy had positive effect on the achievement of both male and female Biology students. More so 5Es learning-cycle instructional strategy showed no significant difference in rural and urban students ability to reason scientifically therefore, it can bridge the gap between rural and urban schools in terms of the scientific reasoning ability. And finally, 5Es learning-cycle strategy had positive effect on the achievement of rural and urban students than other instructional delivery medium such as lecture method.

5.2 Recommendations

Based on the findings of this study, the following recommendations were made:

(i) 5Es learning-cycle instructional strategy should be encouraged in schools for teaching of Biology concepts

(ii) Students should be trained on the use of 5Eslearning-cycle, and engaged in such a way to builtscientific reasoning abilitythat can bring about better results in teaching and learning of Biology and Science subjects

(iii) Biology and other Science courses in particular should be taught using 5Es learning-cycle strategy.

(iv) Workshops,seminars, symposia and conferences should be organized periodically to acquaint new Biology teachers with recent research findings that would lead to effective and meaningful teaching and learning strategies such as 5Es.

5.3 Suggestions for Further Research

The following suggestions for further studies are made:

(i) Similar study should be carried out using other Biology concepts with view to identifying students' problems.

(ii) Research should be carried out on the effects of 5Es learning-cycle in other subject areas to authenticate the validity of its use.

(iii) Research should be carried out on the attitude and interest of students towards the use of 5Es learning-cycle instructional strategy in Biology.

(iv) Research should be carried out on the effects of 5Es learning-cycle instructional strategy on other variables such as students' mastery of concepts in Biology.

5.4 Contribution to Knowledge

This study has contributed to knowledge in science education and other areas of study by establishing the significance of the 5Es learning cycle as an effective alternative method of instruction to the conventional teaching method as the scientific reasoning ability of students in the experimental group was enhanced. The study further established that students exposed to the 5Es learning cycle had an improved mean score on scientific reasoning ability and achievement scores on the concept of respiration, with a clear mean gap of 28.13 and 29.71, respectively, when compared with those students taught with the conventional method.

The study also established that the use of the 5Es learning cycle in teaching is not gender biassed, and both urban and rural students performed almost at same level when exposed to the 5Es learning cycle.

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APPENDIX A

WAEC RESULTS OF BIOLOGY EXAMINATION FOR PERIOD OF 5YEARS (2013 - 2018)

Year	No of students present	No of students pass	No of students fail	% pass	% fail
2013	182659	39125	143534	21	79
2014	228953	80355	148598	35	65
2015	250099	86150	163949	34	66
2016	289520	84520	205000	29	71
2017	326541	98215	228326	30	70
2018	367562	120560	247002	33	67

Source: WAEC Office (2018)

APPENDIX B

WAEC CHIEF EXAMINERS' REPORT

THE WEST AFRICAN EXAMINATIONS COUNCIL

EXECUTIVE SUMMARY OF ENTRIES, RESULTS AND CHIEF EXAMINERS' REPORTS ON THE

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION (WASSCE)

CONDUCTED IN

NIGERIA

IN 2019

General Comments

Weakness/Remedies

Candidate's Strength

Weakness and Remedies

The observed weaknesses are as follows:

- poor spelling of some technical terms e.g Pyruvic acid, glycolytic pathway, adenosine triphosphate
- poor expression in questions requiring explanation,
- poor drawings of diagrams;
- inability to compare biological processes appropriately
- poor performance in questions that require application of knowledge
- not giving a title to the diagram;
- drawing the urinogenital system of a female instead of the reproductive system
- inability to answer questions that require corresponding answers correctly;
- inability to use technical terms to describe the processes that lead to the formation of citric acid in aerobic respiration;

The following solutions were proffered to overcome these weaknesses

- teachers should teach students the rules guiding drawing of biological diagrams teachers should make students draw often while making emphasis to the view of the diagram;
- teachers should be encouraged to attend WAEC coordination,
- teachers should be engaged in seminars and several trainings to aid their teaching students should study the correct spellings of technical terms;
- the correct definition of biological terms should be encouraged,
- students should endeavour to write legibly;
- teachers should lay emphasis on genetics;
- students and teachers should use standard text books,
- teachers and students should cover the syllabus before putting in for the examinations;
- teachers and students should endeavour to use Chief Examiners' Reports to study

APPENDIX C

POPULATION DISTRIBUTION FOR SENIOR SECONDARY SCHOOL

NIGER STATE MINISTRY OF EDUCATION, MINNA

ENROLMENT OF STUDENTS WHO OFFER BIOLOGY IN MINNA ZONAL DIRECTORATE OF EDUCATION BY SCHOOL, GENDER AND LGA

S/N	SCHOOL NAME	TOWN	LGA	TYPE OF SCHOOL (PUBLIC OR PRIVATE)	SECTOR / LEVEL	LOCATION (URBAN OR RURAL)	ENROLMENT BY CLASS								
							SS1			SS2			SS3		
							MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL
1	ABDULLAHI DADA SECONDARY SCHOOL MAIKUNKELE	Maikunkele	BOSSO	Public	JSS and SSS	Urban	42	75	117	63	59	122	47	73	120
2	DAY SECONDARY SCHOOL MAIKUNKELE 'A'	Maikunkele	BOSSO	Public	JSS and SSS	Urban	71	47	118	68	55	123	60	30	90
3	DAY SECONDARY SCHOOL CHANCHAGA MINNA'B'	Chanchaga	BOSSO	Public	JSS and SSS	Urban	215	231	446	144	161	305	163	161	324
4	GOVERNMENT ARMY DAY SECONDARY SCHOOL	Chanchaga	BOSSO	Public	JSS and SSS	Urban	350	341	691	360	362	722	346	759	1105
5	BOSSO SECONDARY SCHOOL MINNA	Shango	BOSSO	Public	JSS and SSS	Urban	274	188	462	211	199	410	162	141	303
6	HILLTOP MODEL SECONDARY SCHOOL	Maitunbi, Minna	BOSSO	Public	ALL LEVELS	Urban	274	492	766	188	292	480	234	324	558
7	NIGER STATE SCHOOL FOR SPECIAL EDUCATION MINNA	Bosso	BOSSO	Public	ALL LEVELS	Urban	24	9	27	25	13	38	22	10	32
8	DAY SECONDARY SCHOOL MAITUMBI MINNA	Maitunbi, Minna	BOSSO	Public	JSS and SSS	Urban	164	200	364	184	200	384	120	90	210
9	SHEIKH MUHAMMAD SAMBO COLLEGE OF ARTS AND ISLAMIC STUDIES TUDUN FULANI MINNA	Tudun-Fulani, Minna	BOSSO	Public	JSS and SSS	Urban	239	35	274	345	49	394	202	35	237
10	DAY SECONDARY SCHOOL GBADA GIDAN MONGORO	Mongoro	BOSSO	Public	JSS and SSS	Rural	174	163	337	115	94	209	97	60	157
11	GOVERNMENT DAY SECONDARY SCHOOL BEJI	Beji	BOSSO	Public	JSS and SSS	Rural	136	132	268	79	87	166	131	86	217
12	DAY SECONDARY SCHOOL GARATU	Garatu	BOSSO	Public	JSS and SSS	Rural	102	59	161	74	47	121	75	42	117
13	GOVERNMENT SENIOR SECONDARY SCHOOL KAMPALA	Kampala	BOSSO	Public	JSS and SSS	Urban	59	65	124	58	80	138	58	51	109
14	DAY SECONDARY SCHOOL SHATTA	Shatta	BOSSO	Public	JSS and SSS	Rural	34	38	72	50	27	77	50	27	77
15	DAY SECONDARY SCHOOL PYATA	Pyata	BOSSO	Public	JSS and SSS	Rural	37	48	85	59	66	125	93	89	182
16	GOVERNMENT SCIENCE COLLAGE CHANCHAGA	Chanchaga	BOSSO	Public	JSS and SSS	Urban	142	186	328	220	251	471	221	234	455
17	MARYAM BABANGIDA GIRLS SCIENCE COLLEGE, BOSSO	Bosso-Minna	BOSSO	Public	SSS ONLY	Urban	0	500	500	0	372	372	0	427	427
18	MODEL SCIENCE COLLEGE TUDUN FULANI	Tudun-Fulani, Minna	BOSSO	Public	JSS and SSS	Urban	87	104	191	82	96	178	60	50	110
19	GOVERNMENT TECHNICAL COLLEGE, MINNA	Tungan-Goro	BOSSO	Public	SSS ONLY	Urban	443	21	464	458	66	524	340	58	398
20	MODEL SECONDAARY SCHOOL FUT	Bosso-Minna	BOSSO	Public	ALL LEVELS	Urban	30	34	64	34	36	70	15	17	32
21	DAY SECONDARY SCHOOL KWASAU	Kwasau	CHANCHAGA	Public	JSS and SSS	Urban	213	125	338			0	0	0	0
22	DAY SECONDARY SCHOOL BARIKIN SALE	Barikin-Sale, minna	CHANCHAGA	Public	JSS and SSS	Urban	228	218	446	150	178	328	0	0	0
23	DAY SECONDARY SCHOOL LIMAWA	Limawa	CHANCHAGA	Public	JSS and SSS	Urban	484	338	822	347	202	549	370	262	632
24	GOVERNMENT DAY SECONDARY SCHOOL, BOSSO ROAD	Bosso	CHANCHAGA	Public	JSS and SSS	Urban	275	285	560	261	314	575	393	323	716
25	WOMAN DAY COLLEGE	Minna	CHANCHAGA	Public	JSS and SSS	Urban	0	132	132	0	107	107	0	85	85
26	ZARUMAI MODEL SCHOOL, MINNA	Minna	CHANCHAGA	Public	ALL LEVELS	Urban	240	128	368	202	206	408	154	155	309
27	GOVERNMENT GIRLS SECONDARY SCHOOL MINNA	Minna	CHANCHAGA	Public	JSS and SSS	Urban	0	852	852	0	948	948	0	849	849
28	AHMADU BAHAGO SECONDARY SCHOOL MINNA	Minna	CHANCHAGA	Public	JSS and SSS	Urban	282	139	421	426	151	577	335	104	439
29	FR. O'CONNELL SCIENCE COLLEGE, MINNA	Minna	CHANCHAGA	Public	JSS and SSS	Urban	802	0	802	474	0	474	505	0	505
30	GOVERNMENT GIRLS SCIENCE COLLEGE, BOSSO ROAD	Minna	CHANCHAGA	Public	JSS and SSS	Urban	0	346	346	0	303	303	0	285	285
31	GOVERNMENT DAY SCIENCE COLLEGE, TUNGA	Tunga	CHANCHAGA	Public	JSS and SSS	Urban	350	341	691	360	362	722	346	759	1105
32	GOVERNMENT VOCATIONAL TRAINING CENTER	Kasuwan-Gwari	CHANCHAGA	Public	JSS and SSS	Urban	117	43	160	103	67	170	81	31	112
33	DAY SECONDARY SCHOOL DANDAUDU	Dandaudu	MUNYA	Public	JSS and SSS	Rural	88	63	151	85	70	155	100	71	171
34	DAY SECONDARY SCHOOL FUKA	Fuka	MUNYA	Public	JSS and SSS	Rural	21	19	40	17	3	20	27	13	40
35	DAY SECONDARYSCHOOL, GUNI	Guni	MUNYA	Public	JSS and SSS	Rural	55	25	80	53	22	75	48	25	73
36	DR. MUA'ZU BABANGIDA ALIYU SECONDARY SCHOOL	Sarkin-Pawa	MUNYA	Public	JSS and SSS	Urban	106	142	248	205	156	361	251	208	459

37	GOVERNMENT SECONDARY SCHOOL DAZA	Daza	MUNYA	Public	JSS and SSS	Rural	126	39	165	192	39	231	110	66	176
38	NIGER STATE TEACHER PROFESSIONAL DEVELOPMENT CENTRE	Mararaban Dandau	MUNYA	Public	JSS and SSS	Rural	229	153	382	368	190	558	364	122	466
39	ABUBAKAR DADA SENIOR SECONDARY SCHOOL	Paiko	PAIKORO	Public	JSS and SSS	Rural	138	15	153	150	24	174	137	22	159
40	DAY SECONDARY SCHOOL ADUNU	Adunu	PAIKORO	Public	JSS and SSS	Rural	45	39	84	86	45	131	140	110	250
41	DAY SECONDARY SCHOOL BAIDNA	Baidna	PAIKORO	Public	JSS and SSS	Rural	56	12	68	45	21	66	51	21	72
42	DAY SECONDARY SCHOOL GWAM	Gwam	PAIKORO	Public	JSS and SSS	Rural	57	40	97	122	52	174	168	53	221
43	DAY SECONDARY SCHOOL ISHAU	Ishau	PAIKORO	Public	JSS and SSS	Rural	126	104	230	102	81	183	106	70	176
44	DAY SECONDARY SCHOOL KAFFIN KORO	Kaffin Koro	PAIKORO	Public	JSS and SSS	Rural	167	17	184	131	8	139	91	14	104
45	DAY SECONDARY SCHOOL KWAKUTI	Kwakuti	PAIKORO	Public	JSS and SSS	Rural	50	35	85	79	42	121	93	49	142
46	DAY SECONDARY SCHOOL MARABAN TUDU-UKU	Mararaban Tudu-U	PAIKORO	Public	JSS and SSS	Rural	95	80	175	81	135	216	115	132	247
47	DAY SECONDARY SCHOOL NIKUCHI	Nikuchi	PAIKORO	Public	JSS and SSS	Rural	135	63	198	120	83	203	130	63	193
48	DAY SECONDARY SCHOOL TUNGAN MALLAM	Tungan-Mallam	PAIKORO	Public	JSS and SSS	Rural	99	63	162	77	34	111	28	17	45
49	DAY SECONDARY SCHOOL, FARIN DOKI	Fari Doki	PAIKORO	Public	JSS and SSS	Rural	105	60	165	49	16	65	70	43	113
50	GOVERNMENT DAY SECONDARY SCHOOL CHIMBI	Chimbi	PAIKORO	Public	JSS and SSS	Rural	104	100	204	83	175	258	138	105	243
51	GOVERNMENT DAY SECONDARY SCHOOL TATIKO	Tatiko	PAIKORO	Public	JSS and SSS	Rural	91	62	153	104	58	160	125	38	163
52	GOVERNMENT DAY SECONDARY SCHOOL TUNGAN AMALE	Tungan-Amale	PAIKORO	Public	JSS and SSS	Rural	27	40	67	25	37	62	17	18	35
53	GOVERNMENT DAY SENIOR SECONDARY, JABO JERE	Jabo-Jere	PAIKORO	Public	JSS and SSS	Rural	33	17	50	30	15	45	0	0	0
54	GOVERNMENT GIRLS SECONDARY SCHOOL KAFFIN KORO	Kaffin-Koro	PAIKORO	Public	JSS and SSS	Rural	0	219	219	0	204	204	0	216	216
55	MARTIN SANDA GIRLS SCIENCE COLLEGE, PAIKO	Sungan-Paiko	PAIKORO	Public	JSS and SSS	Rural	0	115	115	0	119	119	0	101	101
56	SENIOR SECONDARY SCHOOL GABADNA	Gabadna	PAIKORO	Public	JSS and SSS	Rural	40	35	75	33	36	69	38	36	74
57	WOMEN DAY COLLEGE PAIKO	Paiko	PAIKORO	Public	JSS and SSS	Urban	0	56	56	0	120	120	0	100	100
58	AHMADU ATTAHIRU SECONDARY SCHOOL KAGARA	Kagara	RAFI	Public	JSS and SSS	Urban	130	80	210	195	114	309	170	77	247
59	DAY SECONDARY SCHOOL TUNGAN BAKO	Tungan-Bako	RAFI	Public	JSS and SSS	Rural	24	2	26	16	3	19	22	4	26
60	DAY SECONDARY SCHOOL, MAIKUJERI	Maikujeri	RAFI	Public	JSS and SSS	Rural	64	22	86	78	42	120	61	26	87
61	GOVERNMENT DAY SECONDARY SCHOOL PANDOGARI	Pandogari	RAFI	Public	JSS and SSS	Urban	213	118	331	261	165	426	194	102	296
62	GOVERNMENT DAY SECONDARY SCHOOL YAKILA	Yakila	RAFI	Public	JSS and SSS	Rural	63	14	77	65	8	73	44	9	53
63	GOVERNMENT GIRLS ARABIC SECONDARY SCHOOL TEGINA	Tegina	RAFI	Public	JSS and SSS	Rural	0	31	31	0	33	33	0	34	34
64	GOVERNMENT SCIENCE COLLEGE, KAGARA	Kagara	RAFI	Public	SSS ONLY	Urban	357	0	357	263	0	263	265	0	265
65	GOVERNMENT SECODARY SCHOOL TEGINA	Tegina	RAFI	Public	JSS and SSS	Rural	178	195	373	155	97	252	99	94	193
66	MAMMAN KONTAGORA TECHNICAL COLLEGE, PANDOGARI	Pandogari	RAFI	Public	SSS ONLY	Rural	125	8	133	138	6	144	129	12	141
67	MUHAMMADU IRUWA DAY SECONDARY SCHOOL KUSHERIKI	Gusherki	RAFI	Public	JSS and SSS	Rural	94	40	134	100	31	131	96	53	149
68	SALIHU TANKO DAY SECONDARY SCHOOL KAGARA	Kagara	RAFI	Public	JSS and SSS	Urban	72	47	119	117	98	215	77	55	132
69	SENIOR SECONDARY SCHOOL KWANA	Kwana	RAFI	Public	JSS and SSS	Rural	56	21	77	51	17	68	52	11	63
70	SENIOR SECONDARY SCHOOL MADAKA	Madaka	RAFI	Public	JSS and SSS	Rural	141	51	192	159	67	226	139	60	199
71	WOMEN DAY COLLEGE KAGARA	Kagara	RAFI	Public	JSS and SSS	Urban	0	55	55	0	45	45	0	42	42
72	BOBO SECONDARY SCHOOL KUTA	Kuta	SHIRORO	Public	JSS and SSS	Rural	171	78	249	95	66	161	93	55	148
73	DAY SECONDARY SCHOOL SHE	She	SHIRORO	Public	JSS and SSS	Rural	52	48	100	67	78	145	85	83	168
74	DAY SECONDARY SCHOOL BASSA	Bassa	SHIRORO	Public	JSS and SSS	Rural	45	35	80	95	63	158	26	18	44
75	DAY SECONDARY SCHOOL CHIRI	Chiri	SHIRORO	Public	JSS and SSS	Rural	22	13	35	28	18	46	18	7	25
76	DAY SECONDARY SCHOOL GURMANA	Gurmana	SHIRORO	Public	JSS and SSS	Rural	48	46	94	17	15	32	35	19	54
77	DAY SECONDARY SCHOOL KOBWA KUTA	Kubwa-Kuta	SHIRORO	Public	JSS and SSS	Rural	65	67	132	30	100	130	64	60	124
78	DAY SECONDARY SCHOOL KPMAKPMA	Kpmakpma	SHIRORO	Public	JSS and SSS	Rural	42	31	73	35	39	74	31	32	63

79	DAY SECONDARY SCHOOL MANTA	Manta	SHIRORO	Public	JSS and SSS	Rural	43	20	63	103	60	163	123	86	209
80	DAY SECONDARY SCHOOL PINA	Pina	SHIRORO	Public	JSS and SSS	Rural	36	12	48	30	5	35	16	8	24
81	DAY SECONDARY SCHOOL SHAKWATU	Shakwatu	SHIRORO	Public	JSS and SSS	Rural	30	36	66	55	55	110	123	68	191
82	DAY SECONDARY SCHOOL SHIRORO NEPA	Shiroro	SHIRORO	Public	JSS and SSS	Rural	165	135	300	223	120	343	154	100	254
83	DAY SECONDARY SCHOOL, TAWALI	Tawali	SHIRORO	Public	JSS and SSS	Rural	254	171	425	234	182	416	201	155	356
84	DAY SECONDARY SCHOOL, TUMTUM-KUTA	Tumtum-Kuta	SHIRORO	Public	JSS and SSS	Urban	163	65	228	150	56	206	75	20	95
85	GIRLS DAY ESCONDARY SCHOOL, KUTA	Kuta	SHIRORO	Public	JSS and SSS	Urban	0	70	70	0	95	95	0	75	75
86	GOVERNMENT DAY SECONDARY SCHOOL ERENA	Erena	SHIRORO	Public	JSS and SSS	Rural	173	146	319	98	85	183	97	107	204
87	GOVERNMENT DAY SECONDARY SCHOOL, GUSSORO	Gussoro	SHIRORO	Public	JSS and SSS	Rural	25	32	57	30	25	55	33	26	59
88	GOVERNMENT SCIENCE COLLEGE KUTA	Kuta	SHIRORO	Public	JSS and SSS	Urban	57	15	72	61	28	89	146	72	218
89	GOVERNMENT SECONDARY SCHOOL ALLAWA	Allawa	SHIRORO	Public	JSS and SSS	Rural	49	19	68	55	15	70	48	23	71
90	WOMEN DAY COLLEGE KUTA	Kuta	SHIRORO	Public	JSS and SSS	Urban	0	14	14	0	35	35	0	41	41
							10838	9259	20097	10421	9099	19520	9723	8963	18686

SOURCE: 2020/2021 ANNUAL SCHOOL CENSUS (ASC) REPORT

APPENDIX D

LESSON PLAN FOR EXPERIMENTAL GROUP

Lesson: 1

Date: 12/09/21

Subject: Biology

Topic: Respiration

Subtopic: Cellular respiration

Class: SS 11

Time: 8:20-9:40am

Lesson Length: 80 Min.

Instructional Strategy: 5E Learning Cycle

Instructional Material: Chart showing food calorimeter, sugar, glass tube, white anhydrous copper (II) sulphate, lime water, flat-bottom flask, water, glucose- yeast-suspension glass tubing, test tube, charts showing chemical equations for aerobic and anaerobic respiration.

Specific Objectives: At the end of the lesson, the students should be able to;

(i) Define the term respiration

(ii) Mention and describe the types of respiration

(iii) Distinguish the type of respiration

(iv) Explain the fate of energy released in respiration process

(v) State the importance of anaerobic respiration in everyday life

Entry Behavior: students are familiar with characteristics of living things, classes of food, digestion, cell. They are aware of the fact that they breathe and they need energy in their body to do work.

Introduction: The teacher writes the topic on the chalkboard and introduces the lesson by asking the students provocative questions from their previous experience and also from the objectives of the actual experience in order to engage and stimulate or capture their interests and focus their attention in the task ahead.

Step 1: Engagement phase: the teacher asks the following questions;

(i) What characteristics do living things exhibit?

(ii) Among the characteristics mentioned which one is concerned with inhalation of oxygen into the body cells

(iii)What happens when the oxygen inhaled gets to the body cells?

(iv)Why must the carbon (iv) oxide produced be exhaled from the body?

(v) Do you think living organisms can respire without oxygen?

(vi)What happens to the energy produced from the process of respiration?

(vii) What is the function of Mitochondrion in the cell?

The teacher tells the students the objectives of the lesson, and asks them to match the ideas they provided to the objectives of the lesson.

Charts showing food calorimeter containing food sample in air-tight chamber, white anhydrous copper (ii) sulphate, sugar, lime water, chart showing glucose – yeast suspension, and charts showing aerobic and anaerobic respiration, chart showing germinating seeds in flask A and control experiment as flask B are shown to the students for observation and data gathering.

Step II: Exploration phase: ACTIVITY

The teacher divides students into groups for the exploration and assigns specific task or problem to each group. The students demonstrate practical examples to show the products and types of respiration.

Group 1: (a) Is asked to describe what they observe from the food calorimeter and predict the process that would occur. (b) What similar process occurs in living things?

Group 2: Is asked to carry out an investigation by heating some amount of sugar in a hard glass tube and pass the products formed through;

(i) White anhydrous copper (ii) sulphate

(ii) Lime water

Group 3: Is asked to study the chemical equations in the chart and explain their findings.

Group 4: (a) Is asked to use the experimental set up and control experiment in the chart to explain what they observe in the thermometer. (b) If three students among the fifteen students in the class did not observe any change in the thermometer, what percentage did not observe any change?

Step III: Explanation phase: ACTIVITY

The teacher gives students room to explain their finding. Each group representative explains and interprets the results of their observation. Teacher engages students in discussion by asking them to do the following;

1. Explain your observations to others
2. Pay attention to one another's explanations
3. Question one another's explanation

With respect to the idea and observation students are asked to explore, formulate answers to the objectives of the lesson to gain actual experience. When the students are done with their explanations, teacher corrects students mistake and complete the missing parts in the students findings and then teacher explains concepts ideas to the students as follows

(1) Respiration is the process that occurs in living organisms involving the exchange of oxygen and carbon (iv) oxide leading to the release of energy

Cellular respiration involves various chemical activities that take place in the cells to breakdown glucose by series of reactions catalyzed by enzymes to release energy.

(2) Types of respiration: aerobic and anaerobic. The teacher uses chemical equations to explain.

(3) (3) Differences between aerobic and anaerobic respiration

Aerobic respiration	Anaerobic respiration
1. Oxidation needs oxygen to occur	Oxidation does not required oxygen to occur
2. Water and carbon (iv) oxide are by-products formed	Alcohol or lactic acid are by products formed
3. It takes place in mitochondria	It takes places in cytoplasm
4. Energy released is more (36ATP)	Energy released is less (2ATP)

(4) The energy released from respiration is stored in Adenosinetrisphoshate (ATP). ATP is the form in which energy is carried, stored and used by all living cells for the different metabolic process such as anabolic process, active transfer, movement, activating reaction processes. The energy not stored in ATP is converted to heat.

Step IV: Elaboration phase: ACTIVITY

The teacher provides students with activities that would enable them extend what they have learnt in the earlier phases and make connection to real life situations. They are given opportunities to practice the new knowledge, find examples from their lives or things around them that fit into the concept learnt. Students work in groups again, students are asked to do the following;

(i) A group is required to eat pop-corn provided, breath in and then predict the predict the outcome

(ii) Another group is asked to recognize activities in their locality in which anaerobic respiration is involved

(iii)The third group is asked to identify in their environment organisms that respire to generate energy.

Step V: Evaluation phase: ACTIVITY

Students are evaluated to reveal the knowledge they have constructed, students may answer questions orally or make short-written summaries.

Teacher asks the following questions:

(i) Give the meaning of the term cellular respiration

(ii) List the two types of respiration and distinguish them

(iii)How many ATPs are released from each type of respiration in our daily lives?

(iv) How is oxygen directly related to food in the production of energy?

Conclusion: The teacher concludes the lesson by asking the students to read glycolysis ahead before the next lesson

The teacher gives the students written hints on the topic covered

LESSON PLAN FOR EXPERIMENTAL GROUP

Lesson: 2

Date: 19/09/2021

Subject: Biology

Topic: Respiration

Subtopic: Glycolysis

Class: SS II

Time: 8:00a.m – 9:40a.m

Lesson Length: 80 Minutes

Gender: male and Female

Instructional Strategy: 5E Learning Cycle

Innstructional Material: Chart showing glycolytic pathway.

Specific Objectives: At the end of the lesson, the students should be able to;

(i) Define glycolysis

(ii) Enumerate the main stages of glycolysis

(iii) Describe the glycolytic pathway

(vi) Mention the uses of glycolysis

(vii) State the importance of anaerobic respiration in everyday life

Entry Behavior: students are familiar with aerobic and anaerobic respiration and are aware that most animals need oxygen to survive.

Introduction: The teacher writes the topic on the chalkboard and introduces the lesson by narrating the ordeal a friend of hers went through when he was on the track running a race of 100 meters. She says that on that faithful day, the friend went out for the race competition. He represented Edo state in the competition, and he ran the best he could, very fast but unfortunately he fell down hard because he had muscle pull, hit his head on the ground and developed memory loss for many years.

The teacher asks the students questions from the story narrated experiences and also from the objectives of the actual experience

Step 1: Engagement phase: the teacher asks the following questions;

(i) Define the term respiration?

(ii) What type of respiration would the athlete in the story needs to run the race? Why?

(iii) What do you think could have caused the pulled muscles experienced by the athlete?

(iv) How many ATPs are produced at the end of this respiration type in (ii) above?

(v) Mention two uses of anaerobic respiration

(vi) What do you understand by the term glycolysis?

(vii) Glycolysis is also referred to as anaerobic, why?

At this point the teacher tells the students the objectives of the lesson. The teacher shows the students chart showing the glycolytic pathway for observation and data gathering.

Step II: Exploration phase: ACTIVITY

The teacher divides students into groups and gives assignment to each group for them to explore and find answers to the problems.

Group 1: Is asked to find out the number of ATP invested or consumed in the process from the chart provided

Group 2: Is asked to identify the various enzymes in the glycolytic pathway and the relationship with the substrates.

Group 3: Is asked to identify the number of stages in the process of glycolysis and the net ATP produced

Group 4: Is asked to describe the process of glycolysis briefly with the help of the arrow in the glycolytic pathway

Step III: Explanation phase: ACTIVITY

The students' representative explains their findings and interprets the results of what they observed.

From the ideas the students gathered at the explore phase, the teacher asks the students to define, explain and formulate answers to the objectives of the lesson in order to gain actual experience.

Teacher corrects students' mistakes and put them right. Teacher explains the concepts to the students

Glycolysis is a sequence of enzymatic reaction in which glucose (6 C-atom) is broken down to pyruvic acid (3 C-atom) with the release of energy for cellular metabolism. It takes place in the cytoplasm and a net of 2ATP is produced at the end of the process.

(ii)→The stages of glycolysis are

(1) Investment stage

(2) Cleaving stage

(3) Harvest stage

(iii)→ Glycolytic pathway (Embden-Meyerhof Pathway) describes the oxidation of glucose to pyruvic acid with the generation of ATP and NADH

The process begins at the investment stage with the 2moles of ATP consumed for each mol of glucose and glucose is phosphorylated to glucose-6-phosphate by hexokinase

Stage two involves the cleaving of glucose-6- to two 3-carbonunits (glycerate-3-phosphate) by aldolase enzyme.

Stage three is the harvesting stage or the pay off stage. 4 mols of ATP and two mols of NADH are gained or harvested from each initial mol of glucose (The net gain is 2 ATP). Glycerate-3-phosphate is oxidized to pyruvic acid (3-C-Compound) by pyruvate kinase. The fate of the pyruvic acid formed depends on whether oxygen is present or not.

If oxygen is absent the pyruvic acid is fermented to lactate (in animals) or ethanol (in plants).

If oxygen is present pyruvic acid is decarboxylate to Acetyl CoA which then enters the Krebs cycle.

Balance sheet: 2ATP + 4 ATP and 2 NADH

(1) Glycolysis is important in some ways. It occurs in nearly all living organisms produce some of the energy required by cells.

(2) Mature mammalian red blood cells require glycolysis to produce the energy it needs because glycolysis is sole source of ATP. If glycolysis is interrupted, these cells would eventually die.

(3) Energy derived from glucose catabolism is used to recharge ADP into ATP.

(4) Glycolysis is applied in microbial metabolic engineering for chemical synthesis

Step IV: Elaboration phase: ACTIVITY

The teacher engages the students with activities that would probe the students to think and extend what they have learnt to real-life situations and where it can be applied in their day to day living. Students work in group again. Teacher asks the students to do the following;

Group 1: is asked to identify activities in their community where glycolysis is applied

Group 2: is asked to identify living organisms around that respire anaerobically

Group 3: is asked to state ten living organisms where glycolysis takes place

Group 4: is asked to mention areas in their body where glycolysis is applied

Evaluation phase: ACTIVITY

Teacher asks the following questions

(i) Define glycolysis

(ii) In glycolysis, what happens at the investment stage

(iii) What is the end products of glycolysis

(iv) Describe the fate of pyruvic acid formed from glycolysis

(v) List two (2) enzymes involve in glycolysis

Conclusion: The teacher concludes the lesson by encouraging the students to make arrangement for excursion to either yoghurt or cheese factory or pharmaceutical industry to gain more knowledge on how glycolysis is applied in making their products

LESSON PLAN FOR EXPERIMENTAL GROUP

Lesson: 3

Date: 06/10/2021

Subject: Biology

Topic: Cellular Respiration

Subtopic: Krebs Cycle

Class: SS II

Time: 8:40a.m – 10:00a.m

Lesson Length: 80 Minutes

Gender: male and Female

Instructional Strategy: 5E Learning Cycle

Instructional Material: Chart showing Krebs Cycle, citrus fruit, calcium oxide (lime).

Specific Objectives: At the end of the lesson, the students should be able to;

(iv) Define Krebs cycle and state where it takes place in the body cell

(v) Enumerate the main product of Krebs cycle

(vi) State the importance of Krebs cycle

Entry Behavior: students have the basic understanding that

1. They exhale gas
2. Carbohydrate is energy given food substance
3. Students suck up orange juice and other citrus fruit juice
4. Students are familiar with aerobic respiration

Introduction: The teacher introduces the lesson after writing the topic on the chalkboard, by asking the students questions from their previous experience and from the actual experience.

Engagement phase: ACTIVITY;

The teacher asks the following questions

(i) How many ATPs are produced during aerobic respiration?

(ii) Define the term aerobic respiration

(iii)Where does aerobic respiration takes place in the cell

(iv)What is the main content of citrus fruit (orange)

(v) State the importance of aerobic respiration

The teacher states the objectives of the lesson and the students are asked to connect the answers they provided to the objectives of the lesson.

Chart showing Krebs cycle is shown to the students for observation and idea formation.

Exploration phase: ACTIVITY

The teacher assigns tasks to the students after dividing them into groups.

Group 1: Is asked to find describe Krebs cycle based on their observation from the chart

Group 2: Is required to mention the products of krebs cycle in ascending order.

Group 3: Is required to summarize krebs cycle to logically justify a conclusion.

Group 4: (a) Is requested to explain how krebs cycle and glycolysis co-relate (b) Applying information and experience gained from aerobic respiration state the link between aerobic and krebs cycle.

Explanation phase: ACTIVITIES

Group representative explains their findings and interpret the result of their observations. Teacher corrects mistakes and then teacher explains concept idea to students →(1) Krebs cycle or citric acid cycle or tricarboxilic acid cycle is series of chemical reaction in the presence of oxygen which begins with acetylCoA combining with oxaloaxetic acid to form citric acid. Krebs cycle occurs in the mitochondrion.

→(2)The Krebs cycle begins with acetylCoA, a two carbon compound combining with oxaloacetic acid (Four carbon compound) to form citric acid (6 carbon atom). The cycle continues as citric acid is isomerised to isocetrateoxidation& decarboxylation → &-ketoglutarate→succinyl→ CoAsynthesissuccinate→ oxidation→ fumarate→ malate→ Oxaloacetate.

At various stages Co2, NADH &H+ are formed. The hydrogen released combines with oxygen to form water. At the end of Krebs cycle a total net ATPs of 36 are produced. Therefore the breakdown of glucose molecule from glycolysis to Krebs cycle will yield a total net ATPs of 38 →Krebs cycle has several importance. It is the common oxidative pathway for carbohydrate, fat and amino acid.

(3) (a) It is the important metabolic pathway for the energy supply to the body.

(b)It is the central pathway connecting almost all the individual metabolic pathways that is it is at the center of cellular metabolism, playing a steering role in both the process of energy production and biosynthesis.

(c) It finishes the sugar breaking job started in glycolysis.

(d) Citric acid (a product of Krebs cycle) can be used in industry or company to make soft drinks, laxatives, cleaning product, cosmetics, blue print paper.

Elaboration phase: ACTIVITIES

The teacher requests the students to carry out specific task that would enable themextend their actual experiences to real-life situations or where the concept can be applied in everyday life.

Group 1: is asked to find out what is produced when citric acid in citrus fruit juice is removed by adding calcium oxide (lime).

Group 2: is asked to extract citric acid (same as citric acid in Krebs cycle) from citrus fruit juice by adding calcium oxide (lime).

Question: What can the product formed be used for in real life?

Group 2a: is asked to identify the main product of Krebs cycle that aids the cells production capabilities.

Group 2b: Where is citric acid converted to energy in the cell?

Group 3: is asked to identify industries and companies where citric acid or citrate salt are apply to make things

Group 4: is asked to explain what a lemon battery (citric acid) can be used to generate.

Evaluation phase: ACTIVITES

The teacher evaluates the lesson by asking the students questions to reveal the knowledge they have constructed

(i) What other names can Krebs cycle be known as

(ii) What is the product of Krebs cycle to which the cell owe parts of their energy production capabilities to?

(iii)Mention the substance that links glycolysis to Kreb cycle

(iv)How many ATPs are produced at the end of Krebs cycle?

(v) Which other substance is given off during Krebs cycle?

Conclusion: The teacher concludes the lesson by given the students take home assignment

1. Find out the uses of respiration

APPENDIX E

LESSON PLAN FOR CONTROL GROUP (LESSON ONE)

DATE: 14/09/2021

TIME: 8:40a.m -10: 00a.m

SUBJECT: Biology

TOPIC: Respiration

SUB-TOPIC: Cellular Respiration

CLASS: SS II

LESSON LENGTH: 80 Minutes

AVERAGE AGE: 16 Years

INSTRUCTIONAL STRATEGY: Conventional Teaching Method

INSTRUCTIONAL MATERIAL: Board, Biology Textbook, Lesson Note

ENTRY KNOWLEDGE: Students have learnt characteristics of living thing, classes of food, cell and they are aware that they breath and need energy to do work.

SPECIFIC OBJECTIVES: At the end of the lesson, the students should be able to;

(a) Define respiration

(b) Mention and describe the types of respiration.

(c) Distinguish the types of respiration

(d) State the importance of respiration in everyday life.

INTRODUCTION: The teacher introduces the lesson by asking the students the following questions.

(1) State the characteristics of living things.

(2) Define digestion

(3) Mention the classes of food

(4) What is breathing? (5) Which cell organelle is regarded as “POWER HOUSE”?

PRESENTATION:

STEP I: The teacher presents the lesson by defining respiration as the process that occurs in living organisms involving the exchange of oxygen and carbon (iv) oxide leading to the release of energy. Cellular respiration involves various chemical activities that take place in the cells to breakdown glucose by series of reactions catalyzed by enzymes to release energy.

STEP II: The teacher mentions and describes the types of respiration.

(1) Aerobic Respiration: This type of respiration involves the presence of oxygen to breakdown glucose into water, carbon (iv) oxide and energy (ATP).

C6H1206 + 602 6C02 + ⟶ 6H20 + Energy

(glucose) (energy) (carbon(iv)oxide)(water) (ATP)

(2) Anaerobic respiration: This type of respiration does not require the presence of oxygen to breakdown glucose. In anaerobic respiration glucose is broken down to release carbon (iv) oxide, alcohol and energy

C6H1206 + 2C5H50H ⟶ 2C02 + Energy

(glucose)(Alcohol) (carbon(iv)oxide) (ATP)

STEP III: The teacher distinguishes the types of respiration

Aerobic Respiration	Anaerobic Respiration
Oxidation needs oxygen to occur	Oxidation does not required oxygen to occur
Water and carbon(iv)oxide are by-products formed	Alcohol or lactic acid are by products formed.
It takes place in mitochondria of the cell	It takes place in cytoplasm of the cell
Energy released is more (36 ATP)	Energy released is less (2 ATP)

STEP IV: The teacher states the importance of respiration

a) It is employed to breakdown glucose in the body to release energy needed for several metabolic processes.

b) Required during the baking of bread.

c) Needed during vigorous exercise and weight lifting

d) Employed during anaerobic fermentation of carbohydrate to alcohol by yeast.

e) Treatment of sewage by anaerobic bacteria

f) Lactic acid produced during anaerobic respiration is applied during the production of yogurt, cheese, ink, cosmetics.

g) Used as food preservative (lactic acid)

h) Lactic acid from anaerobic respiration is used as starting material in making drugs in pharmaceutical industry.

EVALUATION: The teacher evaluates the lesson by asking the students the following questions;

a) What is the fate of the energy produced during respiration?

b) What type of respiration is required during vigorous exercise?

c) Define aerobic and anaerobic respiration. (d) What is the amount of ATP produced during aerobic respiration?

SUMMARY: The teacher summarizes the lesson by mentioning the important points of the lesson again.

CONCLUSION: The teacher concludes the lesson by urging the students to read on glycolysis.

LESSON PLAN FOR CONTROL GROUP (LESSON TWO)

DATE: 21/09/2021

TIME: 8:00a.m – 9: 20a.m

SUBJECT: Biology

TOPIC: Cellular Respiration

SUB-TOPIC: Glycolysis

CLASS: SS II

LESSON LENGTH: 80 Minutes

AVERAGE AGE: 16 Years

INSTRUCTIONAL STRATEGY: Conventional Teaching Method

INSTRUCTIONAL MATERAIL: Chalk Board, Textbooks, Lesson Note

ENTRY KNOWLEDGE: The students have been taught types of respiration

SPECIFIC OBJECTIVES: At the end of the lesson, the students should be able to;

(a) Define glycolysis

(b) Enumerate the main stages of glycolysis

(c) Describe the glycolytic pathway

(d) Mention the importance of glycolysis

INTRODUCTION: The teacher introduces the lesson by requesting the students to answer the following questions

1. Mention the two types of respiration
2. What type of respiration is required during the baking of bread?
3. How many ATPs are generated at the end of anaerobic respiration?
4. State two uses of anaerobic respiration

ANSWER

a) Aerobic and anaerobic respiration

b) Anaerobic respiration

c) 2ATP

d) Uses of anaerobic respiration

(a) Production of energy for various uses

(b)Required during vigorous exercises

(b) Required during the production of alcoholic drinks by yeast

(c) Required by anaerobes for survival.

PRESENTATION:

STEP I: The teacher presents the lesson by defining glycolysis as the sequence of enzymatic reaction in which glucose (6C-atom) is broken down to pyruvic acid (3 C-atom) with the release of energy for cellular metabolism. It takes place in the cytoplasm of the cell, and a net of 2ATPs are produced at the end of the process.

STEP II: The teacher enumerates the stages of glycolysis

1. Investment stage
2. Cleaving stage
3. Harvesting stage

STEP III: The teacher describes the glycolysis pathway. The glycolytic pathway (Embden-Meyerhof pathway) describes the oxidation of glucose to pyruvic acid with the generation of ATP and NADH. The process begins at the investment stage with 2 mols of ATP consumed for each mol of glucose, and glucose is phosphorylated to glucose-6- phosphate by hexokinase. Stage two involves the cleaving of glucose-6-phosphate to two 3-carbon units (glycerate-3-phosphate) by aldolase enzymes. Stage three is the harvesting stage or pay off stage, 4mols of ATP and two mols of NADH are gained or harvested from each initial mol of glucose (the net gain is 2ATP). Glycerate-3-phosphate is oxidized to pyruvic acid (3-carbon atom) by pyruvate kinase.

STEP IV: The teacher mentions the importance of glycolysis

a) It is required by matured mammalian red blood cells to produce the energy it needs. Glycolysis is the sole source of ATP.

b) Energy derived from glycolysis is used to recharge ADP to ATP.

c) Glycolysis is applied in microbial metabolic engineering for chemical synthesis.

EVALUATION: The teacher evaluates the lesson by asking the following questions;

1. Define glycolysis
2. What happens at the investment stage in glycolysis?
3. List two (2) enzymes involves in glycolysis and the roles they perform in the process.

SUMMARY: The teacher summarizes the lesson by pointing out the main part of the lesson.

CONCLUSION: The teacher concludes the lesson by giving the students take home assignment to read on Kreb's cycle.

LESSON PLAN FOR CONTROL GROUP (LESSON THREE)

DATE: 28/09/2021

TIME: 11:00a.m –12:20p.m

SUBJECT: Biology

TOPIC : Cellular Respiration

SUB-TOPIC: Kreb's Cycle

CLASS: SS II

LESSON LENGTH: 80 Minutes

AVERAGE AGE: 16 Years

INSTRUCTIONAL STRATEGY: Lecture Teaching Method

INSTRUCTIONAL MATERIAL: Chalk Board, Textbook, Lesson Note

ENTRY KNOWLEDGE: Students have learnt aerobic respiration and glycolysis. They are familiar with citrus fruits.

SPECIFIC OBJECTIVES: At the end of the lesson, the students should be able to;

(a) Define Kreb's cycle

(b) Enumerate the main products of Kreb's cycle

(c) State the importance of Kreb's cycle

INTRODUCTION: The teacher introduces the lesson by asking the students the following questions;

(a) Where does aerobic respiration takes place in the body cell?

(b) Is oxygen required for aerobic respiration to take place?

(c) How many ATPs are produced during aerobic respiration?

ANSWER

(a) Mitochondrion

(b) Oxygen is required during aerobic respiration

(c) 36 ATPs

PRESENTATION:

STEP I: The teacher presents the lesson by defining Kreb's cycle as series of chemical reaction that takes place in the presence of oxygen which begins with acety/COA combining with oxaloacetic acid to form citric acid. Kreb's cycle occurs in the mitochondrion.

STEP II: The teacher enumerates the main products of Kreb's cycle. The Kreb's cycle begins with acety/COA (2-carbon atom) combining with oxaloacetic acid (4-carbon atom) to form citric acid (6-carbon atom). The cycle continues as citric acid is isomerised to isocitrate

oxidation

decarboxylation α – ketoglutarate → succinyl ⟶ COA synthesis

succinatefumarate ⟶ malate oxidation ⟶ oxaloacetate.

At various stages C02, NADH and H^+ are formed. The hydrogen released combines with oxygen to form water. At the end of Kreb's cycle a total net ATP's of 36 are produced. Therefore, the breakdown of glucose molecule from glycolysis to Kreb's cycle will yield a total net ATPs of 38.

STEP III: The teacher states the importance of Kreb's cycle

(a) It is the common oxidative pathway for carbohydrate, fat and amino acid.

(b) It is the important metabolic pathway for the supply of energy to the body.

(c) It finishes the sugar breaking process started in glycolysis.

(d) Citric acid (a product of Kreb's cycle) is used in companies to make soft drinks, laxative, cleaning product, cosmetics, blue print paper.

EVALUATION: The teacher evaluates the lesson by asking the students to answer the questions below;

(a) Which substance connects glycolysis to Kreb's cycle?

(b) Why is Kreb's cycle also refers to as citric acid cycle?

(c) How many ATPs are produced at the end of Kreb's cycle?

CONCLUSION: The teacher concludes by summarizing the important points to the students

APPENDIX F

CLASSROOM TEST ON SCIENTIFIC REASONING ABILITY (CTSRA)

SECTION A: BIO DATA

Name of School:

Registration Number:

Class:

Gender: Male (   )   Female (   )

SECTION B: INSTRUCTION

1. Read each question carefully before you answer it
2. Circle only one of the options as your choice to each questions
3. Attempt ALL questions
4. All questions carry equal marks

Time Allowed 90 minutes

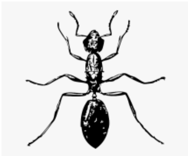
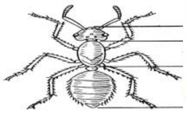
1. Select the item that is different from the table below

#	@	&	A

1 2 3 4

(a) 1(b) 2(c) 3 (d) 4

2. Allof these are insects


These are not insects



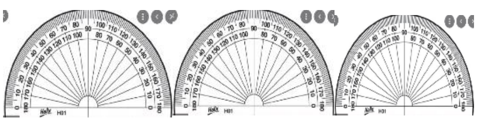
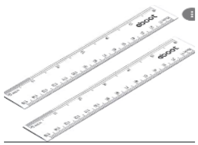
Which of the following is an insect?




1 2 3 4

(a) 1,4 (b) 2,4 (c) 2,3 (d) 1,2,3,4

3. Which of the following statement is not correct about this group of mathematical instrument?


(a) All erasers have the same colour and appearance

(b) All protractor has same colour and shape

(c) There are three rulers

(d) There are two pairs of compasses

4. Arrange the following places in Minna in order of kilometer and closeness to Mobile round about

(1) Army Barrack (3.8km) (2) Tunga (2km) (3) Chanchaga (5km) (4) Police Barrack (1km) (5) Shango (3km)

(a) Shango, Army Barrack, Police Barrack, Chanchaga, Tunga.

(b) Tunga, Army Barrack, Chanchaga, Police Barrack, Shango.

(c) Police Barrack, Tunga, Shango, Army Barracks, Chanchaga.

(d) Police Barrack, Shango, Tunga, Army Barracks, Chanchaga.

5. Supposed ten athletes were instructed to cover a distance of 200meter and 30% took part in the race, how many athletes participated?

(a) 1

(b) 2

(c) 3

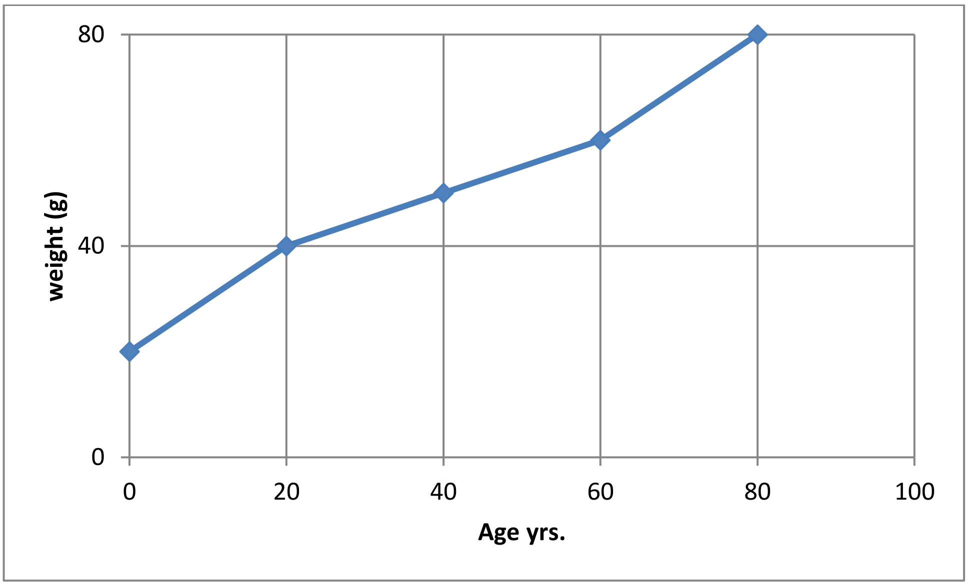
(d) 10

6. What else can be deduced from question 5 above (a) 30% did not participate (b) 70% did not participate (c) 10% participated (d) 70% participated.

7. Supposed A,B,C,D,E and F are different planets and 150, 1800, 58, 4500, 12600 and 105 are the respective distances in millions of kilometer from the sun. Arrange the planets in order of decreasing distance from the sun

(a) A,B,C,D,E,F (b) B,A,C,F,E,D (c) E,D,B,A,F,C (d) C,A,D,B,F,E

8. The graph below represents the relationship between the weight of a man and his age:



Predict the weight of the man at 100 years, assuming the rate of consumption remains constant

(a) 25

(b) 38

(c) 60

(d) None of these iss correct

9. Make a conclusion from the following line of reasoning. All women are either beautiful or ugly. All beautiful women are slim. These women are all slim; therefore

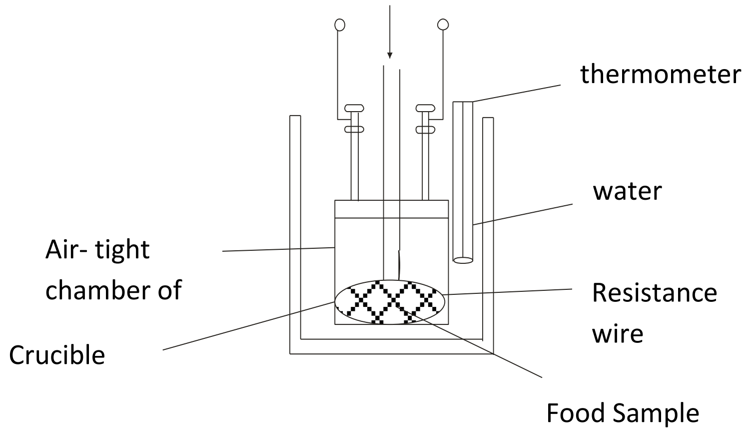
(a) All of these women are ugly

(b) All of these women are beautiful

(c) There are more ugly women then beautiful ones

(d) None of these is correct

Current Source
oxygen



10. A food calorimeter is shown to students as shown in the diagram above. In the calorimeter is a crucible containing food sample in an air tight chamber of oxygen. Make an observation of the set up and state the process that will occur

(a) Digestion (b) Burning (c) Mixture (d) Respiration

11. Four students have different explanations as to what occurs during the process in I0 above, each option represents the students explanation, and which one do you think is the correct explanation?

(a) Oxygen from the chamber combines with the food sample, breaks it down and release energy as heat and light

(b) Carbon (iv) oxide released from the food sample at the end of the process goes into the water

(c) The current source in calorimeter makes the food sample to burn to ashes

(d) The crucible, resistance wire, food sample, water and oxygen are all consumed in the process.

12. What process occurs in living cells in-like-manner as in the process in 10 above

(a) Excretion(b) Reproduction(c) Growth (d) Respiration

13. If clay and sand are two soil samplesused to determine water draining capacity, if it was observed that the water drained from sand is more than the water drained from

clay. What is the relationship between the size of the soil sample and amount of water collected at the end of the investigation?

(a) The larger the soil sample, the more porous the soil sample and the more water that drains

(b) The finer the soil sample, the more porous the soil sample and the more water that drains

(c) The lager the soil sample, the more water retains

(d) The more the air the more sticky the soil sample and better the water draining capacity.

14. In which field of endeavour is the knowledge in 13 above applicable? (a) Agriculture (b) Medicine (c) Catreing (d) Carpentary

15. A researcher working on an experiment to show the relationship between food, oxygen and energy discovered that the production of energy from food depends directly on the presence of oxygen what is the correct relationship for food (F) and oxygen (O)?

(a) $F\alpha$ O (b) F α 1/0 (c) F/O (d) F=O

16. A parent was sipping beer in presence of his ward. The child was watching with keen interest and the child eventually asked his father how beer is produced. The father explained. what do you think is his father's explanation from the options?

(a) A child cannot subject his father to a hot seat

(b) Beer reduces tension

(c) Do not do what I do child

(d) None of these options is correct

17. To test the claim that gasmolecules move faster than solid and liquid molecules, perfume container is opened and water molecule released at the same point

simultaneously. The perfume is perceived at a distance long before the water molecules could reach that same point. Students discuss the observation. Which of the following student's statement is correct.?

(a) This proof that liquid molecules move faster than gaseous molecules

(b) This is proof that gas molecules movefaster than liquid molecules

(c) The molecules of solids can equally move fast (d) Gas molecules and water molecules move at the same rate.

18. An owl hoots last night on top of the roof of a house and sure enough a child in the house died the next morning. Why did this happen?

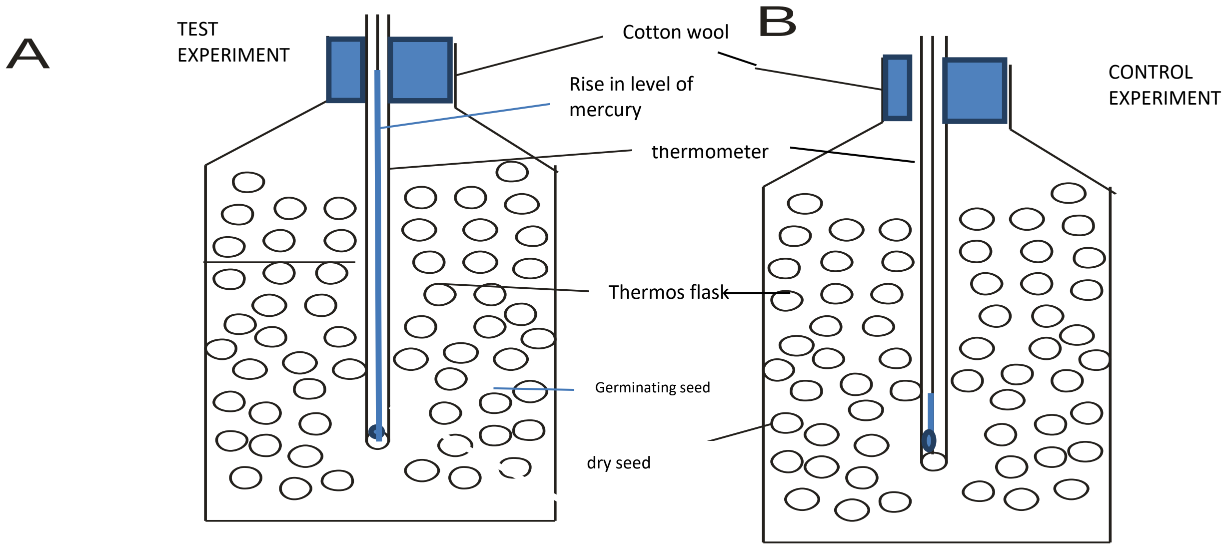
(a) Owl is always believed to be a witch bird

(b) Owl appearance leads to death of a person

(c) The neighbor of the family had this same thing happened a year ago

(d) One can't really say, there is no relationship between owl and death

19. An experimental set up was made as show below that energy is released during cellular respiration



Flask A contains germinating seeds while flask B (the control) contains dry seeds. Students are asked to observe the set up and explain what they observed in the thermometer

(X)7 students noted a rise in mercury level in flask A containing germinating seeds

(Y) 5 students said there is no change in the set up

(Z) 3 students observed errors in the set up

Which observation do you think is correct?

(a)Y (b) Z (c) X (d) Y and Z

20. From 18 above what percentage noted a rise in mercury level in flask A? (a) 20% (b) 15% (c) 7% (d) 47%.
21. Supposed Keyboard, Mouse and Monitor are parts of a computer. If the keyboard is regarded as a hardware, what will the mouse be classified as (a) Software (b) Menwears (c) Kitchen utencil (d) Hardware
22. A cloth dealer sells out wrapper on daily basis below is a table containing the quantity demanded and the prices of item sold.

DAY	QUANTITY DEMANDED	PRICE(₦) PER CLOTH
1	100	5,000
2	80	4,000
3	60	4,000
4	20	3,000
5	10	2,5000

What can you conclude form this information?

(a) The higher the quantity demanded the lower the price

(b) The higher the quantity demanded the higher the price

(c) The lower the quantity demanded the higher the price

(d) None of the options is correct

23. Consider the mathematical formula: T=PV

Which of the following statement given are about the relationship is correct?

(a) If P is doubled and V is zero, then, T is equal to zero

(b) If P is doubled and V is doubled, then T decreases

(c) If P is halved and V is halved, then T increases

(d) If P is O and V double, then T increases

24. A researcher went to an enclosed garden, he saw some things moving from place to place, some have green leaves but were not moving. After some months he visited the garden again and discovered that all these things have grown. What conclusion can the researcher draw from this observation

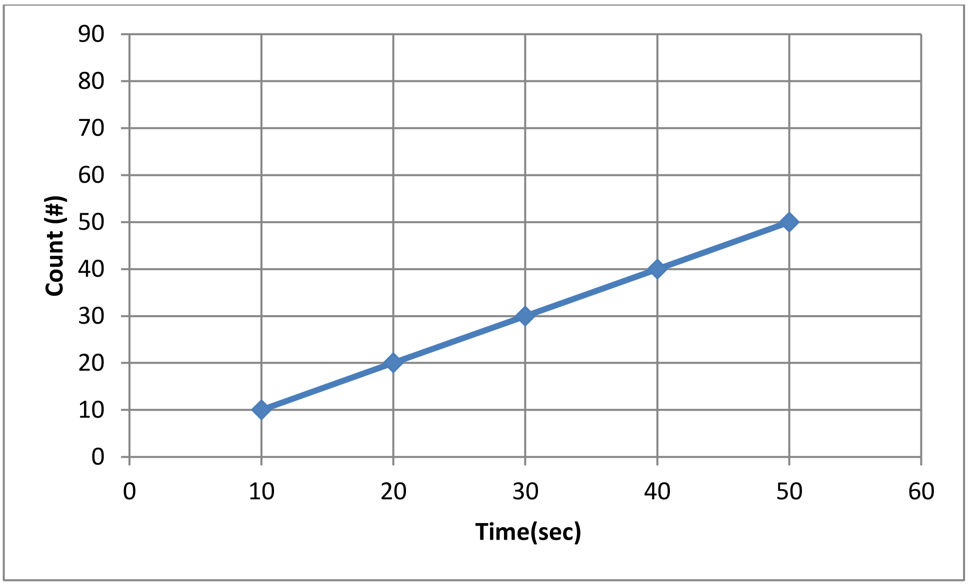
(a) All living things grow

(b) The things with leaves also move about

(c) Only the things moving from place to place can grow

(d) All living things cannot grow

25. A scientist is making a count on the number of time the average human heart contract and relaxes as a function of time during on experimental investigation. At the end of each second the number of time the heart contract and relaxes during the past seconds is recorded and the following graph is generated



Which of the following conclusion can the scientist properly draw from the data of the time interval observed?

(a) The count is generally decreasing

(b) The count is generally increases

(c) The count is uniformly constant

(d) The count is chaotic

APPENDIX G

ANSWER TO CLASSROOM TEST ON SCIENTIFIC REASONING ABILITY

Keys

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

22. B

23. A

24. A

25. B

APPENDIX H

Table of Specification for classroom Test of Scientific Reasoning Ability(CTSRA)

Scientific Reasoning Skill	No. of items with the skill	Question number	Construct	
			Deduction	Induction
Classifying	2	1 and 21	(1)Deduction	(21)Induction
Conceptualizing	1	2	Deduction	
Generalizing	1	3	Deduction	
Ordering	2	4 and 7	(4)Deduction	(7)Induction
Using Maths and data in solution of real-world problem	4	5,6,20 and 22	Deduction	
Predicting	2	8 and 10	Deduction	
Using conditional thinking	1	9	Deduction	
Explaining	2	11 and 16	Deduction	
Applying Information	2	12 and 14	Deduction	
Using Correlational thinking	1	13		Induction
Combinatorial thinking	1	15	Deduction	
Defining precisely the system to be studied	1	17	Deduction	
Using casual reasoning to distinguish coincidence from cause and effect	1	18	Deduction	
Conducting	1	19	Deduction	

controlled scientific investigation				
Using proportional reasoning to make decision	**1**	**23**	**Deduction**	
Using inductive reasoning to make conclusion	**1**	**24**		**Induction**
Summarizing for logically justifying a conclusion	**1**	**25**	**Deduction**	
Total	**25**		**21**	**4**

APPENDIX I

RESPIRATION ACHIEVEMENT TEST (RAT)

SECTION A: BIODATA

Name of School:

Registration Number:

Class:

Gender: Male ( ) Female ( )

INSTRUCTION

1. Read each question carefully before you answer it
2. Circle only one of the options as your choice to each questions
3. Attempt ALL questions
4. All questions carry equal marks

Time Allowed: 60 minutes

SECTION B

1 The process where glucose molecule is broken down in the body to release energy is

(a) Digestion (b) Excretion (c) Respiration (d) Nutrition

2. Which of the following is a type of respiration?

(a) Aerobic (b) Breathing (c) Irritability (d) Ventilation

3. The type of respiration which does not require oxygen to take place is

(a) Aerobic (b) Anaerobic (c) Breathing (d) External

4. Which of the following equation best describe aerobic respiration

(a) $C_6H_{12}O_6 \rightarrow 2CH_3\ CH_2\ OH + 2CO_2$ + Energy

(b) $C_6H_{12}O_6 \rightarrow 2CH_3\ CH\ (OH)COO_2$ + Energy

(c) $6CO_{2+}\ 6H_2O \rightarrow C_6H_{12}O_{6\ +}\ 6O_2$

(d) $C_6H_{12}O_{6\ +}6O_2 \rightarrow 6CO_{2\ +}\ 6H_2O$+ Energy

5. Energy that is produced during respiration is stored in

(a) Water (b) Oxygen (c) ATP (d) Drum

6. ATP means

(a) Adenosinetriphosphate
(b) Adenosinediphosphate
(c) Any tea production
(d) Ade Tunde Pedro

7. An athlete running100m race requires which respiration type to complete the race

(a) Aerobic (b) External respiration (c) Internal respiration (d) Anaerobic

8. What type of reaction takes place in respiration?

(a) Reduction (b) Oxidation (c) Hydrogenation (d) Halogenation

9. Energy produced in respiration that is not stored is converted to

(a) Fire (b) Heat (c) Light (d) Gas

10. Oxidative phosphorylation takes place in the

(a) Nucleus (b) Cell membrane (c) Golgi body (d) Mitochondria

11. Which of the following statement about respiration is not true?

(a) Glucose is broken down catalyze by enzymes
(b) Carbon (iv) oxide is released as a by-product
(c) Energy is release in the process
(d) It occurs in non-living things

12. One of the following could also be referred to as anaerobic respiration

(a) Glycolysis (b) Krebs cycle (c) Citric acid cycle (d) Water cycle

13. At the beginning of glycolysis glucose only becomes reactive when it is

(a) burnt in ethanol (b) Phosphorylated from ATP (c) Halogenated (d) Hydrogenated

14. How many ATPs are produced at the end of anaerobic respiration?

(a) 2 ATPs (b) 36 ATPs (c) 15 ATPs (d) 4ATPs

15. Which respiration type produces more energy at the end of the process?

(a) Anaerobic (b) External Respiration (c) Aerobic (d) Breathing

16. How many stages are involved in glycolysis?

(a) 1(b) 2 (c) 3 (d) 4

17. The first stage of glycolysis is characterized by

(a) Investment of two mols of ATPs in the process for each mol of glucose

(b) Breaking down of 5 ATPs

(c) Production of 2 modes of ATPs

(d) Conversion of glucose-6-phosphate to two 3 carbon unit

18. At the first stage of glycolysis glucose is phosphorylated to

(a) Pyruvic acid (b) Glucose -6- Phosphate (c) Glycerate -3- phosphate(d) Glucose

19. In an experimental set up involving seed germination, if 5 students out of a total of 20 students noted an increase in temperature. What percentage noted the increase?

(a) 25% (b) 30% (c) 27% (d) 33%

20. The third stage of glycolysis is characterized by the harvesting of

(a) One mol of ATP (b) Three mol of ATPs (c)Five mols of ATPs (d) Four mols of ATPs

21. The net ATP produced at the end of glycolysis is derived by

(a) Addition of the two ATPs invested into the process and the four ATP harvested

(b) Subtraction of the two ATPs invested in glycolysis from the four ATPs harvested

(c) Multiplication of the ATPs invested by the ATPs harvested

(d) Division of the ATPs harvested by the ATPs invested

22. What is the end product of glycolysis?

(a) Ethanoic acid (b) Tetra-oxo-sulphate(vi) acid (c) Pyruvic acid (d) Glucose

23. Pyruvic acid is made up of

(a) Two carbon atoms (b) One carbon atoms (c) Three carbon atoms (d) Four carbon atoms

24. In the absence of oxygen pyruvic acid synthesized is converted to ……………. In animals

(a) Ethanol (b) Lactic acid (c) Glucose (d) Amino acid

25. In plant pyruvic acid is fermented to ethanol when

(a) Oxygen is absence (b) Oxygen is presence (c) Oxygen react with hydrogen(d) Pyruvic acid is decarboxylated

26. Where does glycolysis takes place in the cell?

(a) Mitochondria (b) Cytoplasm (c) Rybozome(d) Cell wall

27. Why is glycolysis referred to as anaerobic

(a) It require oxygen (b) It requires water (c) It does not require oxygen (d) It required ingredient

28. Carbon (iv) oxide, water and energy are constituents produced during respiration when ---------- substance is burnt.

(a) Water (b) Lime stone(c) food (d) Carbon (ii) oxide

29. In the presence of oxygen pyruvic acid formed is decarboxylated to

(a) AcetylCoA (b) Pyruvic acid (c) Citric acid(d)Glucose

30. The substance which serves as intermediate linking glycolysis to Krebs cycle is

(a) Citric acid (b) TCA cycle (c) carbon (iv) oxide (d)AcetylCoA

31. ………………… describe the oxidation of glucose to pyruvic acid

(a) Glycolytic pathway (b) NADH (c) Reflex arc (d) Nephron

32. AcetylCoA is compose of

(a) Three carbon atoms (b) Two carbon atoms (c) Five carbon atoms (d) Four carbon atoms

33. In citric acid cycle, citric acid is formed when AcetylcoA combines with

(a) KetoGlutarate(b) Pyruvic acid (c) Oxaloacetic acid (d) Acid

34. How many carbon atoms are present in citric acid?

(a) 3 carbon atoms (b) 2 carbon atoms (c) 5 carbon atoms (d) 6 carbon atoms

35. Which of the following is a catabolic process

(a) Protein synthesis (b) Photosynthesis (c) Respiration (d) Sexual reproduction

36. AcetylCoA could also be form when one of the following is broken down

(a) Fat (b) Water (c) Mineral (d) Firewood

37. When citric acid is formed in Krebs cycle, one of the following is released

(a) Nitrogen (b) Carbon (iv) oxide (c) Sugar (d) Ammonia

38. What is the number of ATP produced at the end of Krebs cycle?

(a) 36 ATPs (b) 38 ATPs (c) 2 ATPs (d) 3 ATPs

39. A complete breakdown of a glucose molecule yields

(a) 36 ATPs (b) 2 ATPs (c) 38 ATPs (d) 5 ATPs

40. Anaerobic respiration is applicable in the following except

(a) production of energy for survival (b) required during vigorous exercises (c) required during the production of alcoholic drinks by yeast(d)It is employed in krebs cycle.

41. The first product generated by the sequence of conversions in kreb cycle

(a) Funmarate (b)Pyruvic acid (c) Citric acid (d) Oxaloacetic acid

42. A series of chemical reactions that breakdown glucose in the presence of oxygen to release carbon(iv) oxide, water and energy is called

(a) Glycolysis (b) Photosynthesis (c) Digestion (d) Kreb cycle

43. The first step in citric acid cycle is the combination of acetyCoA to oxaloacetic acid to form

(a) Citric acid (b) Chloroquine (c) Malate (d) Succcinate

44. Which substance in citrus fruit juice is the same as citric acid in Krebs cycle?

(a) Carbon (iv) oxide (b) Water (c) Hydrogen iron (d) Citric acid

45. Citric acid cycle could also be referred to as

(a) Catabolism (b) Tricarboxylic acid cycle (c) Carbon cycle (d) Water Cycle

46. Krebs cycle could also be referred to as citric acid cycle because

(a) It is sweet

(b) It has six carbon atoms

(c) It is the first product generated by the sequence of conversion in Kreb cycle

(d) It has the capability of generating carbon(iv) oxide

47. Respiration is an example of ……………. Process

(a) Catabolic (b) Anabolic (c) Photosynthetic (d) Chemosynthetic

48. Which enzyme is involved in the synthesis of pyruvic acid to glucose -6-phosphate

(a) pyruvate kinase (b) maltase(c) ptyalin (d) pepsin

49. The process where food is burnt in a food calorimeter in the of oxygen is applicable to what process in the bodyOne of the following is correct about citric acid cycle

(a) Nutriton

(b) Respiration

(c) Homeostasis

(d) Irritability

50 Which of the following is not correct of lactic acid real life application?

(a) it is used in the manufacture of ink

(b) it is used as a starting material in the production of drugs.

(c) it is used in barbers' salon

(d) it is used in making yogurt

APPENDIX J

ANSWER TO RESPIRATION ACHIEVEMENT TEST (RAT)

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

25. A

26. B

27. C

28. C

29. A

30. D

31. A

32. B

33. C

34. D

35. C

36. A

37. B
38. A
39. C
40. A
41. C
42. D
43. A
44. D
45. B
46. C
47. A
48. A
49. B.
50. C

APPENDIX K

Table of Specification for Achievement Test on Respiration

Domain	Knowledge	Comp.	App.	Ana.	Syn.	Eval.	Total
General Respiration	1, 5, 11,47	8, 9, 39	49	35	28	6	11
Aerobic	2, 15	4, 27	19	25	32	29	8
Anaerobic	12, 31	3	7, 40	36	24	14	8
Glycolysis	16, 22, 23, 26	13, 17	21, 50	18	48	20	11
Kreb's cycle	30, 34, 37, 45	10, 41, 46	44	42	33, 43	38	12
Total	16	11	7	5	6	5	50

APPENDIX L

Table of Difficulty Level of RAT

Content	No. of item	Low	Moderate	High
General Respiration	9	5, 11	1, 6, 9, 35, 39	8, 47
Aerobic	6	2	15, 25, 27	4, 32
Anaerobic	7	31	3, 12, 14, 36	7, 40
Glycolysis	11	22, 16	13, 18, 19, 29, 23, 50	17, 21, 26
Kreb's cycle	17	29, 34, 45	24, 33, 37, 38, 42, 43, 46, 48, 49,	10, 28, 30, 41, 44,
Total	50 (100%)	9 (18%)	27 (54%)	14 (28%)

APPENDIX M

RELIABILITY TEST

```
GET DATA /TYPE=XLSX
  /FILE='C:\Users\-\Documents\NMA PILOT DATA 2021.xlsx'
  /SHEET=name 'SCIENTIFIC REASONING'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
CORRELATIONS
  /VARIABLES=T1 T2
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

Correlations

Notes

Output Created		13-JUL-2021 17:24:53
Comments		
Input	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	30
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each pair of variables are based on all the cases with valid data for that pair.
Syntax		CORRELATIONS /VARIABLES=T1 T2 /PRINT=TWOTAIL NOSIG /MISSING=PAIRWISE.
Resources	Processor Time	00:00:04.43
	Elapsed Time	00:00:04.46

[DataSet1]

Correlations

		T1	T2
T1	Pearson Correlation	1	.086
	Sig. (2-tailed)		.650
	N	30	30
T2	Pearson Correlation	.086	1
	Sig. (2-tailed)	.650	
	N	30	30

```
GET DATA /TYPE=XLSX
  /FILE='C:\Users\-\Documents\NMA PILOT DATA 2021.xlsx'
  /SHEET=name 'RAT'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
CORRELATIONS
  /VARIABLES=T1 T2
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

Correlations

Notes

Output Created		15-JUL-2021 05:21:11
Comments		
Input	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	30
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each pair of variables are based on all the cases with valid data for that pair.
Syntax		CORRELATIONS /VARIABLES=T1 T2 /PRINT=TWOTAIL NOSIG /MISSING=PAIRWISE.
Resources	Processor Time	00:00:00.11
	Elapsed Time	00:00:00.14

[DataSet1]

Correlations

		T1	T2
T1	Pearson Correlation	1	.081
	Sig. (2-tailed)		.669
	N	30	30
T2	Pearson Correlation	.081	1
	Sig. (2-tailed)	.669	
	N	30	30

APPENDIX N

LETTER OF INTRODUCTION

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT SCIENCE EDUCATION

Vice Chancellor: **PROF. ABDULLAHI BALA, Ph.D Fssn**
Head of Department: **DR. RABIU M. BELLO PhD, MSTAN**

Federal University of Technology
P.M.B. 65,
Minna, Niger State.
Nigeria.

Date:

Name of Student: MARY J. NMA
Matriculation No: MTech/SSTE/2018/8031
Status: ______________________

TO WHOM IT MAY CONCERN

The bearer is a postgraduate student of the department. his/her humbly request for your assistance/support with information/data necessary for research towards improvement in knowledge skills and attitudes in line with international best practices for quality research output in the University.

The data/information given shall be used only for the purpose of the research and absolute confidentiality shall be maintained.

Please accept the assurances of my esteem regards.

Thank you.

Head of Department
Science Education
Fed. University of Technology
Minna
DATE 13/10/21

Dr. Rabiu M. Bello
HOD, Science Education.

Contacts: +234-803-592-7009
+234-802-635-6884
E-mail: drrabiu@futminna.edu.ng.

APPENDIX O

VALIDATORS OBSERVATION

Classroom Test of Scientific Reasoning Ability (CTSRA)

S

1. Select the item that is odd from the table below

RAT	COW	DOG	WATER
1	2	3	4

(a) 1(b) 2(c) 3 (d) 4

Classifying

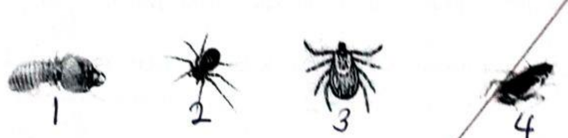
2. All of these are insects

what is the use of this?

These are not insects

Conceptualizing

Which of the following is an insect



(a) 1,4 (b) 2,4 (c) 2,3 (d) 1,2,3,4

3. Which of the following statement is correct about this group of mathematical instrument

please provide a table of specification to show the number of questions that represent each of the reasoning ability. You are not suppose to indicate them on the question paper.

APPENDIX P

VALIDATION FORM

RESEARCH INSTRUMENT VALIDATION FORM

Sir/Ma,

The candidate Mary J. Nma with Admission Number MTech/SSTE/2018/8031 is a student of the department. You are requested to make amends or inputs that will improve the quality of the instrument. Your professional expertise is expected to assist the researcher towards the award of the degree.

Thank you.

28 JUN 2021

Dr. Rabiu M. Bello

HOD (Signature, Date & Official Stamp)

Title of the Research Instrument: Classroom Test of Scientific Reasoning Ability and Respiration Achievement Test.

SECTION A

1. Appropriateness of the Research Instrument title: is appropriate
2. Suggest amendment if not appropriate: —
3. Completeness of Bio-data Information: is okay
4. Suggest inputs if incomplete —
5. Suitability of items generated is suitable
6. Structure of the questionnaire/ test items generated okay
7. Structure of the instrument in line with the objectives of the study. is in line
8. Items coverage and distribution across constructs and domains measured okay
9. Appropriateness of the instrument in relation to the type of data to be collected is appropriate
10. What is the general overview and outlook of the instrument? Simple and clear
11. Rate the Instrument between 1-10 8

SECTION B

Name of the validator: Mrs Sarita Bagg

Designation/Rank: Ass. Lecturer

Name of institution: F.U.T Minna

Department/ School: Science Education

Telephone No/GSM No: 07056590753

E-Mail Address: ____________________

SB . 1/9/2021

* Signature, Date and stamp (if available)

RESEARCH INSTRUMENT VALIDATION FORM

Sir/Ma,

The candidate Mary Joseph Nma with Admission Number MTech/SSTE/2018/8031 is a student of the department. You are requested to make amends or inputs that will improve the quality of the instrument. Your professional expertise is expected to assist the researcher towards the award of the degree.

Thank you.

Head of Dept. Science Education
28 JUN 2021
Fed. University of Tech. Minna

Dr. Rabiu M. Bello

HOD (Signature, Date & Official stamp)

Title of the Research Instrument: Effects of 5E Learning-cycle Instructional Strategy on Secondary School Biology Students' Scientific Reasoning Ability and Achievement in Minna Educational Zone, Niger State

SECTION A

1. Appropriateness of the Research Instrument title: Fairly appropriate
2. Suggest amendment if not appropriate: See comments on the instrument
3. Completeness of Bio-data Information: Satisfactory
4. Suggest inputs if incomplete See comments
5. Suitability of items generated See comments
6. Structure of the questionnaire/ test items generated See comments
7. Structure of the instrument in line with the objectives of the study See comment
8. Items coverage and distribution across constructs and domains measured See comment
9. Appropriateness of the instrument in relation to the type of data to be collected See comments
10. What is the general overview and outlook of the instrument? See comment
11. Rate the Instrument between 1-10 6

SECTION B

Name of the validator: Dr. E. Raymond

Designation/Rank: Assoc. prof

Name of institution: FUT -Minna

Department/ School: ITE/SSTE

Telephone No/GSM No: 08037555545

E-Mail Address: emmanuel.raymond@futminna.edu.ng

2/07/2024

Signature, Date and stamp (if available)

RESEARCH INSTRUMENT VALIDATION FORM

Sir/Ma,

The candidate Mary J. Nma with Admission Number MTech/SSTE/2018/8031 is a student of the department. You are requested to make amends or inputs that will improve the quality of the instrument. Your professional expertise is expected to assist the researcher towards the award of the degree.

Thank you.

Dr. Rabiu M. Bello

HOD (Signature, Date & Official stamp)

Title of the Research Instrument: Classroom Test of Scientific Reasoning Ability and Respiration Achievement Test

SECTION A

1. Appropriateness of the Research Instrument title: Appropriate and suitable for the research.
2. Suggest amendment if not appropriate: it is suitable as a far as I have observed.
3. Completeness of Bio-data Information: Complete
4. Suggest inputs if incomplete it is open ended as far as research is concern.
5. Suitability of items generated it is suitable and un-bias.
6. Structure of the questionnaire/ test items generated All the construct needed are captured in it.
7. Structure of the instrument in line with the objectives of the study.
   it is in line with the stated objective.
8. Items coverage and distribution across constructs and domains measured
   it covers the construct and the domains.
9. Appropriateness of the instrument in relation to the type of data to be collected
   Appropriate
10. What is the general overview and outlook of the instrument?
    it is a valid instrument which can be adapted.
11. Rate the Instrument between 1-10 7

SECTION B

Name of the validator: Saalihu Mohammed A.

Designation/Rank: Principal Education Officer

Name of institution: Model Science College Tyfadani Basso.

Department/ School: Department of Science (Senior Biology Teacher)

Telephone No/GSM No: 09025990733

E-Mail Address: Muhammadsalihu963@gmail.come

[signature] (21/10/2022)

Signature, Date and stamp (if available)

APPENDIX Q

PRETEST RESULT

Summary of pretest scientific reasoning ability using analysis of variance (ANOVA) for experimental and control groups.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	52.108	1	52.108	.847	.358
Within Groups	16617.642	270	61.547		
Total	16669.750	271			

Summary of pretest achievement using analysis of variance (ANOVA) for experimental and control groups.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	316.021	1	316.021	11.735	.001
Within Groups	7271.214	270	26.930		
Total	7587.235	271			