UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECTS OF MINDS-ON AND HANDS-ON ACTIVITIES ON STUDENTS’ COGNITIVE ACHIEVEMENTS IN THE STUDY OF THE EXCRETORY SYSTEM OF MAMMALS

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DECLARATION

STUDENTS' DECLARATION

I, Mawutor Tsama, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and that it has not been submitted, either in part or whole, for another degree elsewhere.

Signature :…………………………………………..

Date :………………………………………………..

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

SUPERVISOR'S NAME: PROFESSOR JOHN K. EMINAH (PhD)

Signature:…………………………………………

Date:………………………………………………

DEDICATION

I dedicate this thesis to my beloved wife, Mrs. Regina Mawuko Tsama, my children, Francisca Sika Menya, Kevin Klenam Tsama and Kelly Kekeli Tsama, and my pastor, Rev. Marie-Irene Dede Akato for their emotional support.

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ABSTRACT

The study sought to determine the effects of minds-on and hands-on activities on form two students' cognitive achievement in the excretory system of mammals among some selected senior high schools in the Ho-West District of Volta Region in Ghana. To guide the study, four (4) research questions were posed and answered. Quasi experimental research design specifically, pre-test, post-test, questionnaire and non-equivalent control group was adopted for the study. A sample of sixty (60) SHS 2 students in two selected mixed sex schools within the selected district were used for the study. Biology Achievement Test in the form of multiple choice and essay and questionnaire were used as instruments for data collection. Data collected were analysed using the Microsoft Excel (2019) and SPSS statistical analysis tool (version 27). Overall item new response score analysis was used to determine the perceptions of the experimental group students of the use of the minds-on and hands-on activity method in teaching excretory system. The findings of the study were; there is a significance difference in the achievement mean scores of students in the experimental group before and after the treatment. The general performance of the experimental group students had significantly improved after the treatment using the minds-on and hands-on activities. There is no significant difference in the mean performances of the male and female experimental group students before and after treatment. Sex is not a significant factor on the students' cognitive achievement in excretory system. There is no significant interaction effect of the minds-on and hands-on activities and sex on the cognitive achievement of students in excretory system. The experimental group students had positive perceptions of the use of the minds-on and hands-on activities for lessons in excretory system. One of the implications of the findings is that, the minds-on and hands-on activity method of teaching is effective tends to perform homogeinity of performance between the male and female students. It was recommended among others that science educators and curriculum planners should incorporate innovative strategies such as minds-on and hands-on activity method of teaching into their various teacher education programmes.

CHAPTER ONE

INTRODUCTION

1.0 Overview

The social and economic development of a country such as Ghana depends on science since it has become the integral and an inevitable component of development. Biology deals with the study of plants and animals and when it is taught without practical activities, the understanding of biological concepts may not be enhanced. Hence the incorporation of practical activities has been identified as the foundation of a good scientific programme which enhances the biological experiences of students. The effects of practical on students' cognitive achievement are investigated and are manuals are developed. Thus, practical activities and its effect on cognitive achievement on students are important to policy makers, biology teachers and biology students.

1.1 Background to the Study

The world being dynamic in nature has led to a lot of changes in the scope of teaching and learning. As a result, the understanding by students have become challenging among the many school disciplines, especially science. Science begins for children when they realize that they can learn about the world and construct their own interpretations of events through their actions and experience. "A child best learns to swim by getting into water; likewise, a child best learns science by doing science" (Rillero, 1994). Doing science, as opposed to simply hearing or reading about it, engages students and allows them to test their own ideas and build their own understanding (Ewers, 2001). Therefore, it is difficult to imagine a science-teaching program without doing science experiences. Science is seen as a body of knowledge that carefully and systematically collect data, verifies and predicts events about the natural world. Nzewi (2010) defined science as the study of natural phenomena, while Mandor (2002) saw science as a body of knowledge with the goal to investigate and understand nature, to explain events in nature and to use these explanations to make useful predictions. According to Atahiru, Abubakar, Haruna, and Habiba (2016), Science is perceived to be one of the most difficult subjects because it involves observations, experimentations and logical inferences to give meaning to some phenomena in our world. Science has numerous branches, which include biology, chemistry, physics, etc.

Science education at the SHS level is an essential and inevitable component in social and economic development. An international consensus as stated in Gluckman (2011) shows that a solid science education is an indispensable requirement to having an economy based on knowledge and innovation. In recent years, it has been increasingly argued that science should be compulsory part of all science curricula of many countries across the globe and that compulsory science education can only be justified if it offers something of universal value to all (Osborne & Hennessy, 2003). It is therefore evident that science education is of great importance and so mechanisms must be put in place to effectively enhance its teaching and learning. For science learners to understand and apply the scientific concepts acquired in the areas of economic and social development, the teaching and learning approaches, strategies and skills used cannot be underestimated. Siemens (2014) opined that one of the important roles in science education is to develop learners' ability to improve their conceptual understanding and acquire knowledge in the subject. The method of instruction and techniques used by a teacher in science teaching is very crucial. Based on the current trends in the world's scientific explorations, new science teachers should be equipped with the skills to integrate the curriculum and technology for effective innovative science teaching (Jang

& Chen, 2010). Clark and Mayer (2016) are also of the view that designing instructions that will promote better understanding of scientific concepts which is key to the development of science education.

The knowledge of biology as a subject by senior high school students makes them well informed and motivated to assume roles in which the practical and theoretical aspects are used in unravelling some basic problems of life (Ude, 2011). Biology curriculum contains a lot of abstract concepts like photosynthesis, osmoregulation, genetics and osmosis. These causes frequent problems in conceptual instruction in biology lessons. Ibe (2004) stated that there should be a renewal of biology curriculum which will base on constructivist learning approach. Constructivism argued that knowledge can be obtained by individuals' active interaction and meaning can be formed based upon their experiences. Students should therefore set up work and observe the concepts in biology lessons on their own through practical activities.

Hands-on science is defined mainly as any instructional approach involving activity and direct experience with natural phenomena or any educational experience that actively involve students in manipulating objects to gain knowledge or understanding (Haury & Rillero, 1994). Some terms such as materials-centered science and activity-centered science are used synonymous with hands-on science or terms such as materials-centered activities, manipulative activities and practical activities are used synonymous with hands-on activities (Doran, 1990; Hein, 1987). Unlike the laboratory works, hands-on activities do not necessarily need some special equipment and special medium. According to Jodl and Eckert (1998), hands-on activities are based on the use of everyday gadgets, simple set-ups or low-cost items that can be found and assembled very easily. McGervey (1995) stated that some hands-on activities can be done for less than a dollar per hand, a few have zero cost. Thus, it will be no disaster if a piece breaks or disappears. To encourage their creativity in problem solving, promote student independence, improves skills such as specifically reading, arithmetic computation, and communication (Haury & Rillero, 1994; Staver & Small, 1990). Lebuffe (1994) emphasizes that children learn better when they can touch, feel, measure, manipulate, draw, make charts, record data and when they find answers for themselves rather than being given the answer in a textbook or lecture.

According to the U.S. National Science Education Standards (1995), students should have minds-on and/or heads-on experiences during hands-on activities. While doing hands-on activity, the learner is learning by doing but while minds-on learning, the learner is thinking about what she or he is learning and doing. Hofstein and Lunetta (1982) state that a minds-on science activity includes the use of higher order thinking, such as problem solving compared to the hands-on activity. Therefore, students should be both physically and mentally engaged in activities that encourage learners to question and devise temporarily satisfactory answers to their questions (Victor & Kellough, 1997).

Hands-on-approach has been proposed as a means to increase students' academic achievement and understanding of scientific concepts by manipulating objects which may make abstract knowledge more concrete and clearer. Through hands-on-approach, students are able to engage in real life illustrations and observe the effects of changes in different variables. It offers concrete illustrations of concepts. This method learner-centered which allows the learner to see, touch and manipulate objects while learning as mathematics are more of seeing and doing than hearing; so also, with science that advocates "do it yourself".

Obanya (2012) in his convocation lecture confirmed the above statement by adding that the average retention rate of learning by lecture is 5% while that of practice by doing (Activity-oriented) is about 75%. It can be seen that retention rate increases progressively with the use of more interactive and activity-oriented teaching methods. On the contrary, Ekwueme and Ekwueme and Meremikwu (2010) observed in their study that some teachers object to the use of interactive activity-oriented method stating that it is time consuming and do not permit total coverage of the syllabus. Fortunately, the new mathematics and basic science syllabus' coverage is determined by how much skills/knowledge students' have acquired rather than how much of the syllabus is covered as learner centeredness is highly advocated Obanya (2012) in his convocation lecture confirmed the above statement by adding that the average retention rate of learning by lecture is 5% while that of practice by doing (Activity oriented) is about 75%. It can be seen that retention rate increases progressively with the use of more interactive and activity-oriented teaching methods (NERDC, 2008).

Practical activities have long had a distinctive and central role in science curriculum as a means of making sense of the natural world. Since the ninetieth century, when schools began to teach science systematically, practical activities have become a distinctive feature of science education. For the past several decades, educational researchers have suggested that practical activities are beneficial and make unique contributions to science education. Science educators have designed practical activities with the intention of promoting students' learning in cognitive and affective domains such as understanding scientific concepts, interest and motivation, scientific practical skills, scientific inquiry, and understanding the nature of science (Hofstein & Lunetta, 1982, 2004; Freedman, 1997; Henderson et al., 2000). For instance, Freedman (1997) showed that students who experienced hands-on laboratory programmes achieved higher scores on mid-term and final science examinations than those who did not participate in such courses.

In fact, some educational researchers postulate that students learn as many new terms in an introductory biology course as in a foreign language course. And these new terms are essential to learn in order to discuss the mechanisms and concepts of biological systems. However, rote memorization is a learning- and teaching method that is becoming more and more passé. Practical activities can be regarded as a strategy that could be adopted to make the task of a teacher (teaching) more real to the students as opposed to abstract or theoretical presentation of facts, principles and concepts of subject matter using varieties of instructional materials/equipment to drive lesson home. The use of practical activities (approach) to the teaching of biology should be compulsory for biology teachers so as to produce students who can acquire the necessary knowledge, skills and scientific competence needed to meet the scientific and technological demands of the society. Practical activities help learners to understand more because the way human nature is, things done by self is difficult to be forgotten because the picture of the incident is always registered in the brain. According to Ibe (2004), the American Association for the Achievement of Science (AAAS) developed a programme known as ‘Science a Process Approach (SAPA). This programme was designed to improve children’s skills in the process of science. The practical approach provides the opportunity for students to seek information using experimental procedures. It calls for careful observation and interpretation of data and has the qualities of questioning, investigating and confronting the unknown. It is for the above reasons that I decided to investigate the effects of minds-on and hands-on activities on students’ cognitive achievement.

1.2 Statement of the Problem

Not much attention has been given to the achievement of biology students especially in biology practical aspect of biology and the schools have been blamed on factors such as inability of the school management to provide materials and equipment for practical work and the failure of biology teachers to recognize the importance of practical activities in science teaching.

Practical work has been able to promote students' positive attitudes and enhance motivation for effective learning in science (Okam & Zakari, 2017). Consequently, a positive attitude toward the importance of practical work meaningfully affects students' achievement in science (Hinneh, 2017). Hence, practical activities are very important for biology education and students taught biology theoretically without the practical activities tend to find it difficult to retain what they have been taught and lack scientific inquiry skills.

For this reason, this study was designed to determine the effect of minds-on and hands-on activities on the cognitive achievement of selected SHS biology students.

1.3 Purpose of the Study

The purpose of this study is to determine the effect of minds-on and hands-on activities' on selected senior high school students' cognitive achievement in excretory system.

1.4 Objectives of the Study

The objectives of this study were to determine;

1. The difficulties students face during lessons on the excretory system of mammals.

2. The effects of minds-on and hands-on activities on the students' cognitive achievement in the study of the excretory system of mammals.
3. The differential effect of the treatment on the cognitive achievement of the male and female experimental group students.
4. The views of the students on the use of minds-on and hands-on activities for biology lessons.

1.5 Research Questions:

The study was guided by the following research questions;

1. What difficulties do the students face during lessons on the excretory system?
2. What are the effects of minds-on and hands-on activities on the students' cognitive achievements in the study of the excretory system of mammals?
3. What are the differential effects of the treatments on the cognitive achievement of the male and female experimental group students?
4. What are the students' views on the use of minds-on and hands-on instructional approaches for biology lessons?

1.6 Significance of the Study

This study is of great importance to policy makers and implementers of the educational sector in the Ho – West District in the Volta Region of Ghana such as the Ministry of Education (Ho - West) to ensure that teachers use practical activities to improve learning in biology and science as a whole. The study is helpful to guide future research since it would form the basis for further research work.

Furthermore, this study is to arouse the curiosity, perseverance and critical thinking ability of biology students and enhance their interest in biological studies. This study also go a long way to improve the cognitive achievement of students' in biology and science as a whole since practical laboratory activities is a method of teaching which enhances understanding of biological concepts.

1.7 Limitations of the Study

The researcher encountered some shortcomings during the study. This study was conducted in Amedzofe Technical Institute and Avatime Vane SHS in the Ho – West District in the Volta Region and so it cannot be generalizable to other schools and other districts of different setting.

Some of the students sampled for the study in Amedzofe Technical Institute were absent from lessons during the treatment stage and this affected their cognitive achievement of the concepts taught.

Even though the study was to a larger extent to help in improving the academic achievement of the participants, their willingness to participate was not encouraging during the implementation of the treatment strategy as a cross section of the class were part of the National Science & Math Quiz group, Drama and Cultural troupes as well as the sports teams. Thus, students had divided attention during the process, as sporting activities were being held at the schools during the time of the work.

Finally, learners' lack of enthusiasm and interest in the study as well as their negative attitude towards biological sciences also affected he study.

Nonetheless, these limitations will by no means underscore the relevance of the outcome of this study.

1.8 Delimitations of the Study

This study was restricted to the use of practical activities (minds-on and hands-on) in teaching biology students. This study was not conducted in other regions but was only conducted in the Ho – West District in the Volta Region of Ghana and to be precise in Avatime Circuit "A". This study was conducted in Avatime Senior High School and Amedzofe Technical Institute; only form two students was sampled for the study. Additionally, this study focused only on the excretory system.

1.9 Definition of Terms

Some terms will be used in this study that may have a different contextual meaning. It is prudent to define those terms at this stage of the proposal.

Active Learning: Active learning engages students in the process of learning through activities and discussions in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work (Freeman et al., 2014).

Sex: Sex is a trait that determines an individual's reproductive function, male or female (Stevenson & Waite, 2011).

Experimental group: A group of students on whom the treatment is administered. They were the group taught using the minds-on and hands-on activities.

Control group: A group of students whose performance is compared to that of the experimental group. They were taught using the discussion method of teaching.

1.10 Abbreviations and Acronyms

AMETECH: Amedzofe Technical Institute.

AVASEC: Avatime Vane Senior High School.

BAT: Biology Achievement Test.

ANOVA: Analysis of Variance.

ANCOVA: Analysis of Covariance.

Co-Op: Cooperative Education.

ELT: Experiential Learning Theory.

1.11 Organization of the Study Report

This study is organized into five chapters. The outline of the chapter one has already been presented. Chapter two comprised of the review of related literature. It begins with an overview of the chapter and then a review of related literature under various strands. Chapter three consists of the research methodology. It is divided into the overview, the design of the study, population and sampling procedure, instrumentation, the validity of the instruments, the reliability of the instruments, data collection, data analysis, pre-treatment findings, treatment, post-treatment and implementation. Chapter four contains presentation and analysis of results. Chapter five covers the summary of findings, conclusion, recommendations and suggestion for further study, references and appendices.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This study investigated the effect of minds-on and hands-on activities on students' cognitive achievement in excretory system. This chapter reviewed literature related to this study. The review focused on the conceptual framework, the theoretical framework and the empirical framework done in the field of science education, specifically on minds-on and hands-on activities in biology.

Conceptual framework

The following were discussed under the conceptual framework:

1. Teaching methods.
2. The activity method of teaching and its advantages.
3. Concept of minds-on and hands-on activities.
4. Importance of minds-on and hands-on activities (Active Learning).
5. Demerits of minds-on and hands-on activities.
6. Effects of minds-on and hands-on (Active learning) on students.
7. Influence of gender on students' achievement in biology.

Theoretical framework

The following were discussed under the theoretical framework:

1. Behavioural theory of learning
2. Cognitivists' theory of learning
3. Constructivist' theory of learning
4. Experiential learning theory

Review of related empirical studies

1. Studies on the effects of minds-on and hands-on activities on students' achievement in science.

2.1 Conceptual Framework of the Study

The conceptual work done on the problem focused on the following: Teaching methods, the activity method of teaching and its advantages, concept of minds-on and hands-on activities, advantages of minds-on and hands-on activities, disadvantages of minds-on and hands-on activities and the effect of minds-on and hands-on activities in teaching biology on students' achievement.

2.1.1 Teaching methods

Teaching is the process of imparting knowledge or idea that involves some activities on part of the teacher and learner. The prime functions of a teacher are to build up the services of intellectual capital and engage in the systematic assemblage of step-by-step facts called methods. Teaching method can be defined as a well-known procedure with more or less defined steps which tend to promote overall teaching strategies. According Aniaku (2013), teaching method describes various ways information is presented to the students specifying the nature of the activities in which the teacher and the learner will be involved during the teaching and learning processes. The main purpose of teaching is the transfer of knowledge.

The poor performances of students in external examinations have been attributed to poor teaching methods among other factors (Aniaku, 2013). To improve on the performance of students, many researchers have recommended the use of effective teaching methods as a remedy for students' poor performance. Nzewi (2002) noted that effective teaching makes learning meaningful, while poor teaching leads to poor learning and resultant poor performance. An effective instructional method is that which stimulates students' interest and involves students' participation. An effective teaching is designed to stimulate learning and improve thinking skills. Effective teaching ranges from the most transmission of factual knowledge to a process that transforms both the teacher and the students through critical thinking.

There are different types of teaching methods such as lecture method, fieldtrip, practical activity method, discussion, problem solving, games and stimulation, demonstration, cooperative and collaborative method and many more. These different methods have different ways of imparting knowledge to the learner. Therefore, for the purpose of this study, the researcher decided to use minds-on and hands-on activities which is a practical method of teaching and learning, to determine its effects students' cognitive achievement in excretory system.

2.1.2 The Activity Method of Teaching and its Advantages

Teaching has generally been perceived to be the transmission of knowledge from one person to another. This transmission of knowledge followed a linear pattern where teachers dominate the class and transfer knowledge to students. This method of teaching generally recognized students as passive listeners rather than active participants of the teaching-learning process. But the researcher believe teaching must have a different dimension, a dimension which places students at the centre of the teaching and learning process, a dimension that allows students to be active participants and a dimension that gives students the opportunity to construct their own knowledge from their past or current experiences. What then will be the best teaching method?

There is no globally accepted method of teaching and there are varied teaching methods adopted by teachers all over the world (Carin, 1993). Farant (1980) indicated that there are a lot of teaching methodologies that teachers can employ during their teaching. However, Farant (1980) and Carin (1993) stipulated that the activity method of teaching has received global recognition over the past decade as one of the best teaching models for science. Brunner (1960) also indicated that the activity method, unlike the lecture method of teaching in which the flow of information follows a linear pattern, encourages students' participation in the lesson. To Brunner, the definition of teaching as the transmission of knowledge from one person to another seems limited in some respect in that it treats the students as being 'empty vessels'. To him teaching must be viewed as the process of guiding students to acquire relevant knowledge and skills as well as building positive attitudes, towards the achievement of lesson objectives.

According to Cain (1990), a teacher's duty is to guide the students to construct their own knowledge by giving them the necessary fundamentals. This is in line with the constructivists' theory of learning which argues that knowledge cannot be transmitted directly from one knower to another, but learners have to actively construct their own knowledge rather than receive preformed information transmitted by others (Driver et al., 1994). Under constructivism, teaching becomes a matter of creating situations in which students can actively participate in activities that enable them to make their own individual constructions (Tobin & Tippins, 1993).

Pine (1989) defined the activity method of teaching as the conscious or planned strategy in which teachers engage their students in the teaching and learning process. Pine continued to reiterate that the students' involvement in the lesson must be seen as important, in that, it is one way of capturing the students' interest I n whatever they are taught and makes teaching and learning practically based. Brown (1982) also indicated that a teacher can involve the students in his or her lesson in the following ways;

i. demonstrations
ii. group and whole class discussions
iii. project work
iv. peer teaching
v. hands-on activities

Carin (1993) on the other hand, gave some advantages of the activity method of teaching and which are outlined below:

a. It builds the students' self-confidence and makes them self-reliant in the pursuance of knowledge.
b. It gives reality for learning and makes learning more practical rather than being abstract
c. It enhances the creative aspect of experience.
d. It provides a means of capturing the students' attention as well as reinforcing their interest.
e. It helps the teacher to probe the students' understanding as well as identifying their alternative concepts for rectification.

All these citations justify the fact that the activity model of teaching remains one of the best and globally accepted teaching methods that a teacher can employ in his or her teaching to ensure that the students grasp the concepts they are taught to improve their understanding.

2.1.3 Concept of Minds-on and Hands-on Activities

Students learn more by not being told but by doing things themselves (Sumil, 2016). Looking back to the history of the origin of hands-on minds-on learning, it is believed that John Dewey was the first advocate of learning by doing and applying hands-on learning but mainly in the field of science (Ghosh, 2017). Hands-on learning developed first, and then it generated into minds-on learning. Hands-on learning is about learning by doing where learning can transform the abstract into concrete through manipulation of objects, tools and materials (Pike, O"Brien, Brownlow, Sanchez, Picot & Anderson, 2008). Minds-on learning refers to the fact that the learners are "interacting in depth and in a thoughtful manner with the learning content" (Sumil, 2016). There is a relationship between hands-on minds-on learning and manipulatives as they involve the learners physically and mentally. The use of manipulatives depends on using the hands by manipulating concrete objects and using the minds by helping students to think and reason (Stein & Bovalino, 2001). Using manipulatives reduces the anxiety that some children suffer from, and thus, increasing a positive attitude towards learning (Senyefia, 2017).

When it comes to applying hands-on minds-on learning, creativity becomes an integral part of the learning process and the instruction itself (Seveckova, 2016). Product creativity can be in the form of either an art product or a craft product for developing young learners" learning (Green & Sinker, 2000). Art and craft works are not only related to learning by doing, but they are also related to the mind and cognitive skills (Farokhi & Hashemi, 2011), and they connect between the two hemispheres of the brain and foster cognitive skills (Vohra, 2018). Hands-on minds-on learning decreases the amount of fear and threat that a child might feel in a traditional learning environment. It gives the opportunity that learning is treated as a practice period in which mistakes are allowed (Bartsch, 2017). Hands-on minds-on learning is a counterbalance to worksheets and tests, since it provides a different assessment technique that is free from test anxiety through using manipulatives (Blakey & McFadyen, 2015) or through product creativity assessment when creating art and craft works (Farokhi & Hashemi, 2011; Sumil, 2016). When 5- to 6-year-old children actively manipulated an object while hearing a new label and then heard that label again, motor areas of their brains were more likely to be activated upon subsequent viewing compared with when they were only allowed to passively watch an experimenter manipulate an object (James & Swain, 2011). Bergman and Sams (2014) claimed that students who stop, start, rewind, and repeat videos do better than those who just watched the video passively.

Science begins for children when they realise that they can learn about the world and construct their own interpretations of events through their actions and experience (Ozlem & Ali, 2011). A child best learns to swim by getting into water; likewise, a child best learns science by doing science (Rillero, 1994). Doing science, as opposed to simply hearing or reading about it, engages students and allows them to test their own ideas and build their own understanding (Ewers, 2001). Therefore, it is difficult to imagine a science-teaching program without doing science experiences (Ozlem &Ali, 2011). Children can learn mathematics and sciences effectively even before being exposed to formal school curriculum if basic Mathematics and Science concepts are communicated to them early using activity-oriented (Hands-on) method of teaching (Ekwueme, Ekon & Ezenwa-Nebife, 2015). Mathematics and Science are practical and activity-oriented and can best be learnt through inquiry (Manor, 2002) and through intelligent manipulation of objects and symbols (Ekwueme, 2007).

Hands-on-approach is a method of instruction where students are guided to gain knowledge by experience. This means giving the students the opportunity to manipulate the objects they are studying, for instance, plants, insects, rocks, water, magnetic field, scientific instruments, calculators, rulers, mathematical set, and shapes (Ekwueme, Ekon & Ezenwa-Nebife, 2015). Various interpretations of what is meant by "hands-on learning" has been proposed so far and the most common and accepted definition was that hands-on learning is learning by doing. It involves enabling the child's ability to think critically in a total learning experience. On the contrary to traditional beliefs, learning by hands-on activities does not mean just managing or modifying the materials, but involving profundity of investigation using ideas, objects and materials as well as drawing the depth of investigations with objects, materials and phenomena. It entails using ideas and implicating the meaning and understanding from the experiences that students perform (Haury & Rillero, 1994).

Hands-on science has also been defined as any science laboratory activity which allows the students to handle, observe and manipulate a scientific process (Lumpe & Oliver, 1991). It can be differentiated from conventional lectures and demonstrations in that, students interact with materials to make observations and it involves many activities. In fact, it is a process of doing mathematics and science where students become active participants in the classroom. Haury and Rillero (2015) stated that hands-on learning approach involves the child in a total learning experience which enhances the child's ability to think critically. It is obvious, therefore, that any teaching strategy that is skilled towards this direction can be seen as an activity-oriented teaching method (Hands-on-approach). Unlike the laboratory works, hands-on activities do not necessarily need some special equipment and special medium. According to Jodl and

Eckert (1998), hands-on activities are based on the use of everyday gadgets, simple set-ups or low-cost items that can be found and assembled very easily.

For students to truly learn science concepts, they both need practical opportunities to apply knowledge and also need help in integrating or exchanging the knowledge they gain (Ozlem & Ali, 2011). Students should have minds-on and/or heads-on experiences during hands-on activities. While doing hands-on activity, the learner is learning by doing but while minds-on learning, the learner is thinking about what he or she is learning and doing. Hofstein and Lunetta (1982) state that a minds-on science activity includes the use of higher order thinking, such as problem solving compared to the hands-on activity. Therefore, students should be both physically and mentally engaged in activities that encourage learners to question and devise temporarily satisfactory answers to their questions (Victor & Kellough, 1997).

2.1.4 Importance of Hands-On and Minds-On Activities (Active Learning)

The core elements of active learning include student activity, discussion and engagement (Prince, 2004). Active learning leads to better attitudes and improvements in students' thinking and writing. Prince (2004) stated that active learning is better than traditional lectures for retention of material, motivating students for further study and developing thinking skills. It is also thought that students will remember more content if brief activities are introduced to the lecture contrasting to the traditional belief to push through as much material as possible in a given amount of time (Prince, 2004). Students remember about 10% of what they read, 20% of what they hear, but 90% of what they do. Minds-on and Hands-on (active) learning classrooms are, well, more active. Students are often applying their ideas, working on collaborative projects or using approaches like design thinking or the agile process to solidify their learning. By working through activities and problems students will be more likely to remember the key concepts and understand than if the teacher lectures at them for the whole class. The minds-on and hands-on activities (active learning) format allows misconceptions to come up naturally in the learning process and students are able to recognize the mistakes they are making and correct them which leads to better retention of material and deeper understanding. Johnson and McCoy (2011) stated that learning is student centred, an active process not a passive experience of absorbing new information and therefore effective teaching should be student-centred and allow students the opportunity to construct knowledge as they encounter new information. Suwondo and Wulandari (2013) stated that the teaching emphasizes the interaction among peers and involves activities and feedbacks, students are given consistent opportunities to participate in the learning in the classroom and develop their critical thinking. Minds-on and Hands-on activities (Active learning) shift the focus of learning – from passively (and possibly unquestioningly) digesting information to being accountable for actively engaging with sources and perspectives. And when students share ideas, they learn to build stronger arguments, challenge presumptions and recognize leaps of logic.

Another benefit of minds-on and hands-on activities (active learning) is that the social environment is created. Bartley and Milner (2011) stated that human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them. When this learning style is implemented correctly it aids in the human learning process and students are able to learn from each other.

Hands-on-approach to learning has been proposed as a means to increase students' academic achievement and understanding of scientific concepts by manipulating objects which may make abstract knowledge more concrete and clearer. Through hands-on-approach (activity-oriented teaching), students are able to engage in real life illustrations and observe the effects of changes in different variables. The students who are educated by multiple intelligences supported with hands-on learning method are more successful and have a higher motivation level than the students who are educated by the traditional instructional methods. (Baş & Beyhan, 2010; Ergül & Kargin, 2014) argue that with the increasing of students' learning motivation, it will boost students' ability to do important works, and they deserve to be appreciated. This method is learner-centred which allows the learner to see, touch and manipulate objects while learning as mathematics are more of seeing and doing than hearing; so also, with science that advocates "do it yourself".

Hands-on science is important to enhance learners' success because students actively involve the learning process by manipulating objects or materials to gain knowledge; so that they can construct their own understanding of scientific concepts. By working with materials or objects, students become more motivated and excited to join the lesson. It enables them to become critical thinkers, active learner, and researcher. Hands-on activities also enhance students' interest and curiosity to follow and understand environmental problems or scientific phenomena in real life (Poude, Vincent, Anzalone, Huner, Wollard, Clement, DeRamus & Blakewood, 2005).

2.1.5 Demerits of Minds-on and Hands-on Activities

On the contrary, Ekwueme and Meremikwu (2010) observed in their study that some teachers object to the use of interactive activity-oriented method stating that it is time consuming and do not permit total coverage of the syllabus. Fortunately, the new basic science syllabus' coverage is determined by how much skills/knowledge students' have acquired rather than how much of the syllabus is covered as learner centeredness is highly advocated.

(Lebuffe, 1994; Ekwueme, Ekon & Ezenwa-Nebife, 2015) emphasize that children learn better when they can touch, feel, measure, manipulate, draw, make charts, record data and when they find answers for themselves rather than being given the answer in a textbook or lecture.

2.1.6 The Effects of Minds-on and Hands-on Activities (Active Learning) on Students

Minds-on and hands-on activities (active) learning can increase the students' attitude towards science. Bartley and Milner (2011) defined students' attitude as what spurs the student on to greater things in his or her educational development and it is the job of the educator to get through to each student as much as possible. It is then important for educators to pay much attention to student's attitude each and every day, monitor how it changes and how your method of instruction affects them. Bartley and Milner (2011) again stated that the hope of any teacher is that their instruction will reach all their students in a way that the students' attitude towards the teacher's specific subject and education in general, will be altered to the point that the students truly enjoy the learning process. One of the many goal's teachers have is to improve students' attitude in science and even further valuing the lifelong learning. Minds-on and Hands-on activities (active learning) methods of teaching can really improve students' attitude towards school and learning in general. Suwondo and Wulandari (2013) stated that Inquiry based learning possesses a wide opportunity for students to develop their scientific attitude to the better, cultivate the fundamentals of scientific thinking in students, this will generate their creativity in solving problems. It is important to give students the opportunity to develop a scientific attitude and be cognizant of what they learning. The results of the two-year study of a biostatistics course showed that inquiry-based active learning was able to establish better scientific attitudes in the students (Suwondo & Wulandari, 2013).

Minds-on and Hands-on activities (active) learning also can make the classroom learning enjoyable. By engaging students, we can show them how much fun learning and particularly science can be. DeWitt (2013) indicated that students have trouble understanding the main idea when only using a textbook, the language is often incomprehensible. By using things and other than lecture and reading the textbook teachers can help students to achieve a new level of learning. Even more than that, they can enjoy what they are learning and be able to apply it to the real world. Some people may argue that minds-on and hands-on (active) learning takes away from the amount of content a teacher can get through or it's not real learning. DeWitt (2013) indicated that the "Cult of seriousness" and how specifically in the scientific community it is frowned upon to use fun or engaging stories, it won't be taken seriously, it is not scientific enough. These ideas are also found in the TEDTalk from Lotto and O'Toole, "true science education gives people a voice and everyone has the potential to discover something new, a small question can lead to a big discovery and change the way someone thinks" (Lotto & O'Toole, 2012).

Minds-on and Hands-on activities (Active) learning also increases students' metacognition. Metacognition is awareness of ones thought process or the learning process. If students are cognizant of what they are learning they are engaged in higher ordered thinking and will make better connections to old material and new material. Johnson and McCoy (2011) stated that students in traditional courses reported weaker cognitive and affective and social gains than students in inquiry-based learning courses and they also found instructions to be less helpful. The students benefited in a positive manner from active learning instructions including positive social, affective and cognitive gains. The students who were in a traditional lecture classroom showed negative changes in motivation and beliefs between the beginning and the end of the course (Johnson & McCoy, 2011). Prince (2004) stated that good activities are designed around important learning outcomes and promotes thoughtful engagement and encourage students to think about what they are learning. The minds-on and Hands-on (active learning) activities that can get students to recognize what they are learning and how they are learning most effectively really hit the bullseye of effective education. Students will reach high order thinking and be more likely to retain the information and apply it for future use. The active learning method also allowed the students to demonstrate ownership of their learning which is essential to foster life-long learning skills in students (Johnson & McCoy, 2011). By students being more aware of their learning abilities they begin to take ownership of their knowledge. This has many positive effects on the student and their learning abilities. This will allow them to really develop their skills for learning and improve their chances for success in high school and higher education. Ultimately the aim of any teaching is to increase student achievement. Active learning increases students' achievement in classes in several ways. Suwondo and Wulandari (2013) indicated that the improvement of student's achievement was associated with the change in instructional design (active learning) implanted in lectures.

Minds-on and Hands-on (active) learning including small group learning has many benefits. If a student does not understand a concept, question or problem they can help each other. Peers are able to break down difficult concepts into easier terms that their classmates may be able to understand. Bartley and Milner (2011) stated that the students showed positive feelings for such interactions with peers, high quality peer-relationships are critical element in the development and socialization of adolescents. By talking to their partners or groups about a question or problem they can build information off of one another and are more likely to solve problems. They also help each other and that collaborative effort can allow for essential growth in the learning process. The group approach allows students to generate ideas, use language, learn from each other and recognize that their thoughts and experiences are valuable and essential to new learning. Small group work is also very beneficial in getting all students in a class to participate, it breaks the class into smaller units and allows some of the shyer students to speak up. Bartley and Milner (2011) viewed that more students can participate in the discussions and can express themselves more candidly, making students more comfortable with one another and their environment. Small group work also improves team work and builds critical skills that students need to be successful in the work force.

2.1.7 Influence of gender on students' achievement in biology

Gender is a social term that is set to differentiate males and females in terms of their different roles and responsibilities. Gender appears more often in recent science education researches. This may be an attempt to find ways of closing the gap between the participation rates of the two sexes in science education.

Akinsola and Igwe as cited by Eze (2008) are of the opinion that, gender issue is a pertinent factor in educational setting in Nigeria and could be a factor that leads to low achievement of learners in biology and for that matter, excretory system.

It has also been observed that there is a narrow participation of females in science and technology courses as well as the number holding professional career in science and technology. Eze (2008) pointed out that, a number of alternatives explanations have been proposed for the gender inequalities in science and technology. Such explanations among other things include:

i. Biological determinism: This explanation proposes that an inequality in science and technology is sex-linked. It is a biological inheritance. This states that, spatial ability is sex-linked in favour of males while verbal expression is sex-linked in favour of females. This claim is debunked by Okeke as cited by Eze (2008), who proved that statistics on ground has shown that so far there is no biological evidence that males have intrinsic superior intellectual abilities over females.

ii. School Type: This factor examines single sex school type versus coeducational types. It is argued that the type of school females attended directly influence their interest and performance in science subjects. This argument initially tilted in favour of girls in single sex schools as being more advantaged in science than females in coeducational schools. Seaker as cited by Eze, (2008), claims that the praise showered on single sex schools for their education of females is particularly related to the fact that they are single sex schools, but which ability exposed them to better learning conditions should also be considered. In Nigeria for instance, most unity schools are federal government schools which attracts females from upper class background (children from rich parents) and may be the student's characteristic of good home background that is responsible for their fostered enrolment and performance in science in single sex schools and not because they are single sex. Nkpa as cited by Eze (2008) therefore concluded that the issue of single sex school fostering enrolment and performance of girls is being challenged. Further research is then needed to settle their debate.

iii. Teacher Influence: Teacher-influence can be observed on the gender of the science teacher, the expectations of the teacher and the classroom interaction of the science teacher with the students. There is a preponderance of male science teachers in most part of the world including Nigeria and Ghana, thereby making science appear masculine. Observation showed that, culture has a lot to play in this imbalance in most parts of Ghana. People initially looked down on the education of females and females have to go to school first before they can decide whether to go for science subjects or not. But with more females in school, more female science teachers are coming on.

From these analyses, teaching method used by teachers would affect male and female learners differently. Suitable teaching method initiates interaction between the teacher and the students in the class and the methods used may set a learning environment that is not equally conducive for the sexes. Students' participation is essential to learning and students that are actively involved may learn more. One of the aims of this study is to find the effective method that gives both females and males equal opportunity to understand excretory system.

2.2 Theoretical Framework of the Study

The theoretical work done was focused on the following theories of learning; behaviourists', constructivists', cognitivists', experientialists' and connectivists' views on learning.

2.2.1 The Contributions of Behavioural Theories to Learning

First of all, behaviour is composed of reactions and movements that an organism gives and does in a certain situation. The term, behaviour is mostly used for actions that can be observed from outside. Behaviourist learning approach mostly focuses on how behaviours are acquired. Behaviourist approach claims that learning can be develop by means of establishing a connection between stimulus and behaviour, and that any behaviour can be changed through reinforcement.

In other words, behaviourist learning theories emphasize changes in behaviour that result from stimulus-response associations made by the learner. Behaviour is directed by stimuli. An individual selects one response instead of another because of prior conditioning and psychological drives existing at the moment of the action (Parkay & Hass, 2000). Behaviourists assert that the only behaviours worthy of study are those that can be directly observed; thus, it is actions, rather than thoughts or emotions, which are the legitimate object of study. Behaviourist theory does not explain abnormal behaviour in terms of the brain or its inner workings. Rather, it posits that all behaviour is learned habits, and attempts to account for how these habits are formed.

In assuming that human behaviour is learned, behaviourists also hold that all behaviours can also be unlearned, and replaced by new behaviours; that is, when a behaviour becomes unacceptable, it can be replaced by an acceptable one. A key element to this theory of learning is the rewarded response. The desired response must be rewarded in order for learning to take place (Parkay & Hass, 2000). Behaviourists address learning as a mechanic process and give particular importance to objectivity.

According to behaviourists, people are not good or bad from birth. Experiences and environment constitute a human’s personality. According to them, human brain can be compared to a black box. Neither can we know what is going on in this black box nor do we need to know it. What is important is not what is happening in this black box, but what is important is what goes in this black box (input) and what comes out of it (output). Outputs are objective, observable and measurable. Inputs and outputs can be adjusted, arranged and controlled. What is important is not the senses of a person, but the reflection of them.

For instance, Miltenberger (2001) claimed that behaviour is what people say and do. The theory of behaviourism concentrates on the study of overt behaviours that can be observed and measured (Good & Brophy, 1990). This theory also viewed the mind as a "black box" in the sense that response to stimulus can be observed quantitatively, totally ignoring the possibility of thought processes occurring in the mind. Behaviourists believe that all theories should have observable processes such as actions. For them, only overt behaviour should be studied and recorded because inner states like motives or mental states cannot be measured objectively. The pioneers of behaviourist approach are I. Pavlov, J.B. Watson, E.L. Thorndike, E.R. Guthrie and B.F. Skinner.

One of the pioneers of behaviourist approach personalities who has a major contribution to the development of the theory of behaviourism is the Russian psychologist known as Pavlov (1849-1936). Indeed, this name rings a bell in most people's minds. According to Dembo (1994) Pavlov is best known for his contribution to the theory of behaviourism mostly through his work in classical conditioning or stimulus substitution. Pavlov's most famous experiment involved a dog, food and a bell. In his experiment; before conditioning, ringing the bell caused no response from the dog. Placing food in front of the dog enabled it to salivate. During conditioning, the bell was rung a few seconds before the dog was presented with food. After conditioning, the ringing of the bell alone produced salivation. Therefore, from Pavlov's experiment four stimulus and response items can be distinguished. It can be stated that the 'food' is an unconditioned stimulus, 'salivation' is an unconditioned response because it’s natural or not learned, the 'bell' is a conditioned stimulus and finally ‘salivation’ is a conditioned response only to the bell.

The above observations are not the only ones made by Pavlov as there are others that resulted from the second phase of his experiment. Evident from the second phase of his experiment are terms such as 'stimulus generalisation'. Here he states that after learning to salivate to the sound of the bell, the dog can still salivate at similar sounds. The other observation he made is known as 'extinction'. The principle at play here is that if the pairing of the bell and food is stopped, salivation in response to the food eventually ceases. Under 'spontaneous recovery', he states that extinguished responses can be recovered but can be extinguished again if the dog is not presented with food. Furthermore, under 'stimulus discrimination', the dog could learn to discriminate between similar bells or stimuli hence able to know which bell would result in the presentation of food and which would not. Finally, 'higher-order conditioning' is yet one of the discoveries made by Pavlov. Here when the dog is conditioned to associate the bell with food, a different unconditioned stimulus can be presented at the same time as the conditioned bell. This later enables the dog to salivate at the new unconditioned stimulus alone. In this case, it also becomes a conditioned stimulus.

Another major contributor to the development of the theory of behaviourism is Thorndike (1874-1949). He is best known for his emphasis on the application of the methods of 'exact science' to educational problems. Due to this, he advocated for an accurate quantitative treatment of information. In line with Thorndike's notion concerning accurate quantitative treatment of information, Rizo (1991) argues that "anything that exists, exists in a certain quantity and can be measured". His major contribution to behaviourism is his theory of 'connectionism', which states that learning involves the formation of a connection between stimulus and response (Dembo, 1994). Later, Thorndike developed three laws based on his stimulus-response hypothesis. The first of these laws is the 'law of effect' which states that the connection between stimulus and response is strengthened when it is positively rewarded and weakened when negatively rewarded. The second law is the 'law of exercise'. Central to this law is the premise that the more the stimulus response (S-R) bond is practiced, the stronger it becomes. The third and last law developed by Thorndike is the ‘law of readiness’ which holds that due to the structure of the nervous system, some conduction units, in given situations are more predisposed to conduct than others. According to Saettler (1990) Thorndike was convinced that a neutral bond would be established between the stimulus and response when the response was positive. Another aspect central in the work of Thorndike is that learning takes place when the bonds between stimulus and response are formed into patterns of behaviour.

Probably the most influential of all the founding fathers of behaviourism is Watson (1878-1958). In line with the other behaviourists, Watson argued for the value of psychology which concerned itself with behaviour in and of itself, not as a method of studying consciousness. This was a major break from the introspective methods of structuralise psychology which considered the study of behaviour valueless. According to Kazdin (2001), Watson studied the adjustment of organisms to their environments, more specifically the particular stimuli leading organisms to make their responses. Influenced by the ideas of Pavlov, Watson held the view that behaviour is established through stimuli-response associations through conditioning. He demonstrated classical conditioning in an experiment involving a baby called Albert and a rat. Initially, when he presented the rat to Albert, he was not afraid in that he actually touched it. Afterwards Watson created a sudden loud noise which Albert was afraid of whenever he presented the rat to him. Since little Albert was frightened by the loud noise, suddenly he became conditioned to fear and avoided the rat. The fear Albert developed for the rat was generalised for other small animals. At the end of the experiment, Watson extinguished the fear by presenting the rat without the noise to Albert. Hence, from the experiment above, we see a confirmation of the claim made by Mergel (1998) that Watson believed that humans are born with a few reflexes and emotional reactions such as those of love and rage. It is important to state that Watson is credited with coining the term 'behaviourism'.

An account of the development of behaviourism cannot be complete without mentioning the contributions of Skinner (1904-1990). Like other behaviourists, Skinner also believed in the stimulus-response pattern of conditioned behaviour. It is worthy stating here that operant conditioning is a process both named and investigated by Skinner. The term 'operant' means how behaviour operates on the environment. Operant conditioning operates on the principle that behaviour may result either in reinforcement, which increases the likelihood of that behaviour to be repeated or punishment, which decreases the likelihood of the same behaviour to be repeated in future. According to Good and Brophy (1990), Skinner's major contributions to behaviourism are his operant conditioning mechanisms. Operant conditioning mechanisms involve Skinnerian concepts such as 'positive reinforcement' or 'reward', 'negative reinforcement', 'extinction' or 'non-reinforcement' and 'punishment'. Skinner has made a lot of major contributions to the development of behaviourism. For instance, according to Dembo (1994) in his 1958 book entitled *Walden two,* he explores an imaginary society based on operant conditioning. Skinner (1958), in his book entitled *Science and Human Behaviour* vividly points out how the principles of operant conditioning function in social institutions such as government, law, religion, economics and education. Although Skinner was a behaviourist, he is also known to be a radical behaviourist. This is because he departs from the methodological behaviourism most notably in accepting treatment of feelings, states of mind and introspection as existent and scientifically treatable. Finally, attention is also accorded to some weaknesses of the theory of behaviourism are discussed as outlined by the critics of the theory in the educational fraternity.

2.2.1.1 Some contribution of Behaviourism to Education

Since education is an act of teaching and learning, then it can be stated here that learning takes a pivotal role in the whole educational process. Learning can then be defined differently depending on which perspective one takes in defining it. The complex process of learning is defined according to behaviourism, cognitivism and constructivism. According to a behaviourist, learning can be defined as “a relatively enduring change in observable behaviour that occurs as a result of experience" (Eggen & Kauchak, 2001). Although the cognitive theorists accept most behaviouristic concepts, they define learning differently. They view learning as the acquisition or reorganisation of cognitive structures through which human beings process and store information (Good & Brophy, 1990). Moreover, learning for the constructivists is the construction of personal perceptions of reality according to one's personal experiences (Jonasson, 1991). It can be stated here that although learning is defined differently, the overall objective of it is some form of behavioural display by the learner. We see that for the behaviourists, learning is said to have taken place when the learner shows change in behaviour. For the cognitive theorists learning occurs when the learner portrays the behaviour of ability to process cognitive structures. We also see that for the constructivists, the final end of the construction of personal perceptions of reality is some particular behavioural disposition that goes with the way one perceives reality. Therefore, it can be stated with confidence that the whole educational complex process of learning is anchored on behaviourism in one way or another.

Essentially, another aspect that can be perceived as a contribution of behaviourism to education is the use of lesson objectives during the instructional process. It is vital to state that learning objectives are actually behavioural objectives in that they set standards on how the learners are expected to behave at the end of the learning experience. Behavioural objectives show the overall purpose of any learning experience such that without them, a lesson can be said to have no direction or an intended goal. A behavioural objective states learning objectives in "specified, quantifiable, terminal behaviours" (Saettler, 1990). Moreover, the ABCD mnemonic device is used to sum up behavioural objectives (Schwier, 1998).

Another contribution made to education by behaviourism is the behaviouristic belief that the teacher has the duty to create a favourable environment for learners. Hence, teachers who accept this behavioural perspective believe that the behaviour of students is a response to their past and present environments and that all behaviour is learned. To enable effective learning, the teacher should control the learning environment in order to ensure that the environment is conducive for learning. This emphasis on the importance of the teacher in ensuring a favourable learning environment is highlighted by Skinner (1968) when he states that;

> *the application of operant conditioning to education is simple and direct. Teaching is the arrangement of contingencies of reinforcement under*

> *which students learn. They learn without teaching in their natural environments, but teachers arrange special contingences which expedite learning, hastening the appearance of behaviour which would otherwise be acquired slowly or making sure of appearance of behaviour which otherwise would never occur.*

It should also be stated that in their endeavour to create a favourable environment for learning, teachers are advised by behaviouristic principles to reinforce appropriate behaviours only and extinguish inappropriate behaviours. Skinner (2014) viewed the teacher's job as modifying the behaviour of students by setting up situations to reinforce students when they exhibited desired responses, teaching them to exhibit the same response in all such situations. These behavioural principles underlie two well-known trends in education: behaviour modification techniques in classroom management and programmed instruction. Although current use of programmed instruction is limited, its principles form much of the basis of effective drill and practice and tutorial courseware. The maintenance of a favourable environment for learning by the teacher is not only advocated for by Skinner but many other behaviourists as well. They stress the importance of a favourable environment in fostering effective learning. For instance, the point above is clearly evident in Darby (2003) when she states that;

> *classical conditioning suggests maintaining a positive environment, or the possibility arises of pupils developing a negative attitude towards a subject because of the unpleasant feelings associated with how it was learned.*

A controlled environment was considered by Skinner to be the prerequisite for total behaviour modification. Therefore, the emphasis on the importance of maintaining a favourable learning environment in school contexts is a behavioural contribution to education.

The use of 'behaviour modification' in the classroom is yet another vital contribution of behaviourism to education. Congelosi, (2000) claimed that behaviour modification refers to the behaviourist approach by which students' environments are manipulated to increase the chances of desired behaviours being rewarded while undesired behaviours go unrewarded. We therefore see that through behaviour modification, students are thus conditioned towards being on task in the class room. There are different behaviour modification methods used in the classroom. For example, student behaviour can be modified through shaping, chaining, extinction, positive and negative reinforcers, discipline plans and token economies (Eggen & Kauchak, 2001). These behaviour modification methods are common practices in elementary schools. The most widely used methods are the two types of reinforcers above (positive and negative reinforcements) and token economy.

In case of positive and negative reinforcers, Skinner highlighted the importance of generalised reinforcers such as giving praise, stars and points to the student immediately after their performance of desired behaviours. This enables students to repeat the desired behaviour. In line with reinforcement, he discouraged the use of punishment in class in favour of merely ignoring inappropriate behaviour as the best way of extinguishing it. Behaviourists believe that punishment is less effective in terms of terminating inappropriate behaviour because it only suppresses behaviour temporarily (Darby, 2003). Moreover, the removal of punishment allows the behaviour to reappear. Furthermore, we see that punishment is also known to have unpleasant side-effects such as group hate and group unhappiness. Token economy is simply a system of exchange. Here the teacher offers a reward to a student when desired behaviours are attained as a conditioned reinforcer. The teacher has to be committed to dispense tokens quickly after desired behaviours. Tokens can be things such as stickers, money and so on. In any educational context, it is very important to assess the learners. We see that this fundamental educational technique is based on the principles of behaviourism. Since from a behaviourist perspective, we defined learning as 'a relatively enduring change in observable behaviour that occurs as a result of experience' (Saettler, 1990). It therefore follows that assessment or indeed evidence of learning must be some capturing of that change. Hence, assessment is a purely behavioural activity because its main objective is to show whether there has been change in the learner's behaviour after a learning experience. Without the behavioural educational technique of assessment, it would be very difficult to know whether learning has taken place. Students should be assessed by observing behaviour. Educators cannot assume that students are learning unless they observe that behaviour is changing through assessment. Assessment therefore acts as a vital instrument through which educators can receive feedback vis-a-vis progress of learning in the classroom.

It can also be stated that behaviourism has made a major contribution to education in the area of teaching methods. According to Driscoll (2000), one major contribution of behaviourism to education is the use of the 'drill and practice methodology' during the instructional process. The central principle in this teaching methodology is that the teacher presents the stimulus to the learners and what is expected from the learners is to respond to it through constant practice. This teaching method is commonly used in language lessons where it is known as the' audio lingual method'. Here, the teacher presents the stimulus to the learners in form of a word inscribed on the black board and reads it aloud. The learners are expected to actively respond to the stimulus by reading the word after the teacher in a chorus form repeatedly until the time they are told to stop doing so by the teacher. In this context, the intention is to make the word sink in the minds of the learners. It is believed that in the 'drill and practice' teaching method, the repetition of the stimulus response habits can strengthen those habits. This belief is also evident in yet another belief among educators that the best way to improve reading is by encouraging students to read more and more in order to strengthen the link between the stimulus (material to be read) and the response (ability to read).

The Pavlovian classical conditioning is not an exception to but an exemplification of several educational implications. As pointed out earlier that if learning is indeed the goal in any classroom, educators need to create an environment conducive to learning. Classical conditioning advocates for the creation of an environment conducive to learning. The point at hand comes out clearly in Edwards (2000) under the sub heading 'educational implications of classical conditioning' when he states that "students should experience academic tasks and contexts that cause or encourage pleasant emotions". The implication of this is that students should be able to feel enthusiasm, excitement or enjoyment in their learning context rather than being in contexts that cause anxiety, disappointment and anger. In the classroom context, mathematics anxiety is a good example of classical conditioning that can be mitigated with classical conditioning. Focusing more specifically on academic learning in terms of the 'content' of the lesson, we see that the theory of behaviourism has made some fundamental contributions to education through Thorndike's 'Theory of Transfer of Identical Elements'.

Thorndike's theory represented one of the most important behavioural principles is the amount of learning that can be generalized between a familiar situation and an unfamiliar one is determined by the number of elements the situations have in common (Schweiso, 1989).

Thorndike concludes in his theory that education does not easily generalise what is taught to the learners. He further stresses that if education is to be preparation for life beyond the school, it should be as life-like as possible. His theory has had a tremendous influence in the introduction of life or social oriented themes in most subjects on the school curriculum. Moreover, he encouraged educators to introduce skills to learners when they are still conscious of their ability to perform them correctly. The best time for this is usually after positive reinforcement. The behavioural experiments of Skinner are seen as a highly rich source of educational implications. We see that regarding the lesson material, Skinner specified that to teach well, educators must decide exactly what it is they want to teach (Darby, 2003).

It is only then that they can present the right material to the learners and know what responses to look for. When educators present the right material to the learners' they can know what responses to look for and hence know when to give reinforcement that usefully shapes behaviour. Skinner (1968) advocated for effective learning in school institutions. In his endeavour to ensure effective learning in schools, he suggests three principles to be used by teachers when he stated that; information to be learned should be presented to the learners in small behaviourally defined steps ... rapid feedback should be given to pupils regarding the accuracy of their learning and that pupils should be allowed to learn at their own pace.

We also see that building on the three principles, Skinner proposed a different teaching method which he called 'programmed learning or instruction' and a 'teaching machine' that would present programmed material. Two techniques of teaching emerged from programmed learning. The first is the linearly structured technique where all pupils follow the same sequence of learning steps and the second technique involves the creation of different paths for different pupils according to their answer at each frame. It is vital here to state that studies have shown that both teaching techniques are as effective as conventional teaching (Schunk, 1996). From the programmed instruction portrayed above, it is evident that based on operant conditioning, Skinner's teaching machine requires the learner to complete or answer a question and then immediately receive feedback on the correctness of the response.

In school contexts, there are a number of issues that affect the educational achievement of the learners. One of the issues that has a direct impact on the educational achievement of the learners is lack of self-esteem. According to Blascovich and Tomaka (1991), self-esteem is an individual's sense of his or her value or worth, or the extent to which a person values, approves of, appreciates, prizes or likes him or herself.

The problem of lack of self-esteem in schools is most evident in maladjusted children. A maladjusted child is "continually seeking help in gaining self-esteem and a feeling that somebody cares about him" (Wheldall, 1981). In order to give such children more direct help in terms of enhancing their self-esteem, educational psychologists have turned to behavioural techniques. According to De Klyen (1976), research has provided evidence that behavioural changes brought about by the use of behaviour modification produces higher self-steem in maladjusted children. The major findings from research with maladjusted children show that a substantial and sustained increase in positive reinforcement enhances self-esteem as reflected in both verbal reports of self-esteem and overt behaviours considered to be related to self-esteem. Reinforcement is defined as anything which increases the probability of a response or particular behaviour (Green

& Hicks, 1984). Moreover, we see that positive reinforcement occurs when something rewarding happens after the behaviour. Therefore, in the case at hand, we see that maladjusted children in schools are beneficiaries of a behavioural modification technique of positive reinforcement.

2.2.1.2 Weakness of Behavioural Theory of Learning

Despite its great positive contributions to education, the theory of behaviourism is not an exception to some critical responses from different scholars in academia. For instance, in educational contexts the use of generalised reinforcers such as the giving of praise, stars, points, tokens and so on can be useful but just like other methods of behaviour modification, can have its own failures. It is believed that external rewards may create some unexpected problems in the classroom because they "may undermine intrinsic motivation and cause children to lose interest in learning without rewards being supplied" (Edwards, 2000). Some critics of behaviourism have argued that it is very difficult for a teacher to give constant reinforcement to one particular student because there are too many other students in the classroom in need of the teacher's reinforcement. It is also common for critics to argue that behaviour modification techniques ignore the causes of behaviour. This is because behaviour modification techniques only focus on how behaviour can be changed or completely extinguished. Moreover, one requirement for negative reinforcement is the presence of the disliked activity in order for the child to be excused from it. Here the problem is that the disliked activity might have negative effects upon the child, as in the case of punishment (Darby, 2003).

From a humanist perspective, behaviourism is found wanting in the area of the relationship between the teacher and the pupil. This is because behaviourists believe that the teacher knows best when to decide what is rewarded or punished. The teacher justifies his or her actions as being in the interest of the child. To the humanists, the behaviourist relation between the teacher and the pupil is unequal therefore contrasts with the humanist approach. Behaviourism as a theory in itself has been criticised of lacking detail in its account of the learning process. For instance, Bransford et al. (2000) argued that;

> *behaviourism does not capture the complexity and breadth of learning and it fails to acknowledge the subjective, creative and intuitive dimensions and prior learning.*

Due to the above, behaviourism cannot stand on its own as a theory of teaching. Hence, it is best used in conjunction with other methods. Moreover, since behaviourism is based on memorisation of tasks by the learner, it is not useful in the teaching of complicated subject matter. This is because a learner cannot rely on memorisation in the learning of complicated subject matter. The point here is that behaviourism is not appropriate for all subject matter.

2.2.2 Contributions of Cognitivists Theory to Learning

The genesis of cognitivist as a learning theory can be traced back to the early twentieth century. The shift from behaviourism to cognitivist stemmed from the behaviourist tradition’s failure to explain why and how individuals make sense of and process information (i.e., how the mental processes work). The works of Edward Chase Tolman, Jean Piaget, Lev Vygotsky, Jerome Bruner, and German Gestalt psychologists were instrumental in engendering the dramatic shift from behaviourism to cognitive theories. Edward Tolman is usually considered a pioneer in initiating the cognitive movement (Bruner, 1990). These cognitive psychologists investigated mental structures and processes to explain learning and change in behaviour. Like behaviourists, they have also observed behaviour empirically but only in order to make inferences about the internal mental processes. As opposed to behaviourist orientation's emphasis on behaviour, the cognitive school focuses on meaning and semantics (Winn & Snyder, 1996). The primary emphasis is placed on how knowledge is acquired, processed, stored, retrieved, and activated by the learner during the different phases of the learning process (Anderson, Reder, & Simon, 1997; Greeno, Collins, & Resnick, 1996).

The cognitive school views learning as an active process "involving the acquisition or reorganization of the cognitive structures through which humans process and store information" and the learner as an active participant in the process of knowledge acquisition and integration (Good & Brophy, 1990; Merriam & Caffarella, 1999; Simon, 2001). This theory describes knowledge acquisition as a mental activity involving internal coding and structuring by the learner (Derry, 1996; Spiro et al., 1992) and suggests that learning happens best under conditions that are aligned with human cognitive architecture (Sobel, 2001).

Piaget explored the genesis of cognitive structures and the process that underlies learning and knowledge construction. Trained as a biologist, Piaget later shifted his interest to how human beings make sense of their environment and experience. The key notions that Piaget employed to elucidate his cognitive theory basically derive from biological concepts. According to Piaget, the process of intellectual and cognitive development resembles a biological act, which requires adaptation to environmental demands (Gillani, 2003). Having done a large number of experiments to explore the ways children think, Piaget argued that children do not passively receive environmental stimulation. Rather, they actively seek it, naturally exploring and acting on their world in order to understand it (Bransford, Brown, and Cocking 2000; Fox 2001). Piaget's studies and ideas focused on the mechanism of learning within the context of natural sciences instead of the type of logic that learners use (Booth, 1994; Fosnot 1996). He posited that the biological maturation that human beings go through causes distinct stages in cognitive development.

According to Piaget, the mechanism of change in cognition is equilibration, which is a dynamic interplay of progressive equilibrium, adaptation and organization, and growth and change in the master developmental process (Fosnot, 1996; Ho, 2004). Once encountered with a new learning situation, the individual draws on his or her prior knowledge to make the new experience understandable (Gillani, 2003). The concept of schema occupies a central place and has an explanatory power in Piaget's theory. Schema2 refers to a hypothetical mental structure for organizing and representing generic events and abstract concepts stored in the mind in terms of their common patterns. They can be considered "as a series of interrelated index cards that represent different environmental patterns in one's mental structure" (Gillani, 2003). Schemata constantly get restructured as one encounters new patterns in his or her learning experiences. Three processes characterize the schemata acquisition and the changes in existing schemata:

1. accretion, which refers to remembering new information on the basis of existing schema without altering the schema;
2. tuning, which happens when new information that does not fit the existing schema causes schema to get modified in order to be more compatible with experience; and

3. reconstructing, which is characterized by the formation of totally new schema on the basis of previous ones that cannot accommodate new experience (Rumelhart & Norman 1978).

While Piaget attempted to study and explain learning in terms of the role of contradiction and equilibration, Vygotsky explained learning by means of dialogue (Fosnot, 1996). Another key difference between their works is that while Piaget explored the development of logical thinking, Vygotsky focused on categorical perception, logical memory, conceptual thinking, and self-regulated attention (Gredler, 1997). In contrast to Piaget's assertion that children's development must precede their learning, Vygotsky posited that social learning is likely to precede development. Vygotsky's social cognition learning model views culture as playing a key role in the development of cognition. Vygotsky' s study of learning concentrated on the interplay between the individual and society, and how social interaction and language come into play in affecting learning or the development of cognition (Fosnot, 1996; Gredler, 1997; Jarvis, Holford, and Griffin, 2003; Schunk, 2004). Vygotsky's work on social cognition was further explored in subsequent works by other psychologists who developed the notion of scaffolding (Fosnot, 1996)

2.2.2.1 Implications of Cognitivism for Classroom Practice

Instruction based on cognitive principles should be authentic and real. The teacher is expected to provide a rich classroom environment that fosters a child's spontaneous exploration. Students are encouraged to explore instructional materials and to become active constructors of their own knowledge through experiences that encourage assimilation and accommodation (Wadsworth, 1996). Teaching is tailored to the needs, interests, and backgrounds of students (Fenstermacher & Richardson, 2005; McLeod, 2003). The teacher is more concerned with constructing a meaningful context than directly teaching specific skills. From the cognitive perspective, because students learn by receiving, storing, and retrieving information, the teacher is urged to thoroughly analyse and consider the instructional materials, proper tasks, and relevant learner characteristics to help learners to effectively and efficiently process the information received (McLeod, 2003). Instructional materials should include demonstrations, illustrative examples, and constructive feedback so that students can have mental models to embody. Because information contained in instructional material is first processed by working memory, for schema acquisition to occur instruction should be designed to reduce working memory load and to facilitate the changes in the long-term memory associated with schema acquisition (Sweller, 1988). In order to activate and utilize schema for learning, Barton states that the learner should be "made aware of his background knowledge and exposed to strategies to 'bridge' from pre-requisite skills to learning objectives" (McLeod, 2003). The teacher also is expected to have a set of schemata for instructional activities in order to adroitly handle interactions between disparate goals and activities. "These schemata include structures at differing levels of generality, with some schemata for quite global activities such as checking homework and some for smaller units of activity such as distributing paper to the class" (Leinhardt & Greeno, 1986). The teacher uses advanced organizer techniques to help students understand and organize ideas, concepts, themes, issues, and principles (Marzano, 1998). Students are encouraged to use metacognitive strategies such as goal specification, process specification, process monitoring, and disposition monitoring (Marzano, 1998)

To help students' process information effectively and efficiently, the teacher needs to employ the following strategies and principles when teaching their subjects:

- Provide organized instruction. Make the structure and relations of the material evident to learners through concept maps or other graphic representations. In multimedia instruction, present animation and audio narration (and/or text descriptions) simultaneously rather than sequentially.
- Use single, coherent representations. These allow the learner to focus attention rather than split attention between two places, for example, between a diagram and the text or even between a diagram with labels not located close to their referents.
- Link new material with what is currently known. This provides a sort of mental "scaffolding" for the new material.
- Carefully analyse the attention demands of instruction. Count the number of elements in instructional messages. Make sure that the learner will not attend to too many different elements at the same time.
- Recognize the limits of attention (sensory register). Help learners focus their attention through techniques such as identifying the most important points to be learned in advance of studying new material. Recognize the limitations of short-term memory. Use the concept of chunking. Do not present 49 separate items. Make them 7 groups of 7. Use elaboration and multiple contexts.
- Match encoding strategies with the material to be learned. For example, do not encourage the use of mnemonic techniques unless it is essential to memorize the material. If you want it to be processed more "deeply," then find encoding strategies that are more inherently meaningful.
- Provide opportunities for both verbal and imaginable encoding. Even though it is not clear whether these are actually two different systems, imaging does help students remember.

- Arrange for a variety of practice opportunities. The goal is to help the learner generalize the concept, principle, or skill to be learned so that it can be applied outside of the original context in which it was taught. Provide for systematic problem-space exploration instead of conventional repeated practice. Provide worked examples as alternatives to conventional problem-based instruction.
- Eliminate redundancy. Redundant information between text and diagram has been shown to decrease learning.
- Help learners become "self-regulated." Assist them in selecting and using appropriate learning strategies such as summarizing and questioning (Perry, 2002; Wilson, 1995).

Basic characteristics of a classroom instruction based on cognitive theories can be summarized as follows:

- Emphasis on the active involvement of the learner in the learning process (learner control)
- Metacognitive training (e.g., self-planning, monitoring, and revising techniques)
- Use of hierarchical analyses to identify and illustrate prerequisite relationships (cognitive task analysis procedures)
- Emphasis on structuring, organizing, and sequencing information to facilitate optimal processing (use of cognitive strategies such as outlining, summaries, synthesizers, advanced organizers, etc.)
- Creation of learning environments that allow and encourage students to make connections with previously learned material (recall of prerequisite skills; use of relevant examples, analogies) (Ertmer & Newby, 1993)

2.2.3 Contributions of Constructivists Theory

Constructivism as paradigm or worldview hypothesize that learning is active and constructive process. Information received by the learner is constructed throughout the journey of learning. According to this theory, people will actively construct knowledge according to their own understanding about reality. New information is linked to a previous knowledge thus mental representation are subjective (Applefield et al., 2001). A major theme in Bruner's constructivist theory is that learning is an active process, whereby students learn best by constructing new ideas and building new schemas based upon current and past knowledge. The cognitive processes behind this construction draw heavy influence from cultural and social aspects of students' lives, implementation of rewards and punishments, and students' motivation to learn the material. Educational models that utilize constructivist theory consider these influences and attempt to match education systems and curricula to each socio culturally distinct group of students. They also build programs and train instructors to encourage students to discover principles on their own, using the knowledge they already have to embrace and internalize information (Mos, 2003). Traditional education models, however, do not employ these techniques and are based on out dated educational theory. With socio-cultural diversity being an ever-growing issue for educators and educational system designers, constructivist education models should be more widely used in education.

2.2.3.1 Bruner's Constructivist Theory

The main theme inherent in constructivism is that people learn by constructing new ideas and concepts by interpreting them through comparison with previous knowledge. People attribute meaning to new ideas, and this process represents learning (Hein, 1991). This implies that learning is not about simply being exposed to new information but is an active process whereby learners examine, code, decode, and interpret new concepts and ideas. Learners select and transform information, construct “hypotheses,” and rely on cognitive structures to build and refine their schemas (Kever, 2003; Mos, 2003). Broken down, Bruner emphasizes that people interpret their world through the similarities and differences between objects and events. Learners thus compare new ideas to the ones they already have and learn through the similarities and differences they find. A person’s socio-cultural background and situation play a highly important role in dictating what sorts of information that person will learn, as well as forming the cognitive processes that person uses to build and use schemas (Kever, 2003).

Piaget encouraged children to reason about the problem he posed to them. Through this, he discovered that younger children were not “dumber” than older ones, nor were they behind in any way. Younger children simply thought about things in a completely different way than did the older ones, because they have a conception of the world that is distinct from that of older children (Gardner, 1972). Piaget examined the differences between younger and older children’s cognition, and Bruner examines the differences between that of different cultures. These differences between cultures in this sense arise from necessity. All cultures develop habits, traditions, and activities adapted to their specific needs. These needs stem from environmental and many other factors, and the culture’s cognitive development and learning, as well as the relative strengths and weaknesses pertinent to creating and adapting schemas, are adapted specifically to help meet these needs (Glassman, 1996). This is the basic overview of how people’s environments and cultures play key roles in their cognitive development, and this paper will now discuss some aspects of Bruner’s constructivism that more directly relate to education.

2.2.3.2 Constructivist Educational Design Models

Constructivist educational models address the same three education issues in completely different ways than traditional models. Constructivist teaching methods are student-centered, not instructor-centred. Where traditional education models emphasize direct transfer of information from instructor to student, constructivist models emphasize less instructor participation and much more student action. In fact, constructivist education is based on students' work, rather than that of instructors (Schuh, 2003). Constructivist classes are made up of small groups, usually comprising between five and 16 students and one instructor. The main idea is that the instructor will help students develop effective course goals, and students work together to accomplish those goals. Such education is built upon discussion among students with only brief and necessary guidance from instructors. This implies that constructivist designers make use of a different approach than traditional educational designers. Also different from traditional models is the constructivist encouragement of student interaction and discussion. The major role that discussion plays results from Socratic learning theory, mentioned above. Aulls refers to such discussion as academic discourse and notes that substantive academic discourse facilitates students' exploration of curriculum topics and material. Such discussion is more than simple, mundane exchanges between instructors and students; it involves students talking about the subject and arriving at their own conclusions (Aulls, 2002). Instructors should not be interested so much in students' responses, but the way students arrive at and defend those responses. In this process, students display elements of scientific reasoning. One some level, all students should recognize problems, formulate hypotheses, construct mental models, research and test their hypotheses, adjust their mental models, and reach however, creates a large unpredictability factor for education designers. Constructivist designers embrace this factor in the design phase by keeping pre-specified content to a minimum and ensuring that instructors encourage students to actively seek their own knowledge sources to deepen and enrich their comprehension of the course material (Skaalid, 2003). What most constructivist designers do is formulate clear course goals, comprehension objectives that students should accomplish by the end of a course. These goals provide a structure and clear "measuring stick" for instructors while empowering students with as much academic freedom as possible. Indeed, this academic freedom most clearly illustrates instructors' role in constructivist education. The most important of constructivist instructors' tasks is keeping students on track and guiding them toward the accomplishment of course goals (Echevarria, 2003). Such goals also provide students with contextual frameworks that help them determine from which perspective they approach course material (Boekaerts, 1996). Another difference between traditional and constructivist course design is instructor involvement in the design process. Traditional designers usually perform the process without much interaction between themselves and course instructors. On the other hand, constructivist course designers usually work closely with instructors to ensure smooth design implementation and eliminate any nasty surprises that could hinder the learning process (Skaalid, 2003). In summary, constructivist teaching methodology is student-centered, emphasizes the ways students construct their knowledge, and encourages students to interact with each other as much as possible. These constructivist teaching methods require high student activity levels, and the corresponding learning methods reflect those levels. The most important constructivist learning method is problem solving. Petraglia maintains that effective constructivist education provides problems that students must handle like real-life problems and that people solve problems better through social cognition rather than alone. Constructivist course goals should provide realistic problems that elicit social cognition, facilitate student application of external knowledge sources, and encourage students to utilize scientific reasoning (Echevarria, 2003; Petraglia, 1998). Scientific reasoning is another learning technique that students employ in constructivist education. As mentioned above, students must formulate and test hypotheses, build and adjust mental models, and form conclusions based on the course material and their own research (Echevarria, 2003). Through this process and lack of excessive interference by instructors, students also develop self-regulation techniques. Common personal attributes associated with good self-regulation are heightened self-efficacy, willingness to participate, commitment, time management, and efficient strategy use (Boekaerts, 1996). In addition, the group work and cooperative discussions in constructivist education allow students to hone their communication and argumentation methods. These methods are more skills that students can use outside the classroom, and they reinforce social cognition (Aulls, 2002). Constructivist learning techniques not only help students learn as efficiently as possible, they also give students the opportunity to practice and perfect skills needed in real life. Since students have so much academic roaming area, constructivist educational designers cannot rely on objective, direct assessments the way traditional ones can. In order to remain flexible to meet the assessment needs of flexible curricula, constructivist instructors must assess their students with subjective, context-based techniques. The most common of these are essays and open-question exams. Instructors usually apply both types of assessment to single individuals, but they can also adapt essays to be worked in small groups. Essays and open questions force students to think outside the constrictions of multiple-choice tests and memorized responses. In keeping with constructivists' emphasis on students' argumentation and the ways they arrive at their responses, essays and open questions provide an excellent way for students to communicate their thoughts to instructors that traditional assessments do not provide (Jonassen, 2003). As discussed, constructivist teaching, learning, and assessment methodology all depends on high levels of student activity and is much more subjective than traditional methodologies. In addressing the second design issue, learning environment, constructivist education models are different from traditional ones in almost every aspect. Traditional learning environments are formal, promote distance retention between students and instructors, and discourage verbal activity by students. Constructivist learning environments, however, are usually more informal, promote close working relationships between students and instructors, and rely on verbal activity by students. As mentioned in the context of traditional learning environments, relationship building requires interaction between students and instructors. In constructivist classrooms, instructors see many aspects of students' personalities and can easily assess each student's communication, argumentation, and problem-solving skills. Students, in addition, are exposed to instructors' group leadership abilities and often senses of humor (Jonassen, 2003; Kever, 2003). These interactions form bonds that are impossible to form in traditional learning environments. These bonds also make students feel more comfortable in their academic environment, which builds confidence and boosts learning performance. This effect also comes from constructivist education's reliance on and encouragement of student discussion and activity. In traditional education settings, students are punished for expressing themselves at "inappropriate times" and often develop the feeling that their opinions are worthless or unimportant. This feeling can bleed over into real life and later the workplace, resulting in low self-esteem and reluctance to express opinions and views. In a constructivist educational environment, however, students are made to feel that their contributions are important and worthy of being expressed (Schuh, 2003). Constructivist educational models also approach the third common design issue more in-depth than traditional models. The third issue is integrating students' prior experience into course aspects, and constructivist models' key factor here is the student centered approach. Since their curricula and methodologies are not designed around instructors, but students, constructivist educational models are much more flexible and far easier to adapt than traditional ones. Discussion's conclusions with minimal guidance from instructors (Echevarria, 2003). This high student emphasis level, major role puts students in the spotlight and automatically brings previous experience to the fore. Whenever any students have extra knowledge about topics or problems, the constructivist learning environment encourages them to share their experience with the rest of the group, where all groups members can benefit from the knowledge (Mclnerney, Mclnerney, & Marsh, 1997; Schuh, 2003). In a more restrictive sense, prerequisite requirements (like in traditional educational models) installed in courses ensure that all group members can follow discussions and make worthwhile contributions to them. In short, constructivist educational models put forth student-centered methodologies, foster open, challenging learning environments, and highly integrate students' prior experience in the learning process.

2.2.3.3 Practical Application

This paper has shown that constructivist education models have already been successfully implemented, now it will explore some ways to convert traditional education systems into effective, constructivist ones. The first area of focus for improvement will be the traditional design process. Most traditional designers base their final curricula on available content material. This design strategy is constrictive for instructors and students and does not provide enough flexibility or adaptability. To remedy this, education designers should create less restrictive course goals and not focus excessively on course material. This method, as already mentioned briefly, both encourages students to seek out their own materials and provides enhanced flexibility for instructors to adapt curricula to different student groups and academic situations (Skaalid, 2003). Another common design error that traditional designers make is material oversimplification. The idea behind this simplification is to make the material easier to teach and to learn, but it actually strips away most of the material that should stimulate critical thinking in students. Instead of simplifying material, education designers should challenge instructors to devise more efficient discussion methods. Efficient discussion allows students to reach many conclusions by themselves that they normally would not (Jonassen, 2003). Other ways to improve traditional education systems lie in the way instructors execute designers' course plans. This paper has already mentioned that instructors should be closely involved with the course design process, but faulty execution can ruin even the best plans. For example, instructors and designers should perform progress-monitoring tasks continuously throughout the project cycle, not only once in the beginning. This constant monitoring provides up-to-date feedback and allows designers and instructors to modify education systems and correct problems before they become too severe. Traditional instructors place too much emphasis on design goals or objectives when implementing new education models, where objectives are not limits but heuristics for guiding operational performance. Limiting students according to course objectives defeats the purpose of constructivist educational models. Another point on flexibility is to allow for additional goals and/or objectives to arise during a course. Instructors that follow course goals to the letter often reject additional course goals, and this an unnecessary limit for students. Another consideration in improving existing programs is that education designers (in concert with instructors) must tailor implementation strategies to the course material and goals.

To avoid going wrong in this regard, designers should utilize rapid prototype techniques or conduct small-scale experiments to determine a program’s compatibility with its material (Skaalid, 2003). Still, an institution must consider some issues before converting to a constructivist education system. One of the possibly negative consequences of such conversion could be the loss of objectivity and formality that accompany traditional education methods.

As previously discussed, constructivist assessment methods are highly subjective, whereas automated traditional assessments are reasonably objective in comparison. Another negative consideration is the financial one. It costs more to have many small classrooms that it does to have a few large lecture halls. Smaller class sizes and groups mean either lower admissions or hiring more instructors. To be the most effective, students should have ready access to resources like libraries, the internet, e-mail, etc. The advantage of these expenditures is naturally better education, but if an institution cannot afford such adjustments, then it is unfeasible to attempt them.

2.2.4 Contributions of Experiential Learning Theory

Experiential learning is a cyclical process that capitalizes on the participants' experiences for acquisition of knowledge. This process involves setting goals, thinking, planning, experimentation, reflection, observation, and review. By engaging in these activities, learners construct meaning in a way unique to themselves, incorporating the cognitive, emotional, and physical aspects of learning.

Experiential Learning Theory "provides a holistic model of the learning process and a multi-linear model of adult development" (Baker, Jensen, & Kolb, 2002). In other words, this is an inclusive model of adult learning that intends to explain the complexities of and differences between adult learners within a single framework. The focus of this theory is experience, which serves as the main driving force in learning, as knowledge is constructed through the transformative reflection on one's experience (Baker, Jensen, & Kolb, 2002). The learning model outlined by the Experiential Learning Theory (ELT) contains two distinct modes of gaining experience that are related to each other on a continuum: concrete experience (apprehension) and abstract conceptualization (comprehension). In addition, there are also two distinct modes of transforming the experience so that learning is achieved: reflective observation (intension) and active experimentation (extension) (Baker, Jensen, & Kolb, 2002). When these four modes are viewed together, they constitute a four-stage learning cycle that learners go through during the experiential learning process (Figure 6.1). The learners begin with a concrete experience, which then leads them to observe and reflect on their experience. After this period of reflective observation, the learners then piece their thoughts together to create abstract concepts about what occurred, which will serve as guides for future actions. With these guides in place, the learners actively test what they have constructed leading to new experiences and the renewing of the learning cycle (Baker, Jensen, & Kolb).

The ELT model for learning can be viewed as a cycle consisting of two distinct continuums, apprehension-comprehension and intension-extension. However, these dialectical entities must be integrated in order for learning to occur. Apprehension comprehension involves the perception of experience, while intension-extension involves the transformation of the experience. One without the other is not an effective means for acquiring knowledge (Baker, Jensen, & Kolb, 2002). Another way to view this idea is summarized as follows, "perception alone is not sufficient for learning; something must be done with it" and "transformation alone cannot represent learning, for there must be something to be transformed" (Baker, Jensen, & Kolb).

The ELT model attempts to explain why learners approach learning experiences in such different manners but are still able to flourish. Indeed, some individuals develop greater proficiencies in some areas of learning when compared to others (Laschinger, 1990). The ELT model shows that during the learning process, learners must continually choose which abilities to use in a given learning situation and resolve learning abilities that are on opposite ends of a continuum (Baker, Jensen, & Kolb, 2002). Indeed, learners approach the tasks of grasping experience and transforming experience from different points within a continuum of approaches. However, it is important that they also resolve the discomfort with the opposite approach on the continuum in order for effective learning to occur. Thus, if a learner is more comfortable perceiving new information in a concrete manner and actively experimenting during the processing of the experience, the learner must also undergo some abstract conceptualization and reflective observation in order to complete the cycle and lead to effective learning. Thus, a learner who experiments with models and manipulates them in the process of learning must also be able to conceptualize and form observations based on what s/he experiences. This must occur, even if the learners do not consider themselves strong in these areas (Baker, Jensen, & Kolb). This is at the heart of the ELT model and Kolb's view of the adult learner.

2.2.4.1 Applications of Experiential Learning Theory

There are currently many applications of Experiential Learning Theory within educational systems, especially on college campuses. These examples include field courses, study abroad, and mentor-based internships (Millenbah, Campa, & Winterstein, 2000). Additional examples of well-established experiential learning applications include cooperative education, internships and service learning. There are also numerous examples of computer-based interventions based on experience.

Cooperative Education (Co-Op) is a structured educational strategy integrating classroom studies with work-based learning related to a student's academic or career goals. It provides field-based experiences that integrate theory and practice. Co-Op is a partnership among students, educational institutions, and work sites which include business, government, and non-profit community organizations. Students typically earn credit and a grade for their co-op experience while working in a paid or unpaid capacity. College and university professional and career-technical programs such as engineering, media arts and business often require cooperative education courses for their degrees. The National Commission for Cooperative Education (http://www.co-op.edu/) supports the development of quality work-integrated learning programs. Internships Closely related to cooperative education are internships. An internship is typically a temporary position, which may be paid or unpaid, with an emphasis on on-the-job training, making it similar to an apprenticeship. Interns are usually college or university students, but they can also be high school students or post graduate adults seeking skills for a new career. Student internships provide opportunities for students to gain experience in their field, determine if they have an interest in a particular career, create a network of contacts, and, in some circumstances, gain school credit. Service-Learning Service learning is a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities with the emphasis on meeting community needs. Because of its connection to content acquisition and student development, service-learning is often linked to school and college courses. Service-learning can also be organized and offered by community organizations.

Learn and Serve (2010) supports the service-learning community in education, community-based initiatives and tribal programs, as well as all others interested in strengthening schools and communities using service-learning techniques and methodologies. Field Course Scenario A university offers a field-based campus course in wildlife and research management that requires students to actively participate in activities other than those normally encountered during a lecture or recitation section of class. These students are introduced to various vegetation sampling techniques in the one-hour lecture period, but application and use of the techniques occurs when students must describe the vegetation's structural differences between two woodlots on campus. Students are provided with a general goal statement requiring them to differentiate between the two areas based on structure but are not told how to determine these differences or how detailed the description of structure must be (e.g., vertical cover or vertical cover broken out by height strata). Students must first determine the objectives of the project before proceeding. Once these have been agreed on with all members of the group, methods for collecting the data are determined. Students may work with others in the class or with the instructor to determine the most appropriate sampling design. After selecting an appropriate sampling design, students are required to collect the data, and thus learn about the technique(s) through experience with it (concrete experience). By doing so, students learn how to use the technique and are able to more readily decide if the technique is suitable under different sampling regimes (reflection and generalization). During this process, students gain a broader understanding of the technique and its applicability; much of this may never be addressed or presented in a classroom setting. Based on the prerequisites for the course, the instructor worked from the assumption that students have an understanding of ecological concepts and basic statistics. Having these prerequisites facilitates students putting the techniques to use in the environment being studied. An additional benefit of allowing students to experiment with techniques is that unexpected events may occur e.g., it rains halfway through sampling. These unstructured events can further increase a student's confidence, excitement, and familiarity with a technique requiring the student to make decisions about how to proceed or when to stop (active experimentation). These types of events are difficult to model in a classroom, and even if possible, many students do not know how to deal with unexpected circumstances when their only training has been through discussion. Feeling adequately trained to handle these circumstances will require students to have first-hand knowledge and experience with real-world situations

Another popular use of experiential learning which has been around for a long time is role play. It has been used for educational and training purposes, for military strategic and tactical analysis and simply as games. We role play in childhood-imitating our parents, playing with dolls and cars, building sand castles and pretending we are princes and warriors-with the result that learning takes place, preparing us for life. Role Play Scenario The subject of this lesson is a controversy that has deep roots in American History, the Constitution and the Bill of Rights. Using the PBS documentary video In The Light Of Reverence, the teacher has the students closely examine the struggles of the Lakota Sioux to maintain their sacred site at Mato Tipila (Lakota for Bear's Lodge) at Devils Rock in Wyoming. Although the site at Devil's Rock was never ceded by treaty to the U.S. government, it is now under the administration of the National Park Service. Rock climbers claim any U.S. citizen should have complete access to the site because it is on federal land. In deference to the religious practices of the Lakota, the National Park Service asks that people do not climb there during the entire month of June. The case has been litigated up to the Supreme Court. After watching the video and discussing various aspects of the controversy, students role-play members of four teams: the Lakota, rock climbers, National Park Service, and the courts. Using extensive online resources linked to the lesson, students research the issues and evaluate the sources. The first three teams present their demands in a hearing. The court tries to help them reach a compromise and then adjudicates any unresolved issues. The lesson continues as students compare the plight of the Lakota to that of the Hopi and Wintu, who also struggle to maintain their sacred lands. The students will understand the concept of "rights in conflict" arising under the First Amendment (freedom of religion), interpret a current conflict from multiple perspectives, learn to advocate for a point of view, and learn to resolve a conflict through a conflict resolution scenario. Simulations and Gaming Simulations and gaming within instruction also involve direct experience and thus are valid examples of experiential learning. Within game interactions, there are often several cycles presented to the participant. These cycles generally consist of participation by the user, decision making, and a period of analysis. This process coincides greatly with the Experiential Learning Cycle outlined above (Marcus, 1997). In addition, it has been found that simulations which shorten the debriefing period at the end of the game session can diminish their own effectiveness. This means that games which do not allow for appropriate reflection are not as effective as if proper reflection occurs. Thus, it is apparent that the reflective observation and abstract conceptualization portions of simulations and games are vital to learning, which has also been established by the Experiential Learning Theory (Ulrich, 1997). E-learning Yet another application of experiential learning is in the field of e-learning. Specifically, there has been an effort to utilize this model to increase the effectiveness of Continuing Professional Development (CPD) e-learning courses. It was found that many of these courses did not allow for concrete experience and active experimentation due to the fact that the learning processes were based on more traditional learning methods and not capitalizing on the self-directed nature of the learners (Friedman, Watts, Croston, & Durkin, 2002). However, with the use of different technologies such as multimedia resources, web-based discussions, online planners, and creative tasks, e-learning courses could be improved in a manner that would strengthen the entire experiential learning cycle for the learner (Frank, Reich, & Humphreys, 2003). Steps to Integrating Experiential Learning in the Classroom:

1. Set up the experience by introducing learners to the topic and covering basic material that the learner must know beforehand (the video scenario as well as discussion).
2. Engage the learner in a realistic experience that provides intrigue as well as depth of involvement (mock trial).
4. Allow for discussion of the experience including the happenings that occurred and how the individuals involved felt (discussion afterwards).
5. The learner will then begin to formulate concepts and hypotheses concerning the experience through discussion as well as individual reflection (discussion afterwards, but also could be done with journaling).
6. Allow the learners to experiment with their newly formed concepts and experiences (interpreting current conflict and conflict resolution scenario).
7. Further reflection on experimentation (discussion, but could also be done through journaling).

Criticisms of Experiential Learning Theory Since Kolb created the Experiential Learning Theory and the accompanying learning model, his work has been met with various criticisms about its worth and effectiveness. One of the criticisms of this model is that the concrete experience part of the learning cycle is not appropriately explained in the theory and remains largely unexplored. Herron (as cited in Yorks & Kasl, 2002) believes that "the notion of feeling is nowhere defined or elaborated, thus concrete experience is not properly explored. The model is really about reflective observation, abstract conceptualization, and active experimentation." Another common criticism of the theory that exposes a weakness is that the idea of immediate and concrete experience is problematic and unrealistic (Miettinen, 2000). Other criticisms of the ELT are that the concepts outlined by Kolb are too ill-defined and open to various interpretations and that the ideas he presents are an eclectic blend of ideas from various theorists that do not fit logically together. Another, perhaps more biting criticism of Kolb's work is that his ELT model is only an attempt to explain the societal benefit of his Learning Styles Inventory and thus may actually be a well derived marketing ploy (Miettinen, 2000). Also, it is believed that the phases in the ELT learning model remain separate and do not connect to each other in any manner (Miettinen). However, the most tangible weaknesses of the ELT and the ELT learning model are the vast differences between it and the ideas established by John Dewey, whose beliefs are largely attributed to the establishment of the ELT. Dewey believed that non-reflective experience borne out of habit was the dominant form of experience and that reflective experience only occurred when there were contradictions of the habitual experience. But, in a glaring weakness of the ELT, Kolb does not adequately discuss the role of non-reflective experience in the process of learning (Miettinen, 2000). In addition, Dewey believed that observations of reality and nature were the starting point of knowledge acquisition. Kolb, however, believes that the experience is the starting point of knowledge acquisition and disregards the observations concerning the subjective reality of the learner, another blatant weakness (Miettinen). A final weakness in the ELT that was noticed is its lack of discussion concerning the social aspect of experience. The ELT learning model focused on the learning process for a single learner and failed to mention how the individual fit into a social group during this process and what role this group may play. Also, there was no discussion on how a social group may gain knowledge through a common experience.

Educational Implications

Experiential Learning Theory outlines the manner in which learners gain knowledge and understanding through experiences. Though some may debate which steps are present in experiential learning, there is no debate about the worth of experience in learning. Through experience, learners are able to construct first hand a sense of understanding of the events going on around them. Educators have begun to harness the power of experience in study abroad courses, field studies, role plays, and numerous computer-based interventions. The future could bring even more applications of this theory, a possibility as exciting for the learner as much as it is the facilitator.

2.2.5 Connectivist Theory of Learning

Siemens (2005) claimed that the theory of connectivism is characterised as the learning theory of the digital age. One underlying assumption in this theory is that knowledge is distributed and "can reside outside of ourselves". Downes (2007) contends that "knowledge is distributed across a network of connections, and therefore learning consists of the ability to construct and traverse those networks". This actionable knowledge is assembled from a network of connections arising from experience and interactions within a community (Garcia & Ferreira, 2014).

Connectivism paves the way for a new model of learning, adequate to knowledge society, in which "learning is a process of connecting specialized nodes or information sources" (Siemens, 2004). Siemens coined the term „connectivism" to describe learning networks and according to the new learning paradigm, „knowledge is created beyond the level of individual human participants, and is constantly shifting and changing.

Knowledge in networks is not controlled or created by any formal organization, although organizations can and should „plug in" to this world of constant information flow, and draw meaning from it" (Bates, 2015). Connectivism, as a learning theory, has its origins in distributed learning (Siemens, 2004), being relevant to digital society, in the opinion of proponents, and holds another epistemological position compare to Driscoll's classification (2005): objectivism (linked to behaviourism as learning theory), pragmatism (linked to cognitivism) and interpretivism (linked to constructivism), and in the end of the current scheme enshrined evolution of learning theories.

In connectivism learning is actionable knowledge. Learners exploit the weak ties between nodes, recognize the patterns, connect to the small world of individual knowledge (meaning making) and extend personal network. Therefore, as Siemens and Downes show, connectivism assumes knowledge sharing between nodes of knowledge, which are individuals or organisations with some expertise in a particular field, which can induce learning. Learners cannot not learn, they learn in every interaction that they have with the network, with the world. Hence, "the activities that learners undertake when they conduct practices, in order to learn, are like developing or growing their selves, together with the society, in certain (connected) ways" (Downes, 2007). Downes says it takes a different approach from education sciences of the phenomenon of learning by acceptance of the connectivism which:

"(a) seeks to describe „successful" networks (as identified by their properties, which I have characterized as diversity, autonomy, openness, and connectivity)

(b) seeks to describe the practices that lead to such networks, both in the individual and in society (which I have characterized as modelling and demonstration (on the part of a teacher) and practice and reflection (on the part of a learner)" (Downes, 2012)

Downes (2012) took to characterizing connectivism from three perspectives: knowledge, learning and community. He noted that „These three are intended to be represented as a cycle. Knowledge informs learning; what we learn informs community; and the community in turn creates knowledge. And the reverse: knowledge builds community, while community defines what is learned, and what is learned becomes knowledge.

Collaboration whereby members of a group collectively help each other towards achieving a pre-established goal is a key concept in connectivist learning. "In this form of learning knowledge is acquired through interaction" (Garcia & Ferreira, 2014). Collaboration makes the process of learning efficient and relevant because of an assumption that knowledge and expertise reside in the networks. There is room for individual and group learning in these interactions.

Siemens (2004) outlines eight principles of connectivism:

- Learning and knowledge rest in a diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in non-human appliances.
- Capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning.
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.

- Decision-making is in itself a learning process.

The connectivist principles outlined suggest new roles for the teacher or instructor. One role involves assisting each learner to build and make the relevant connections in their learning networks. The other roles include directing students to appropriate resources and other experts, as well as creating experiences that stimulate continual learning. Learning occurs as the learner engages in different forms of network formation at the neural (cognitive), concept, and social levels (Siemens, 2005; Wang et al., 2014). For transformative learning to occur, each learner's depth of cognitive engagement should increase as the learner pushes their way through levels of interactions.

The four levels of interactions are as follows: operation interaction, wayfinding interaction, sensemaking interaction, and innovation interaction.

In a connectivist learning context, each learner should be assisted by a facilitator, peers, experts, and non-human support mechanisms to create and maintain a personal learning network (PLN) immersed in other networks. This could develop through the four phases of interactions namely operation, wayfinding, sensemaking and innovation:

- In the operational interaction phase, the learner uses technological tools such as blogs, wikis and social networks to participate in learning.
- During the wayfinding phase, learners learn how to navigate the networking terrain by identifying the right resource nodes (people or information). Actual connectivistic learning begins here in the learner-content and learner-group interactions.
- The sensemaking phase is a stage where learner–content and learner–group interactions occur at a deeper level. In this phase, the technological, social and

conceptual grid is tightened as learners aggregate, make decisions, reflect, and build a coherent understanding of information collaboratively

- The highest level of cognitive interaction and engagement occurs at the innovation interaction stage when learners are able to create or modify artefacts, and engage deeply with others while reflecting on these artefacts.

Similar to constructivism, the learner is central to the learning process in connectivism. However, the networking processes in connectivism add a dimension to the social context in which the collaborative activity enhances knowledge construction (learning) in a slightly different way. In constructivism, learning is "determined by the complex interplay among learners' existing knowledge, the social context, and the problem to be solved" (Tam, 2000, para.14). In connectivism, the concern is more with an understanding of the distribution of expertise and intelligence over the learning network, and the role of technologies in assisting the learner to construct knowledge (Ng'ambi, 2013). Dewey's (1938) view was that the *problematic* or context was the driver behind the design of any learning activity. From a connectivist perspective, the driver is the activation of learner participation in interactions resulting in the formation of different types of networks (cognitive, concept, and social) supported by technology (Siemens, 2004; Wang et al., 2014). The learning activity should therefore be designed in a manner that develops, supports, and maintains network formation and human connections.

Two characteristics seem to be central to a connectivistic notion of learning activity design:

- A simulating and motivating learning activity that asks of and allows for learners to create artefacts in personal networks linked to other social networks.

- A technogically-supported environment that supports meaningful dialogue and collaboration.

2.3 Empirical Background to the Study

2.3.1 Studies on the effects of minds-on and hands-on activities on students' achievement in science.

Shymansky, Kyle and Albort (1982) stated that several curriculums were carried out to improve appreciation of the nature of the science four decades ago. Studies about those curricula illustrated that student in science programs using hands-on materials, activity-based approaches have much more achievement than do students in traditional text-book oriented science programs (Bredderman, 1982; Kyle et al., 1988; Shymansky et al., 1983).

According to Wideen (1975), students in the Science Process Approach (SAPA) curriculum program had higher scores on science achievement than students in the traditional curriculum program when the researcher acted upon the study in 25 classrooms. However, students' interest about science was not changed for both experimental and control groups. Also, Bredderman (1985) reported the results of a meta-analysis of 15 years of research on activity -based science programs. This synthesis of research was based on 57 studies involving 13000 students in 1000 classrooms in this study. All of the studies involved comparing activity-based programs (the Elementary Science Study, Science-A Process Approach, or the Science Curriculum Improvement Study) with comparable classrooms using a traditional or text-book approach to science teaching. A variety of student performance measures were analyzed. The differences were found in science process skills where students in activity-based programs performed 20 percentile units higher than the comparison groups. The students in these programs scored higher than the control groups in the following measures (ranked from largest to smallest differences): creativity, attitude, perception, logical development, language development, science content and mathematics.

Students who were disadvantaged economically and academically gained the most from the activity-based programs (Bredderman, 1985).

Another meta-analysis of 105 experimental studies of activity-based science conducted by Shymansky et. al. (1983). Researcher categorized students' performance as achievement process skills and analytical skills. It was found that students were given instructions from activity-based programs had the greatest gains in all categories. When the study was reanalysed, it showed that students who participated in hands-on programs achieved 9% points more than their traditional elementary school counterparts on an overall performance assessment.

In accordance with Bredderman (1983) and Shymansky et. al., (1983) student in a hands-on, activity-based programs confirmed higher achievement and problem-solving skills than students in traditional textbook based programs. Nevertheless, students in inquiry program had more advantage in the area of science process skills as identifying hypothesis, setting up and designing experiments and making predictions than in the area of content skills as basic knowledge of terms, measurement and recitation (Reynolds 1991; Staver & Small, 1990; Stohr-Hunt, 1996).

The study of Glasson (1989) was related with the relative effect of hands-on and teacher demonstration laboratory methods on declarative knowledge (factual and conceptual) and procedural knowledge (problem solving) achievement. About 54 ninth grade students (27 male and 27 female) contributed in the study. The students in two intact classes were assigned randomly to two treatment classes, one thought by hands-on laboratory method and the other by a teacher demonstration method. Two instructional methods conclude with declarative knowledge and procedural knowledge. Declarative knowledge was tested with 20 multiple-choice items. Results indicated that students in the hands-on laboratory class performed significantly better on the procedural knowledge test than student did in the demonstration class.

The relationship between the amount of time that students spent experiencing hands-on science and science achievement was studied by Stohr-Hunt (1996). In the study, analysis of variance (ANOVA) of 24599 eight grade students from 1052 participating school was used. Cognitive test battery was performed to measure student's achievement frequency of hands-on experience was collected through self-administrated teacher questionnaire. It was found that significance difference present across the hands-on frequency variable with respect to science achievement. Especially, students who take part in hands-on activities everyday or once a week scored significantly higher on standardized test of science achievement than students who participated in hands-on activities once a month, less than once a month, or never. Moreover, Meitchtry (1992) studied in grades six through eight and found that the use of hands-on science activities provides the concrete learning experiences students needed to better understand the presented science concepts.

Furthermore, research indicates that activity-based science can improve students' attitude towards science (Kyle et al., 1985, 1988; Rowland, 1990). There seems to be some evidence from exemplary programs that even poorly thought hands-on science is more interesting to students than the typical textbook based program (Penick & Yager, 1993). Elementary school students in science programs using hands-on materials have much more positive attitudes about the nature of science and their ability to learn science than do science in traditional textbook-oriented science programs (Bredderman, 1982; Kyle et al., 1988; Shymansky et al., 1982). However, some studies showed that students' attitude toward science are decreasing from elementary to high school (Hofstein et al., 1990; Simpsons & Oliver, 1990; Yager & Yager, 1985). Moreover; Shymansky, Hedges and Woodworth (1990) carried out a meta-analysis of earlier studies found that children in Hands-on programs demonstrated higher achievement, improved skills and a more positive attitude towards science.

Kyle et al. (1988) compared the attitude towards science of students who had completed one year the Science Curriculum Improvement Study (SCIS) with students in non-SCIS classes. The student's sample was comprised of 228 SCIS students (54% male and 46% female) and non- SCIS students (52% male and 48% female). Students were selected randomly from second through sixth grade classes. Result of the study indicated that attitude of students who have experienced one year of an inquiry-oriented process approach curriculum were enhanced greatly when compared to students in textbook-oriented science classes. Additionally, Gardner and Coworkers (1992) reported that use of hands-on activities advance students attitude towards science. Similarly, results of Powers (1990) showed that students preferred using hands-on instruction in the classroom. The students indicated that they learned more science by doing and exhibited a better attitude toward science. Besides, Elias (1992) designed a program to bring hands-on science into the local schools whether he conducted various science experiments for students demonstrating basic scientific principles. In this study, students are allowed to participate and they left his demonstrations with a renewed interest in science and better understanding of how science is done.

A series of studies conducted in Israel (Milner, Ben Zvi, & Hofstein, 1986) have shown clearly that enrolment in science courses in secondary schools are highly affected by various affective variables, for example, students' interest in scientific information and activities and their feelings towards school science. It is suggested that the future developments in the area of science curricula should aim at meeting the interests, feelings and needs of a diverse population. This research sample consisted of two categories of junior high school and senior high school students. The junior high school sampled (8th grade) consisted of 1550 students from all over the country who had not enrolled in extracurricular science activities and 100 students who had enrolled voluntarily in extracurricular science activities.

The senior high school sample (11th grade) consisted of 1450 students who had no enrolled in the extracurricular activities and 53 students enrolled in such activities.

Many researchers have shown relationship between attitude toward science and achievement in science knowledge. The quasi-experimental study of Bristow (2000) was completed for 57 sixth grade middle school students to examine effects of hands-on teaching method on students' learning science and attitude towards science. Control groups took traditional approach or textbook instruction: however, experimental groups took hands-on teaching method. Students' achievement was assessed by multiple-choice test and students' attitude was assessed by Likert type attitude scale. ANOVA results demonstrated that there was no diverse divergence between students' achievement for control and experimental groups; however, students who received hands-on activities have more positive attitude toward science than students who received textbook instruction. Similarly, the study of Freedman (1997) with 270 9th grade students proved that hands-on instruction influenced in a positive direction as the students' attitude towards science, and influence their achievement in science knowledge. On the other hand; Turpin (2000) established diverse results of Bristow's research. Over again, students' achievement and attitudes toward science were assessed for hands-on instruction and traditional instruction. About 531 seventh grade students were in experimental group that was applied activity-based curriculum and 398 seventh grade students were in control group that was applied traditional curriculum. Iowa Test of Basic Skills (ITBS) science scores was used to measure students' achievement and Science Attitude Survey was used to evaluate students' attitude toward science. According to the analysis of covariance (ANCOVA), it was showed that student in activity-based curriculum had significantly higher scores for science achievement that that students in traditional curriculum. But there was no difference in students, attitude toward science for two groups. Besides Hardal (2003) examined the effects of hands-on activities on student's achievement and attitudes towards physics. She conducted her study with 130 ninth grade public school students in Turkey. There were two experimental group which instructed with hands-on activities and there were two control groups which instructed with textbook. Physics Achievement Test and Physics Attitude Scale were used to both groups to assess and compare the effectiveness of hands-on activities and traditional method in physics course. The result of the study indicated that there was no significant difference in the achievement of the experimental and control groups in favour of the experimental group.

A similar significance difference was not found between two groups in the attitude towards physics. The work of Yager and Yager (1985) with sixth through eleventh grade students demonstrated that 60% of sixth grade students who were in science class and had more hands-on activities and 25% of eleventh grade students who got less hands-on activities had less funny time. For that reason, science was less fun and exciting for the larger students stay in school. Similarly, Simpsons and Oliver (1990) reported that attitude towards science dropped from 6th to 8th grades. On the other hand, a series of studies pointed different aspects of hands-on science program. For example, Morey (1990) examined major disadvantages of hands-on science as lack of time, money and equipment and teacher preparation. Likewise, Bybee (1993) cited that lack of materials could be cause for use of traditional instruction in science classroom.

Freeman and colleagues conducted a meta-analysis of 225 studies comparing "constructivist versus exposition-centred course designs" in STEM disciplines (Freeman et al., 2014). They included studies that examined the design of class sessions (as opposed to out-of-class work or laboratories) with at least some active learning versus traditional lecturing, comparing failure rates and student scores on examinations, concept inventories, or other assessments. They found that students in traditional lectures were 1.5 times more likely to fail than students in courses with active learning (odds ratio of 1.95, $Z = 10.4$, $P<<0.001$). Further, they found that on average, student performance on exams, concept inventories, or other assessments increased by about half a standard deviation when some active learning was included in course design (weighted standardized mean difference of 0.47, $Z = 9.781$, $P<<0.001$). These results were consistent across disciplines: they observed no significant difference in the effects of active learning in biology, chemistry, computer science, engineering, geology, math, physics, and psychology courses. They performed two analyses examining the possibility that the results were due to a publication bias (i.e., a bias toward publishing studies with larger effects), finding that there would have to be a large number of unpublished studies that observed no difference between active learning and lecturing to negate their findings: 114 reporting no difference on exam or concept inventory performance and 438 reporting no difference in failure rate. The authors conclude that the evidence for the benefits of active learning are very strong, stating that, "If the experiments analysed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit—meaning that enrolling patients in the control condition might be discontinued because the treatment being tested was clearly more beneficial."

These results support other, earlier reviews (e.g., Hake, 1998; Prince, 2004; Springer et al., 1999). In one such review, Ruiz-Primo et al examined published studies that examined the effects of active learning approaches in undergraduate biology, chemistry, engineering and physics courses; and identified 166 studies that reported an effect size when comparing the effects of an innovation (i.e., active learning approaches) to traditional instruction that did not include the innovation. Overall, they found that inclusion of the active learning approaches improved student outcomes (mean effect size = 0.47), although there are important caveats to consider. First, the authors coded the active learning activities as conceptually oriented tasks, collaborative learning activities, technology-enabled activities, inquiry-based projects, or some combination of those four categories, and important differences existed within the categories (for example, technology-assisted inquiry-based projects on average did not produce positive effects). Second, more than 80% of the studies included were quasi-experimental rather than experimental, and the positive benefits (average effect size = 0.26) were lower for the experimental studies in which students were randomly assigned to a treatment group. Finally, many of the studies did not control for pre-existing knowledge and abilities in the treatment groups. Nonetheless, the review does provide qualified support for the inclusion of active learning approaches in instruction.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter is devoted to the procedures followed to conduct the study. It contains the description of the research design, the study area and the population and sampling procedure. This is followed by the description of the research instrumentations, data collection and data analysis procedures.

3.1 Design of the Study

According to Labaree (2009), a research design refers to the overall strategy that you chose to integrate the different components of the study in a coherent and logical way, thereby ensuring you will effectively address the research problem, it constitutes the blue print for the collection, measurement and analysis of data. Singleton and Strait (2010) also defined research design as the overall strategy one chooses to interrogate the different component of a study in a coherent and logical manner, thereby ensuring that the research problem has been effectively addressed. The research design is intended to provide an appropriate framework for the study.

The research design employed in this study is the quasi-experimental research design which is a quantitative research approach. Quantitative research involves the collection of data so that information can be quantified and subjected to statistical treatment in order to support or refute alternative knowledge claims (Leedy & Ormrod, 2001; Williams, 2011).

Quantitative research employs strategies of inquiry such as experiments and surveys, and collect data on predetermined instruments that yield statistical data (Creswell, 2003; Williams, 2011). According to Christensen and Johnson (2000), a quasi-experimental design is an experimental research design that does not provide for full control of potential confounding variables. In most instances, the primary reason that full control is not achieved is because participants cannot be randomly assigned. Nworgu (2006) indicated that quasi-experimental design as one which 'random assignment of subjects to experiment and control groups is not possible.

Quasi-experimental design has the pre and post-test design as well as the post-test only design. The pre and post-test design of the Quasi-experiment is a design used to test the effectiveness of a method or a program (Bradley, 2018). Quasi-experimental design works with two groups of students or participants. One group is known as the control group with the other as the experimental group. The two groups were all given the pre-test to answer. After, only the experimental group was taken through the treatment. After the treatment, the two groups were both given the post-test questions to answer. They were given the post-test to find out whether the treatment given was effective or not. In experimental research, the Quasi-experimental design generates results faster than the other types of experimental design. It is also less expensive to conduct. It again goes an extra mile to avoid internal validity threat that may come out or show up. According to Barnighausen, Geldsetzer, Tugwell and Levis (2017), quasi-experimental design further avoids the threat of internal validity that may arise when participants in non-blinded experiments change their behaviour in response to the experimental assignment such as compensatory or resentful demoralization.

3.2 Study Area

This study was conducted at Amedzofe Technical Institute and Avatime Senior High School known as AMETECH and AVASEC respectively. AMETECH is a technical school located at Amedzofe and AVASEC is located in Avatime-Vane in the Volta Region. Amedzofe and Avatime-Vane are about 7.5 km away from each other. AMETECH is about 10.5 km and Avasec is about 3.0 km away from the Ho – West District Office in Dzolokpuita which is the District capital. The two schools are a day and boarding with both males and females. The courses offered by AMETECH are Electrical Engineering Technology, Automobile Technology, Agricultural Technology, Fashion and Design Technology, Building Technology Design and Wood Technology Design where the core subjects Integrated Science, Mathematics, English and Social Studies are made compulsory. The courses offered by AVASEC are Home Economics, Visual Arts, General Arts and Business Accounting where the core subjects Integrated Science, Mathematics, English and Social Studies are also made compulsory.

3.3 Population of the Study

Chaudhury (2010) defined population as an entire group about which some information is required to be ascertained. Pilot and Hungler (1999) stated that population is an aggregate or totality of all the objects, subjects or members that confirm to a set of specifications. Singlet and Strait (2010) defined population as a complete set of elements (persons or objects) that possesses common characteristics defined by a sampling criteria established by the researcher. Amedzofe Technical Institute has a total student population of about 517 of whom 400 are boys and 117 are girls and Avatime Senior High School has a total student population of about 550 of whom 400 are boys and 150 are girls as at the time the study was conducted. The two (2) schools have a sum of a total student population of about 1067 of whom 267 are girls and 800 are boys. Target population is defined as the group of individuals or participants with the specific attributes of interest and relevance (Bartlett et al., 2001; Creswell, 2003). The target population consisted of all the biology students in Avatime Senior High School and Amedzofe Technical Institute.

Bartlett, Kotrlik and Higgins (2001) stated that the accessible population is reached after taking out all individuals of the target population who will or may not participate or cannot be accessed at the study period. It is the final group of participants from which data is collected by surveying either all its members or a sample drawn from it. It represents the sampling frame (Bartlett et al., 2001), if the intention is to draw a sample from it. The accessible population consisted all the form two Biology students in Fashion Design Technology and Electrical Engineering department in Amedzofe Technical Institute and all the form two students in General Arts and Home Economics department in Avatime Senior High School.

3.4 Sampling and Sampling Procedure of the Study

Singlet and Strait (2010) stated that samples are the selected elements (objects or people) chosen for a study. The main purpose of sampling is to achieve representativity; the sample should be assembled in such a way as to be representative of the population from which it is taken (Gilbert, 1993). The sample should be a representative of the population to ensure that we can generalize the findings from the research to the population as a whole. The sample size for the study was 60 form two biology students made up of 25 girls and 35 boys.

The sampling procedure the researcher used was a purposive sampling. Crossman (2013) asserted that purposive sampling usually called judgmental sample is one that is selected based on the knowledge of a population and purpose of the study. The researcher used purposive sampling to select 13 girls and 17 boys to form the experimental group in Amedzofe Technical Institute. He again used the purposive sampling to select 12 girls and 18 boys to form the control group in Avatime Senior High School. Purposely sampling was most suitable because it allowed the researcher to appropriately exclude students who do not have the previous knowledge the researcher based the research on.

3.5 Instrumentation

Lyons and Seow (2000) noted that instrumentation design is concerned with a creative thinking process that revolves around making tools or instruments to meet a specific need, or to solve a specific problem. Instrumentation requires the possession of a sound knowledge of the process of transforming problem-solving ideas into reality. The emphasis in instrumentation is on the realisation of an object, an instrument or tool that can be tested and evaluated to check whether the design really solves the problem that informed its development.

The data collected were based on the students' cognitive achievement of the concept, "excretory system". These are tools used to collect information on the students about the problem under study. The main instruments used to collect data for the study were two tests and questionnaire (Likert scale).

The tests were pre-treatment and post-treatment tests. The tests were used to collect quantitative data from both the control and experimental groups. The fourteen (14) itemized questionnaire data from the experimental group on their perceptions or opinions towards the use of minds-on and hands-on activities as a teaching strategy for teaching excretory system.

3.5.1 Tests (Biology Achievement Test)

Nitko (2001) defined test as an instrument or systematic procedure for observing and describing one or more characteristic of a student using of either a numerical scale or a classification scheme. According to Fianu (2005), a test is a series of questions which serve as a measuring tool used for collecting specific information from subjects to aid in finding solution to a research problem. Even though some respondents or testees may not supply accurate answers as they may suffer from faulty memory or not be able to express their ideas adequately in writing which is weakness of test as an instrument, the researcher chose to use it because it is an effective way of securing information from students and also an ideal method that will help to measure students' performance.

The main instrument for data collection used was Biology Achievement Test (BAT) developed by the researcher based on the biology topic taught, excretory system, selected from the SHS 2 Integrated Science (Biology) curriculum. This instrument was used to assess the effect of minds-on and hands-on activities on students' cognitive achievement. The Biology Achievement Test (BAT) is twelve (12) items multiple choice test and three (3) essay-type tests drawn from excretory system by the curriculum for SHS 2 Integrated Science (Biology). Each multiple-choice item has four response options namely A, B, C, and D with only one of the options as the key and the other options as distractors. The Biology Achievement Test (BAT) involved the Pre-treatment Biology Achievement Test (BAT) and the Post-treatment Biology Achievement Test (BAT). The pre-treatment Biology Achievement Test was administered by the researcher to both the control and the experimental group before treatment was administered to only the experimental group. The blue print for the construction of the Biology Achievement Test on Excretory is shown in Appendix A. the process objectives is as follows; Recall 40%; Comprehension, 40% and

Application, 20%. The researcher was guided by Thorndike and Hagen's (1969) principle of using only those objectives that are assessable either wholly or in part by a paper and pencil test when making the blue print for the test. The weighing of the content was based on the provision of the curriculum content for teaching excretory system in SHS 2 classes.

3.5.2 Questionnaire (Likert Scale)

Questionnaires are important useful instruments for collecting survey information and are comparatively straight forward to analyses (Wilson & Maclean, 1994). According to Best and Khan (2003), a questionnaire is a set of questions related to the objectives of the study and hypothesis, which the respondent is required to answer. However, a questionnaire may have low respond rate and little flexibility to the respondent with respect to the respond format. The researcher adopted the close –ended format of questionnaire due to the following reasons as proposed by Siniscalco and Auriat, (2005):

1. The respondent is restricted to a finite (and therefore more manageable) set of responses.
2. They are easy and quick to answer.
3. They have response categories that are easy to code.

Researchers use questionnaires to obtain information about the thoughts, feelings, attitudes, beliefs, values, personalities and behavioural intentions of research participants. The questionnaire was close ended-to prevent teachers and students from giving irrelevant answer. Questionnaires often make use of checklist and rating scales. The researcher decided to use rating scales (Likert Scale). Leedy and Omrod (2001) stated that rating scale is more useful when a behaviour needs to be evaluated on a continuum. They are also known as Likert scales. The questionnaire is a five-point Likert scale questionnaire developed by the researcher; it is containing fourteen items with five response options. The response options are Strongly Agree, Agree, Neutral (Undecided), Disagree, Strongly disagree. On the scale, Strongly Agree = 5, Agree = 4, Neutral (Undecided) = 3, Disagree = 2 and Strongly Disagree = 1, for positive statements and were reversed for negative statements.

3.6 Validity of the Main Instrument

Merriam (1998) stated that validity address the following question: did the research actually measure what it intended to measure? This is the accuracy of the instrument. Validity refers to the appropriateness, meaningful, correctness and usefulness of the inferences a researcher makes from research item (Fraenkel and Wallen, 2003). Validity depends on the amount and type of evidence there is to support the interpretations researchers wish to make concerning data they have collected (Fraenkel & Wallen, 2003).

To ensure the content validity of the instruments used to collect data, the researcher made sure that the items and questionnaires used were based on the problem identified and the objectives set. The questionnaires were given to the supervisor who is lecturer in the science department of University of Education, Winneba (UEW) for careful scrutiny and all his comments and suggestions were taking into consideration to prevent any ambiguity in the questions.

Before the instruments were given to the supervisor, three colleague science teachers were given the questionnaire to review and make their comments on its face validity. Two of these science teachers hold a Master of Education Science. The researcher then made sure that all the words and instrument were clear, and free from any ambiguity.

3.7 Reliability of the Main Instrument

Reliability refers to the degree of consistency or accuracy with which an instrument measures the attribute it is designed to measure (Polit & Hungler 1997; Uys & Basson 1991). If a study and its results are reliable, it means that the same results would be obtained if the study were to be replicated by other researchers using the same method. Dressel and Marcus (1982), define reliability as the extent to which a test or procedure produces similar result under constant conditions on all occasions. That is, the instrument should produce similar results when they are administered at different times. Reliability in quantitative research is essentially a synonym for dependability, consistency and replicable over time, over instruments and over groups of respondents (Cohen, Mannion & Morrison, 2007). It is concerned with precision and accuracy.

In other to determine the reliability of the instruments, the researcher used the test-retest approach within a suitable period. A trial test was carried out on 30 SHS 2 Science students each of Kpedze Senior High School at Kpedze and Taviefe Senior High School at Taviefe which helped me to correct the mistakes and loop holes in the test items used for the Biology Achievement Test (BAT) and the questionnaires used for the interview. The students were given a maximum of one hour to attempt all the questions on the test. The students were also given a one week notice before the conduct of the test. They were also made aware that the test would be centered on excretory system. The students were also made aware of the structure of the tests even before the day they sat for the paper. The rules governing the conduct of the tests were explicitly stated in the question paper.

3.8 Treatment

A pre-test was conducted for all sixty (60) students. The test was marked, scored and recorded. The treatment was administered after the pre-test activities. A treatment was carried out for a period of four weeks with each week having four sessions. The duration for each session was an hour. During this period, participants (experimental group) of the study were taught the concept of excretory system using minds-on and hands-on activities whiles the control group were taught using the lecture method (traditional method) on the topic as the experimental group. For the purposes of convenience, some lessons were conducted outside of the usual contact hours.

The sixty (60) students were drawn from AMETECH and AVASEC with thirty (30) from each school. Students from AMETECH formed the experimental group whiles AVASEC formed the control group. Students used for this study were taken from SHS two.

Those in the experimental group were taught using pictures, drawings and models on excretory system. The control group were taught using the lecture method. The treatment took four weeks. The first week was in treating the various parts of the excretory system by using pictures and models to present the various parts of the excretory system to the experimental group. The second week was used to explain functions of the various part and the processes involved in excretory system. The remaining two weeks were used to guide the students to make models in excretory. Separate lesson plan for teaching both groups were prepared and used. The researcher groomed a biology teacher at the control group school to teach the selected topic using the lecture method using the prepared lesson plan given. The individual lesson plan can be found at the appendix.

After the four weeks of treatment, both groups were given the post-test questions to answer. The post-test questions of only the experimental group had the questionnaire attached for them to respond to as well. After, the scripts were collected and scored to generate data for the post-test and the questionnaire as well.

3.9 Experimental Procedure

One week was used to discuss the research topic with the authorities in the experimental school. A meeting was held with the headmaster and the assistant to discuss the details of the study. The researcher established rapport with the heads of department and the integrated science teachers and students and arranged with them to administer the questionnaires at their convenient times. The researcher uses the opportunity to offer guidance to biology teachers and head of department on necessity of using minds-on and hands-on activities method to teach excretory system. The researcher presented his lesson plans and notes to the head of department and the biology teachers for inspections and suggestion if need be.

Prior to the treatment, a pre-treatment test was administered to the participants of the study to assess their cognitive achievement in excretory system. The outcome is this test was collected and stored. For four weeks, the participants were given instruction on the concept excretory system using minds-on and hands-on activities. After the treatment, a post-treatment test together with the Likert scale type of questionnaire was administered to the participants. The questionnaire was for only those in the experimental group. The scores obtained by the students on the post-treatment test was also recorded and stored. Data collected from the administration of these tests and questionnaire were organised and statistically analysed.

3.10 Method of data collection

Data for the study were collected through pre-test, post-test and Likert scale questionnaires. Pre-test was administered to the subjects before treatment to measure the students' achievement and to provide the researcher with base line data about the subjects. The researcher administered post-test to the subjects one (1) week after the treatment. The post-test items were rearranged to measure the students' achievement in excretory system. Data which was obtained from the two tests were recorded separately. Also, questionnaire was administered one (1) week after the treatment to determine the perceptions of the experimental group students of the use of minds-on and hands-on activities method in teaching excretory system.

3.11 Method of data analysis

Microsoft Excel (2019) and SPSS statistical tool (version 27) were adopted to analyse the data collected. The scores from the tests were analysed using mean, median, standard deviation, paired and unpaired t-tests. The mean, median, standard deviation, and t-tests answered the research questions. The data was organized into frequencies and percentages and presented using frequency tables.

3.12 Ethical consideration

Utmost care was taken to ensure that the anonymity of the research subjects was assured. Additionally, the research subjects were free to opt out of the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The purpose of this chapter was to present data from the study in order to determine the effect of minds-on and hands-on activities on students' cognitive achievement in excretory system. This chapter also contains the results.

4.1 Presentation of the results from research question one (1).

Research question one (1): What difficulties do the students face during lessons on the excretory system?

The results showed that some students faced a number of challenges during lessons on the excretory system (Table 1).

Table 1: The difficulties faced by the students on excretory system

Serial Number	Difficulties faced by the students on excretory system
1	Some students confused egestion with that of the excretion.
2	The students cannot identify the four main excretory organs of mammals.
3	Some students cannot identify the skin as the largest excretory organ.
4	The students cannot identify the reason why the right kidney is slightly lower than the left kidney.
5	The students cannot relate the main excretory organs with their excretory products.

The histogram that displays the performance of the experimental group students in the pre-test before treatment is shown in Figure 1. Figure 1 displays that eight students scored between 1-10% marks; thirteen students scored between 11-20% marks; five students scored between 21-30% marks; and only four students scored between 31-40% in the pre-test conducted before treatment.

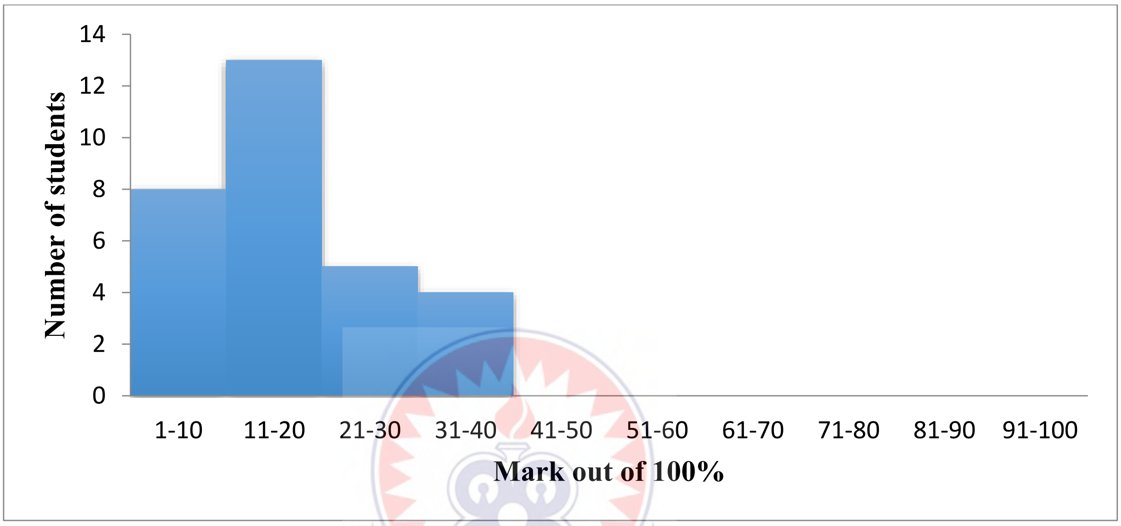

Figure 1: Histogram showing the performance of the experimental group students in the pre-test before the treatment.

The histogram that contains the performance of the control group students in the pre-test before treatment is shown in Figure 2. Figure 2 displays that ten control group students scored between 1-10% marks; sixteen students scored between 11-20% marks; three between 21-30% marks and only one student scored between 31-40% marks in the pre-test.

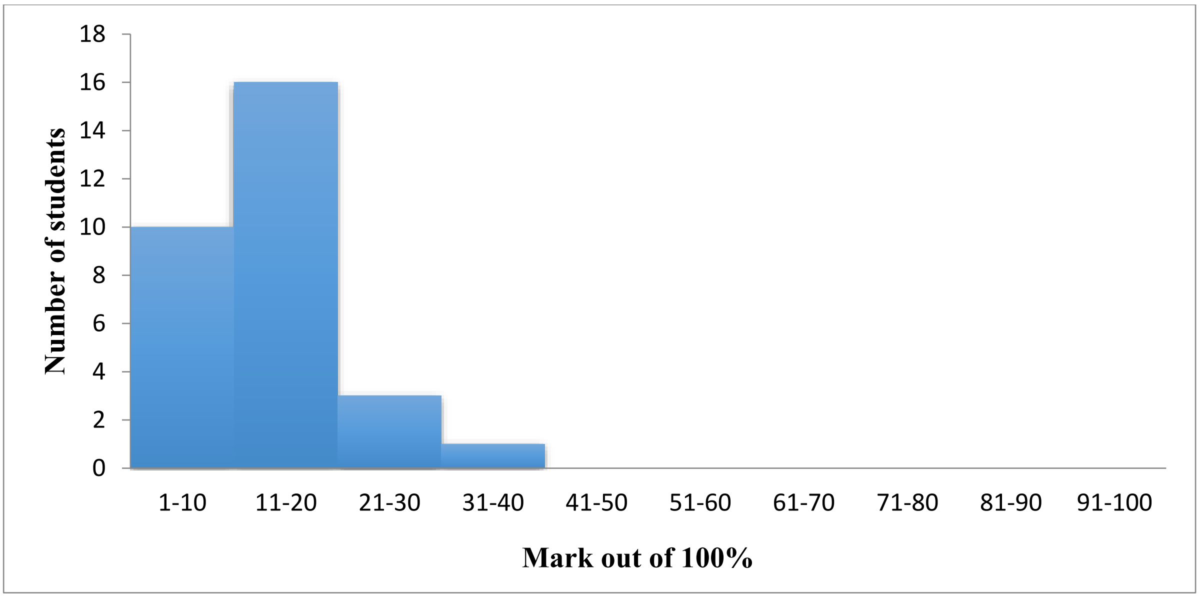

Figure 2: Histogram showing the performance of the control group students in the pre-test before the treatment.

Table 1 shows the responses of both the students of the pre-test. From the responses of the pre-test, most of the students confused egestion with excretion. The pre-test responses shows that the students had the idea that egestion is the same as excretion since egestion involves the removal of undigested food substances through the anus whiles excretion also involves the removal of waste metabolic products or substances from the body or cell of a living organism. Therefore, most of the students confuse the understanding of excretion with that of egestion.

It is evident from the pre-treatment test responses that students in both groups, thus the control and the experimental groups could not identify the four main excretory organs of mammals. The students rather identified the nostril, the anus, the mouth and the heart as part of the main excretory organ of mammals.

Also, the responses from the pre-treatment test show that, the students could not identify the skin as the largest excretory organ. From the responses of the pre-test, most of the students were identifying the lungs, the brain and the kidneys as the largest excretory organ in the human body.

Again, the responses from the pre-treatment test show that the students could not identify the reason why the right kidney is slightly lower than the left kidney. From the responses of the pre-treatment test, the students identified reasons such as the right kidney is bigger than the left kidney and also a considerable space occupied by the heart. This responses from the pre-treatment test indicate that the student cannot identify the location of the kidneys in mammals and the organs that are very close to the kidneys.

The pre-treatment test response from the students shows that the students cannot relate the main excretory organs with their products in a mammal. Some of the students identified urine as the excretory product of the liver instead of the bile pigments, urea and cholesterol. Some students also were not able to relate urea, water, mineral salts and uric acid as the excretory products of the kidneys but rather identified salt and sugar as the main excretory products of the kidneys. Moreover, some of the students also identified only the skin as the excretory organ for excreting carbon dioxide neglecting the lungs.

Again, Figure 1 shows that eight students scored between 1-10% marks; thirteen students scored between 11-20% marks; five students scored between 21-30% marks; and only four students scored between 31-40%. Also ten students scored between 1-10% marks; sixteen between 11-20% marks, 3 between 21-30% marks and only one student scored between 21-30% marks (Figure 2).

The results show that the control and the experimental group students have wrong ideas in excretory system thus the low performance in the pre-treatment scores. This finding agrees with the findings of Allen (2014) which stated that, science misconceptions are individual knowledge gained from educational experience or informal events that are irrelevant or not having the meaning according to scientific concepts.

Therefore, the distribution of the pre-test results is positively skewed. This reveals that, the experimental and control group students performed poorly in the pre-treatment test. The analysis of the pre-test results revealed that, almost all the experimental and control group could not identify the excretory products that are associated with the various excretory organs and they could not also identify the four main excretory organs of mammals. This finding indicates that, students in general have various ways of learning hence not using a practical activity approach of teaching a concept such as excretory system may not enhanced the understanding of students.

4.2 Presentation of the results from research question two (2).

Research question two (2): What are the effects of minds-on and hands-on activities on the students' cognitive achievement in the study of the excretory system of mammals?

After administering the pre-test to the students and the results were loaded. The minds-on and hands-on activity approach was implemented on the experimental group students to determine the effects on the cognitive achievements.

The summary of the mean pre-test scores before treatment are found in Table 2.

Table 2: Statistical data showing the summary of the mean pre-test score of the control

group and experimental group.

Group	N	Mean	SD
Control	30	14.633	6.552
Experimental	30	19.167	9.158

The effects of the minds-on and hands-on activities on students' cognitive achievement was found by subtracting the mean pre-test score from the mean post-test score of the experimental group students.

The mean pre-test score and the mean post-test scores of the experimental group are found in the Tables 3 and 4.

Table 3: Statistical data showing the mean performance of the experimental group students in the pre-test before treatment.

Marks (x)	Number of Students (f)	F(x)
7	3	21
10	5	50
13	2	26
17	5	85
20	6	120
23	2	46
27	3	81
33	2	66
40	2	80
TOTAL	$\sum f = 30$	$\sum f(x) = 575$

$$\text{Mean} = \frac{\sum f(x)}{\sum f} = \frac{575}{30} = 19.167$$

The histogram of the marks obtained by the experimental students in the pre-test is shown in Figure 3. The histogram in Figure 3 indicates that eight students scored between 1-10% marks; thirteen students scored between 11-20% marks; five students scored between 21-30% marks; and only four students scored between 31-40% in the pre-test conducted before treatment.

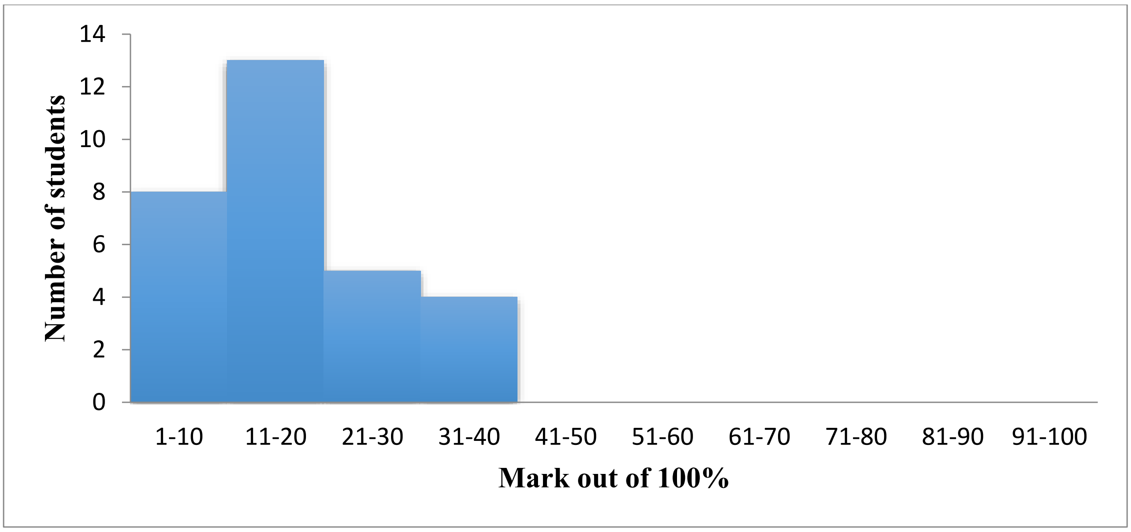

Figure 3: Histogram showing the distribution of the pre-test results of the experimental students.

Table 4: Statistical data showing the mean performance of the experimental group students in the post-test after treatment.

Marks (x)	Number of Students (f)	F(x)
45	1	45
48	1	48
49	1	49
50	2	100
51	2	102
52	2	104
53	2	106
56	1	56
60	4	240
61	1	61
62	2	124
63	1	63

64	2	128
68	2	136
69	2	138
74	1	74
78	1	78
80	1	80
84	1	84
TOTAL	$\sum f = 30$	$\sum f(x) = 1816$

$$\text{Mean} = \frac{\sum f(x)}{\sum f} = \frac{1816}{30} = 60.533$$

The histogram of the marks obtained by the experimental students in the post-test is shown in Figure 4. The histogram in Figure 4 indicates that five experimental group students scored between 41 to 50% marks; eleven students scored between 51 to 60% marks; ten between 61 to 70% marks; three between 71 to 80% marks and only one scored between 81 to 90 marks in the post-test conducted after treatment.

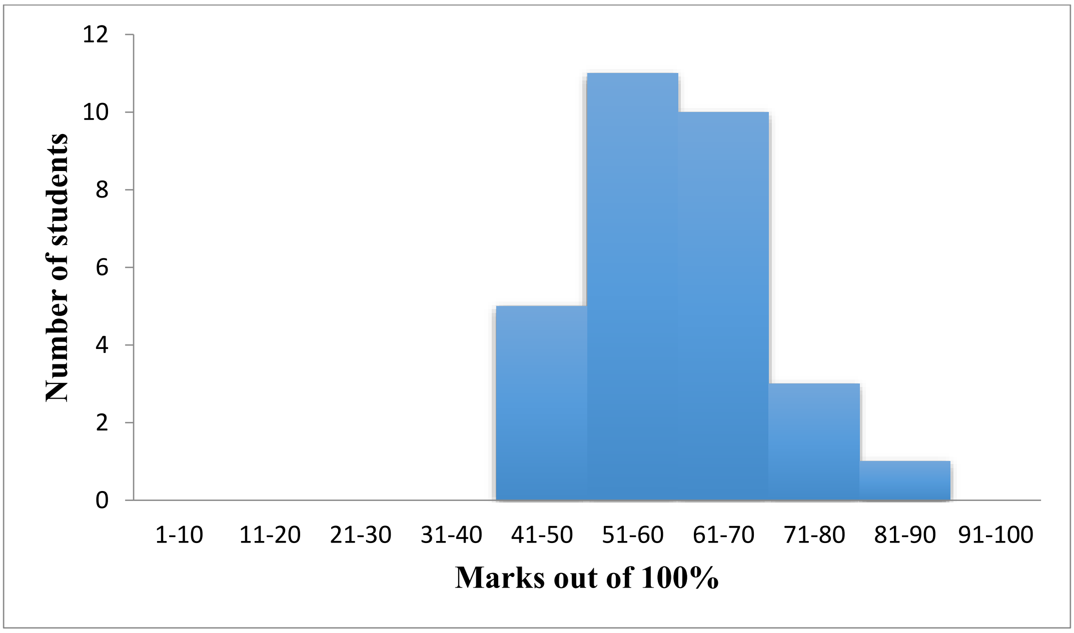

Figure 4: Histogram showing the distribution of the post-test results of the experimental students.

The statistical data showing the difference in mean performances of the experimental students in the pre-test and the post-test is shown in Table 4. Table 4 indicates the post-test mean, the pre-test mean and the mean differences of the experimental and the control group students

Table 5: Statistical data showing the difference in mean performances of the experimental and the control students in the pre-test and the post-test.

Group	Post-test mean	Pre-test mean	Mean Difference
Experimental	60.533	19.167	41.366
Control	26.7	14.633	12.067

Table 2 shows the statistical tendencies of the pre-test between the experimental and the control groups. The mean value of 14.633 and 19.167 of the control and experimental groups respectively indicates that a lot of students' scores were below 20%. Therefore, the mean score of the test results confirms the low knowledge and wrong ideas students had on the excretory system before the use of the treatment. The standard deviation described the measure of spread of the pre-test results of both the control and the experimental group students.

The mean performance of the experimental group students in the pre-test before treatment indicates that most of the experimental group students' scores were around 19. The results gathered from the pre-treatment test of the experimental group students showed how poorly they performed before the treatment.

Only eight students from the experimental group scored between 1-10% marks; 13 students scored 11-20% marks; five scored between 21-30% marks and four students scored between 31-40% marks in the pre-test.

Also the mean performance of the post-test results after the treatment indicates that a lot of the experimental students' scores after treatment were around 60. Therefore, the mean score of the post-test result confirms the high knowledge the experimental group students had on the excretory system after the treatment was administered.

Moreover, Figure 4 shows that five students scored between 41-50% marks; 11 students scored between 51-60% marks, three students scored between 71-80% and one student scored between 81-90%.

Finally, the pre-test mean score is 19.167 and mean post-test score is 60.533 as shown in Table 5. It means that the mean post-test score is higher by 41.366. This implies that, the performances of the experimental group students were improved after the treatment. Therefore, the minds-on and hands-on activities had improved the students' cognitive achievements in the study of the excretory system.

This implies that, after the treatment, the experimental group students;

- Could differentiate clearly between egestion and excretion.
- Could identify the four main excretory organs of mammals.
- Could explain the reason why the right kidney is slightly lower than the left kidney.
- Were able to identify the skin as the largest excretory organ in humans.
- Acquired significant idea on the functions of the processes involved in urine production.

- Could identify the excretory products that are associated with the various excretory organs.

These findings agree with the findings of Hassen (2015) who asserted that, the most important reason for academic failure is the use of teacher-centred methods which turns some students or all of them into passive learners.

The findings agree with the Ausubel's theory which emphasizes that, learning of new knowledge is dependent on what is already known. In other words, construction of knowledge begins with our observation and recognition of events and objects through concepts we already possess. We learn by constructing a network of concepts and adding to them.

Moreover, the mean post-test score of the control group students increased from 14.633 to 26.7 this indicates that, the control group students also performed relatively better in the post-test than the pre-test. However, the mean score gained by the control group students between the two tests is 12.067. Thus, the mean score gained by the control group students reveals that, they still possess wrong ideas and still have difficulties in the study of the excretory system.

4.4 Presentation of the results from research question three (3).

Research question three (3): What is the differential effect of the treatment on the cognitive achievement of the male and female experimental group students?

Table 6 shows the statistical data of the measures of the central tendency of the pre-test results of the male and female experimental group students compared.

Table 6: Statistical data of pre-test of the sexes; male and female experimental group students compared.

Male Students		Female students	
Mean	19.11764706	Mean	19.23076923
Median	17	Median	20
Mode	17	Mode	20
Number of male students	17	Number of Female Students	13

Table 6 shows the statistical data of the measures of the central tendency of the pre-test results of the male and female experimental group students compared.

Table 7: Statistical data of post-test of the sexes; male and female experimental group

students compared.

Male Students		Female students	
Mean	57.11764706	Mean	65
Median	53	Median	64
Mode	60	Mode	68
Number of male Students	17	Number of female Students	13

Table 6 shows that, the mean score (19.23) of the female experimental students relatively higher than the mean score (19.11) of the male experimental students. The difference in the mean scores between the female and the male experimental students is 0.12.

This indicates that, the female experimental students performed relatively better than their male counterparts before treatment.

This finding contradicts the finding of Eze (2008) which indicates that, an inequality in science and technology is sex-linked. Eze (2008) states that, spatial ability is sex-linked in favour of males while verbal expression is sex-linked in favour of females. However, this finding supports the finding of Eze (2008) who proved statistically that, there is no biological evidence that males have intrinsic superior intellectual abilities over females. Table 7 shows that, the achievement mean score of the female experimental students is 65 and that of the male students is 57.11 in four significant figures. Thus, the analysis shows that, the achievement mean score of the female experimental students is relatively greater than the achievement mean score of the male experimental students with the mean difference of 7.89. This implies that, the mean performance of the female experimental group students is greater than the male students after the treatment. Therefore, the female experimental group students performed relatively better than the male experimental group students after the treatment.

4.5 Presentation of results from Research question four (4).

Research question four (4): What are the students' views on the use of minds-on and hands-on instructional approaches for biology lessons?

In order to determine the views of the experimental students on the use of minds-on and hands-on activities for biology lessons, they were given a questionnaire containing ten statements. The item response score and the item new response score for each student was determined. The overall item new response score (4.3) was calculated by dividing the total item new response score (129.2) by the thirty students.

The analysed data showing the sum and the mean of the item response scores from the views of the items of questionnaire of the experimental group students is found in Table 8.

Summary of the questionnaire and the rest of the items can be seen in the Appendix I.

Table 8: Results from ten items of questionnaires showing the views of the experimental group students of the use of minds-on and hands-on instructional approaches for biology lessons.

Experimental students	Item response scores	Item mean response score
ES1	42	4.2
ES2	44	4.4
ES3	46	4.6
ES4	42	4.2
ES5	47	4.7
ES6	46	4.6
ES7	48	4.8
ES8	33	3.3
ES9	49	4.9
ES10	44	4.4
ES11	47	4.7
ES12	45	4.5
ES13	43	4.3
ES14	43	4.3
ES15	43	4.3
ES16	38	3.8

ES17	45	4.5
ES18	42	4.2
ES19	44	4.4
ES20	42	4.2
ES21	39	3.9
ES22	43	4.3
ES23	48	4.8
ES24	41	4.1
ES25	35	3.5
ES26	44	4.4
ES27	41	4.1
ES28	44	4.4
ES29	40	4
ES30	44	4.4
Total	1292	129.2
Overall item mean response		4.3

From Table 8, the overall item new response of thirty experimental group students is 4.3. the individual item responses were as follows; Strongly agree (SA) = 5, Agree (A) = 4, Uncertain (UC) = 3, Disagree (DA) = 2 and Strongly disagree (SD) = 1. Thus, having the overall item new response of 4.3 indicates that, the experimental group students had positive views of the use of minds-on and hands-on activities in biology lessons.

This finding agrees with the finding of Adekunle (2016) as cited by Ayisi (2022) who conducted a survey involving 7500 secondary school students in Nigeria to determine their perceptions about computer education in Abuja. This implies that, students normally have positive views about the appropriate instructional approaches by researchers.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS

5.0 Overview

This chapter contains the summary of the findings, conclusions and the educational implications. The recommendations and the suggestions for further study were presented.

5.1 Summary of the major findings

The following were found from the analysis of the data:

1. Almost all the control and the experimental group students were allocating the various excretory organs wrongly to their excretory products, they were changing the function of the urethra with ureter and they could not identify the functions of the parts of the excretory system. This revealed the difficulties encountered by the students in excretory system.
2. The general performance of the experimental group students had significantly improved after the treatment using the minds-on and hands-on activities. The minds-on and hands-on activities had positive effect on the students' achievement in excretory system.
3. The female experimental group students performed relatively better than the male experimental group students before treatment.
4. The female experimental group students performed relatively better than the male experimental group students after the treatment.
5. The experimental group students had positives views on the use of the minds-on and hands-on activities for lessons in excretory system.

6. Sex is not a significant factor on the students' cognitive achievement in excretory system.

Based on the findings, conclusions were made, educational implications of the study were outlined and some recommendations were proffered. Finally, suggestions for further study were presented.

5.2 Conclusions

The minds-on and hands-on activity method of teaching is more effective in enhancing students' cognitive achievement in excretory system of mammals. The retention ability of students can be better enhanced through the use of minds-on and hands-on activities method of teaching.

Also, sex is not a significant factor in both cognitive achievement of students in excretory system. There is no significant interaction effect of the minds-on and hands-on activity method and sex on students' cognitive achievement in excretory system. Finally, the experimental group students had positive views of the use of the minds-on and hands-on activities for lessons in excretory system.

5.3 Educational implications

The findings of this study have several implications among which the significant ones are outlined below;

1. The findings of the study imply that when students are taught biology with minds-on and hands-on activities, they are bound to perform better. It is now the duties of the teachers of biology to put this into action in order to enhance the performance of students.

2. The findings imply that; minds-on and hands-on activities improve the retention ability of the students in excretory system. Hence, the minds-on and hands-on activity method can be used to improve students' retention in biology concepts.
3. The findings of the study also imply that the minds-on and hands-on activities tend to promote homogeneity of performance between the male and female students. In other words, practical method of teaching is sexually friendly. Thus, the minds-on and hands-on activities can be employed to foster mutual relationship between male and female students in the teaching and learning of excretory system.

5.4 Recommendations

Based on the findings of the study, the researcher made the following recommendations:

1. Science educators and curriculum planners should incorporate innovative strategies such as minds-on and hands-on activity method into their various teacher education programmes so that it eliminates the difficulties students face during biology practical lessons.
2. Government should utilize the services of various bodies such as Science Association of Ghana (STAG), faculties and institutes of education in universities to organize in-service training programmes, workshops, seminars and conferences for serving biology teachers to update their knowledge on the use of the minds-on and hands-on activity method of teaching to enhance students' cognitive achievement and retention in biology practical lessons such as the excretory system of humans.
3. Biology teachers in various schools should be encouraged to teach biology using minds-on and hands-on activity method of teaching without the idea that

some sexes of students have higher cognitive achievement than others when it comes to biology practical lessons.

4. Biology teachers should try as much as possible to key in to the use of the minds-on and hands-on activity method of teaching during biology lessons so that it enhances learning and retention of what has been learnt on the part of the students.

5.5 Suggestions for further study

Based on the factors that might have affected the findings of the study, the following suggestions were made by the researcher:

1. Future researchers can replicate this study by using a larger sample size in order to see the comparability of the findings.
2. Wider area of coverage can be used by future researchers in replicating the present study.

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APPENDIX I

PRE-TEST DATA COLLECTION INSTRUMENT

(BIOLOGY ACHIEVEMENT TEST)

These questions seek to find out your basic knowledge about excretory system. Please respond to each item to the best of your knowledge. Your truthful response to each of the items will be greatly appreciated. Your response will be kept confidential and will not affect your examination results. It will be used purposely for a research.

Please fill or tick [√] in the appropriate space provided below

Participant number: [ ]

Gender	Male [ ]	Female [ ]	
Age	14-16 [ ]	17-19 [ ]	20-22 [ ]

INSTRUCTIONS: answer all questions

1. Apart from excretion, select another function of the skin from the following:

A. To give the body shape

B. To prevent bleeding

C. To regulate heat in the body

D. To protect delicate organs

2. Which of the following is NOT an excretory organ?

A. Skin

B. Kidney

C. Heart

D. Lungs

3. Urea is made up of

A. Protein stored in the urethra

B. Protein broken down in the liver

C. Protein broken down in the kidneys

D. Urine, salt and water

4. Which one of the following substances is NOT excreted by the human body?

   A. Salt

   B. Urea

   C. Saliva

   D. Carbon dioxide

5. Which of the following is NOT part of the urinary system?

   A. Liver

   B. Urethra

   C. Bladder

   D. Kidney

6. What is the function of the ureter?

   A. To carry urine out of the body

   B. To store urine

   C. To carry urine from the kidney to the bladder

   D. To remove waste from the blood

7. What is manufactured in the liver by removing excess protein?

   A. Urea

   B. Urine

   C. Sugar

   D. Carbon dioxide

8. The largest organ in the human body is

   A. The kidneys

B. The brain

C. The skin

D. The lungs

9. A man has taken a large amount of protein in his diet. He will excrete more of

A. Urea

B. Uric acid

C. Sugar

D. Salts and sugar

10. Explain the difference between excretion and egestion.

11. The reason why the right kidney is slightly lower than the left is

A. The left kidney is bigger than right

B. Considerable space occupied by the heart

C. Considerable occupied by the liver on the right side

D. The right kidney is bigger than the left

12. Which of the following organs excretes carbon dioxide?

A. Kidney

B. Lungs

C. Liver

D. Skin

13. Name the four main excretory organs of mammals.

i. ……………………………………….. iii. ……………………………………….

ii. ……………………………………….. iv. ………………………………………..

14. State the functions of the following parts of the urinary system in humans.

i. Urethra

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………

ii. Bladder

………………………………………………………………………………………

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15. What is meant by Selective re-absorption?

………………………………………………………………………………………

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APPENDIX II

RESPONSES TO PRE-TEST

1. C [3.33 marks]
2. C [3.33 marks]
3. B [3.33 marks]
4. C [3.33 marks]
5. A [3.33 marks]
6. C [3.33 marks]
7. A [3.33 marks]
8. C [3.33 marks]
9. A [3.33 marks]
10. Excretion is the removal of waste metabolic substances from the body of a living organism whiles Egestion is the removal of undigested food substances from the body through the anus.

    [3.33 marks]
11. C [3.33 marks]
12. C [3.33 marks]
13. i. Skin [6.66 marks]

    ii. Bladder [6.66 marks]

    iii. Liver [6.66 marks]

    iv. Kidneys [6.66 marks]
14. i. It is used to expel urine out of the body from the bladder. [9.99 marks]

    ii. It is a muscular-sac structure which stores urine. [9.99 marks]

15. It is the process whereby certain molecules such as ions, glucose and amino acids after being filtered out of the capillaries along with nitrogenous waste products (urea) and water in the glomerulus are reabsorbed from the filtrate as they pass through the nephron.

[13.32 marks]

TOTAL MARKS = 99.99marks Approximated to 100marks.

APPENDIX III

POST-TEST DATA COLLECTION INSTRUMENT

These questions seek to find out your basic knowledge about excretory system. Please respond to each item to the best of your knowledge. Your truthful response to each of the items will be greatly appreciated. Your response will be kept confidential and will not affect your examination results. It will be used purposely for research.

Please fill or tick [√] in the appropriate space provided below

Participant number: [ ]

Gender	Male [ ]	Female [ ]	
Age	14-16 [ ]	17-19 [ ]	20-22 [ ]

INSTRUCTIONS: answer all questions

1. What is meant by Selective re-absorption?

…………………………………………………………………………………

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2. State the functions of the following parts of the urinary system in humans.

   i. Urethra

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

………………………

ii. Bladder

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………

3. Name the four main excretory organs of mammals.

i. ………………………………………..

iii..……………………………………

ii. ………………………………………..

iv.……………………………………

4. The reason why the right kidney is slightly lower than the left is

   A. The left kidney is bigger than right
   B. Considerable space occupied by the heart
   C. Considerable occupied by the liver on the right side
   D. The right kidney is bigger than the left

5. Apart from excretion, select another function of the skin from the following:

   A. To give the body shape
   B. To prevent bleeding
   C. To regulate heat in the body
   D. To protect delicate organs

6. Urea is made up of

   A. Protein stored in the urethra
   B. Protein broken down in the liver
   C. Protein broken down in the kidneys
   D. Urine, salt and water

7. Which of the following is NOT an excretory organ?
    A. Skin
    B. Kidney
    C. Heart
    D. Lungs
8. Which one of the following substances is NOT excreted by the human body?
    A. Salt
    B. Urea
    C. Saliva
    D. carbon dioxide
9. Which of the following is NOT part of the urinary system?
    A. Liver
    B. Urethra
    C. Bladder
    D. Kidney
10. What is the function of the ureter?
    A. To carry urine out of the body
    B. To store urine
    C. To carry urine from the kidney to the bladder
    D. To remove waste from the blood
11. What is manufactured in the liver by removing excess protein?
    A. Urea
    B. Urine
    C. Sugar
    D. Carbon dioxide

12. The largest organ in the human body is

    A. The kidneys

    B. The brain

    C. The skin

    D. The lungs

13. A man has taken a large amount of protein in his diet. He will excrete more of

    A. Urea

    B. Uric acid

    C. Sugar

    D. Salts and sugar

14. Explain the difference between excretion and egestion.

15. Which of the following organs excretes carbon dioxide?

    A. Kidney

    B. Lungs

    C. Liver

    D. Skin

APPENDIX IV

MARKING SCHEME FOR POST-TEST

1. It is the process whereby certain molecules such as ions, glucose and amino acids after being filtered out of the capillaries along with nitrogenous waste products (urea) and water in the glomerulus are reabsorbed from the filtrate as they pass through the nephron.

   [13.32 marks]

2. i. It is used to expel urine out of the body from the bladder. [9.99 marks]

   ii. It is a muscular-sac structure which stores urine. [9.99 marks]

3. i. Skin [6.66 marks]
   ii. Bladder [6.66 marks]
   iii. Liver [6.66 marks]
   iv. Kidneys [6.66 marks]
4. C [3.33 marks]
5. C [3.33 marks]
6. B [3.33 marks]
7. C [3.33 marks]
8. C [3.33 marks]
9. A [3.33 marks]
10. C [3.33 marks]
11. A [3.33 marks]
12. C [3.33 marks]
13. A [3.33 marks]

14. Excretion is the removal of waste metabolic substances from the body of a living organism whiles Egestion is the removal of undigested food substances from the body through the anus.

[3.33 marks]

15. C [3.33 marks]

TOTAL MARKS = 99.99marks Approximated to 100marks.

APPENDIX V

QUESTIONNAIRE FOR STUDENTS IN THE EXPERIMENTAL GROUP

This questionnaire was designed to evaluate your perceptions on the effect of minds-on and hands-on activities on students' cognitive achievement in excretory system. Please respond to each of the items to the best of your knowledge. Your truthful responses will be greatly appreciated. Your responses will be kept confidential and will not affect our examination results. It will be used purposely for research.

2. Background Information

INSTRUCTIONS; Please tick [√] in the appropriate spaces provided below

Gender Male [ ] Female [ ]

Age 14-16 [ ] 17-19 [ ] 20-22 [ ]

3. Student's perception about the use of minds-on and hands-on activities as a teaching method for teaching excretory system.

INSTRUCTIONS; please read the following statements and indicate how much you agree or disagree with each of the statements by ticking the appropriate option provided in a scale form below;

Strongly agree (SA) = 5, Agree (A) = 4, Uncertain (UC) = 3, Disagree (DA) = 2, Strongly disagree (SD) = 1

S/N	ITEM	SA	A	UC	DA	SD
1	Minds-on and Hands-on activities made the lesson learner-centred					
2	Minds-on and Hands-on activities motivated me on excretory system					
3	I recommend Minds-on and Hands-on activities to other science teachers					

4	My performance was improved by Minds-on and Hands-on activities					
5	Minds-on and Hands-on activities enhanced my critical thinking skills					
6	Minds-on and Hands-on activities increased my interest in excretory system					
7	Minds-on and Hands-on activities helped me to understand excretory system better					
8	Minds-on and Hands-on activities helped me to retain more information					
9	Minds-on and Hands-on activities helped me to concentrate on the lesson					
10	Minds-on and Hands-on activities made the lesson practical					

APPENDIX VI

LESSON NOTES FOR CONTROL GROUP

<table>
<tr><th>WK</th><th>DURATION/ TOPIC/ SUB-TOPIC</th><th>OBJECTIVES / TLM</th><th>TEACHER-LEARNER ACTIVITY</th><th>CORE POINTS</th><th>REMARKS</th></tr>
<tr><td></td><td>DAY
Tuesday
DURATION
2hrs
TOPIC
Excretory System</td><td>OBJECTIVES
By the end of the lesson, the student should be able to:</td><td>Teacher introduces the lesson by asking students questions on excretion to review their RPK.
Teacher takes students through the concept of excretion and egestion.</td><td>Excretion is the process by which waste metabolic products are removed from the body of a living organism whiles Egestion is the removal of undigested food substances through the anus.
<table><tr><th>Excretion</th><th>Egestion</th></tr><tr><td></td><td></td></tr></table></td><td>1) Explain what is meant by excretion and egestion.
2) State four differences between</td></tr>
</table>

	SUB-TOPIC Excretion and Egestion	i) Explain the concepts excretion and egestion. ii) Identify **four** differences between excretion and egestion. **TLM** Charts	With the aid of chart of the excretory system, students were taught the differences between excretion and egestion	Removal of toxic waste from the body	Removal of undigested food		excretion and egestion.
				Wastes are removed through lungs, skin, kidneys and liver	Undigested food substances removed through the anus		
				Products are excess water, CO_2, excess mineral salts,	Products are faeces and water		

1				bile pigments and urea		
				Wastes are removed from the cells and tissues	Undigested foods are removed from the alimentary canal	
	DAY Thursday **DURATION** 2hrs **TOPIC**	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Identify **four** excretory organs and their products	Review the RPK of students using questions	**Organs**	**Products**	1) State **four** excretory organs and their products
				Lungs	CO_2 and water	
				Kidneys	Water, urea, mineral salts, uric acid and other	

<table>
<tr><td></td><td>Excretory System
SUB-TOPIC
Excretory organs in mammals and their products</td><td>TLM
Charts on excretory organs</td><td>Teacher uses the chart to describe the excretory organs and their products</td><td><table><tr><td></td><td>nitrogenous compounds</td></tr><tr><td>Liver</td><td>Bile pigment, urea, cholesterol</td></tr><tr><td>Skin</td><td>Mineral salts, water, traces of urea and CO_2</td></tr></table></td><td></td></tr>
<tr><td>WK</td><td>DURATION/ TOPIC/ SUB-TOPIC</td><td>OBJECTIVES / TLM</td><td>TEACHER-LEARNER ACTIVITY</td><td>CORE POINTS</td><td>REMARKS</td></tr>
<tr><td></td><td>DAY
Tuesday</td><td>OBJECTIVES</td><td>Teacher introduces the lesson by asking students questions</td><td>Ureter</td><td>1) Label the parts of the excretory system.</td></tr>
</table>

	DURATION 2hrs **TOPIC** Excretory System **SUB-TOPIC** Excretion	By the end of the lesson, the student should be able to: i) Describe the structure of the excretory system of humans. ii) Describe the functions of the urethra, ureter and the bladder.	on excretion to review their RPK. Teacher takes students through the structure of the excretory system. With the aid of chart of the excretory system, the teacher describes the functions of the ureter, urethra and the bladder.	Ureters are the tubes that transport urine from the kidneys to the bladder. There are two ureters in the human body, one connected to each kidney. **Urethra** The urethra is the tube that allows urine to pass outside the body. The brain signals the bladder muscles to tighten. This squeezes urine out of the bladder. **Bladder** The bladder is a triangular-shaped, hollow organ is located in the lower belly. It is held in	2) Describe the functions of the ureter, urethra and the bladder.

2		**TLM** Board illustration on the excretory system		place by two ligaments that are attached to other organs and the pelvic bones. The bladder's wall relaxes and expand to store urine. They contract and flatten to empty urine through the urethra.	
	DAY Thursday **DURATION** 2hrs **TOPIC** Excretory System	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Identify **the** parts of the kidney ii) Explain the **two main** function of the kidney	Review the RPK of students using questions Teacher uses the illustration to help students identify the parts of the kidney. With the aid of the illustration on the board, teacher explains	**Parts of the Kidney** Capsule, medulla, pyramid, cortex, ureter, renal artery, renal vein and pelvis. **Function of the Kidney** i) Excretory Functions The kidneys removed nitrogenous materials, excess water and salts from the body.	1) Identify the parts of the kidney. 2) Explain the two main functions of the kidney.

<table>
<tr><td></td><td>SUB-TOPIC
Kidney and its functions</td><td>TLM
Board illustration on kidney</td><td>the two main functions of the kidney</td><td>ii) Homeostatic functions
The kidneys balance and regulates the amount and concentration of water to mineral salts in the body. This is referred to as Osmoregulation.</td><td></td></tr>
<tr><td>WK</td><td>DURATION/ TOPIC/ SUB-TOPIC</td><td>OBJECTIVES / TLM</td><td>TEACHER-LEARNER ACTIVITY</td><td>CORE POINTS</td><td>REMARKS</td></tr>
<tr><td></td><td>DAY
Tuesday
DURATION
2hrs
TOPIC</td><td>OBJECTIVES
By the end of the lesson, the student should be able to:
i) Describe the processes involved in the formation</td><td>Teacher introduces the lesson by asking students questions on their RPK.
Teacher discusses with students the processes involve in urine formation.</td><td>Ultrafiltration
Ultrafiltration is the filtration of fluid from the blood in the nephron (Bowman’s capsule) under pressure.
Selective re-absorption
Selective re-absorption is the reabsorption into the blood useful metabolites like glucose and</td><td>1) Describe the processes involved in the formation of urine by the kidney in humans.</td></tr>
</table>

	Excretory System **SUB-TOPIC** Kidney	of urine by the kidney in humans. ii) Describe the functions of the afferent and efferent arteries, Glomerulus and collecting duct of the nephron. **TLM** Board illustration on the nephron	With the aid of board of the nephron, the teacher describes the functions of the afferent and efferent arteries, Glomerulus and collecting duct.	amino acid from the glomerular filtrate into the proximal tubule. **Functions of some Parts of the Nephron** ***Afferent and Efferent Arteries*** They are responsible for the production of pressure for ultrafiltration because of narrow nature of efferent branch than the afferent branch. ***Glomerulus*** This provides large surface area for filtration of blood that enters the kidney. ***Collecting duct*** It reabsorbs water according to the state of the body under the influence of ADH	2) Describe the functions of the afferent and efferent arteries, Glomerulus and collecting duct of the nephron.

3	**DAY** Thursday **DURATION** 2hrs **TOPIC** Excretory System **SUB-TOPIC** Kidney and its functions	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Identify **the** layers of the skin ii) Explain the functions of the skin **TLM** Chart illustration on the skin	Review the RPK of students using questions Teacher uses the illustration to help students identify the layers of the skin. With the aid of the illustration on the chart, teacher explains the functions of the skin.	**Layers of the Skin** Epidermis and Dermis. **Function of the Skin** ***i) Protection Functions***. It protects the body tissues and prevent injury to the tissues. ***ii) Sensory functions*** It is sensitive to touch, pain and temperature (heat and cold). ***iii) Excretory Functions*** It eliminates some urea, salts and water from the blood and excrete them in the form of sweat. ***iv) Homeostatic Functions***	1) Identify the layers of the skin. 2) Explain the functions of the skin.

				It helps to control our body temperature since the body loses or gains heat directly through the skin.	
WK	**DURATION/ TOPIC/ SUB-TOPIC**	**OBJECTIVES / TLM**	**TEACHER-LEARNER ACTIVITY**	**CORE POINTS**	**REMARKS**
	DAY Tuesday **DURATION** 2hrs **TOPIC**	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Identify the parts of the lungs in humans.	Teacher introduces the lesson by asking students questions on their RPK. Teacher discusses with students the parts of the lungs.	**Parts of the Lungs** Pharynx, larynx, trachea, alveoli, bronchi, bronchioles, mouth and nostril. **Functions of Lungs** They are responsible for the excretion of gaseous wastes from the body. The main waste gas excreted by the lungs is carbon dioxide,	1) Identify the parts of the lungs in humans. 2) Describe two functions of the

	Excretory System **SUB-TOPIC** Lungs	ii) The main function of the lungs. **TLM** Board illustration on the lungs	With the aid of board of the lungs, the teacher describes the functions of the lungs.	which is a waste product of cellular respiration in cells through the body. Carbon dioxide is diffused from the blood into the air in the tiny sacs called alveoli in the lungs. By expelling carbon dioxide from the blood, the lungs help maintain acid-base homeostasis. Water vapour is also picked up from the lungs and other organs of the respiratory tract as exhaled air passes over their moist linings and the water vapour is excreted along with the carbon dioxide.	lungs during excretion.
	DAY Thursday	**OBJECTIVES**	Review the RPK of students using questions	**Parts of the Liver**	

4	**DURATION** 2hrs **TOPIC** Excretory System **SUB-TOPIC** Liver and its functions	By the end of the lesson, the student should be able to: i) Identify **the** parts of the liver ii) Explain the functions of the liver **TLM** Board illustration on the Liver	Teacher uses the illustration to help students identify the parts of the liver. With the aid of the illustration on the board, teacher explains the functions of the liver.	Gallbladder, hepatic duct, cystic duct, spleen, hepatic artery, duodenum, pancreas, stomach and bile duct **<u>Function of the Liver</u>** The liver regulates most chemical levels in the blood and excretes a product called bile. This helps carry away waste products from the liver. All the blood leaving the stomach and intestine passes through the liver.	1) Identify the parts of the liver. 2) Explain the functions of the skin.

APPENDIX VII

LESSON NOTES FOR EXPERIMENTAL GROUP

<table>
<tr><th>WK</th><th>DURATION/ TOPIC/ SUB-TOPIC</th><th>OBJECTIVES / TLM</th><th>TEACHER-LEARNER ACTIVITY</th><th>CORE POINTS</th><th>REMARKS</th></tr>
<tr><td></td><td>DAY
Tuesday
DURATION
2hrs
TOPIC
Excretory System</td><td>OBJECTIVES
By the end of the lesson, the student should be able to:
i) Explain the concepts excretion and egestion.</td><td>Teacher introduces the lesson by asking students questions on excretion to review their RPK.
Teacher takes students through the concept of excretion and egestion.</td><td>Excretion is the process by which waste metabolic products are removed from the body of a living organism whiles Egestion is the removal of undigested food substances through the anus.
<table><tr><th>Excretion</th><th>Egestion</th></tr></table></td><td>1) Explain what is meant by excretion and egestion.
2) State four differences</td></tr>
</table>

	SUB-TOPIC Excretion and Egestion	ii) Identify **four** differences between excretion and egestion. **TLM** Charts, Models, Drawing & Pictures	With the aid of models of the excretory system, students were taught the differences between excretion and egestion	Removal of toxic waste from the body	Removal of undigested food	between excretion and egestion.
				Wastes are removed through lungs, skin, kidneys and liver	Undigested food substances removed through the anus	
				Products are excess water, CO_2, excess mineral salts,	Products are faeces and water	

<table>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td><table>
<tr><td>bile pigments and urea</td><td></td></tr>
<tr><td>Wastes are removed from the cells and tissues</td><td>Undigested foods are removed from the alimentary canal</td></tr>
</table></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DAY
Thursday
DURATION
2hrs
TOPIC</td>
<td>OBJECTIVES
By the end of the lesson, the student should be able to:
i) Identify four excretory organs and their products</td>
<td>Review the RPK of students using questions</td>
<td><table>
<tr><td>Organs</td><td>Products</td></tr>
<tr><td>Lungs</td><td>CO_2 and water</td></tr>
<tr><td>Kidneys</td><td>Water, urea, mineral salts, uric acid and other</td></tr>
</table></td>
<td>1) State four excretory organs and their products</td>
</tr>
</table>

	Excretory System **SUB-TOPIC** Excretory organs in mammals and their products	**TLM** Charts, Models, Drawing & Pictures on excretory organs	Teacher uses the chart to describe the excretory organs and their products	nitrogenous compounds Liver Bile pigment, urea, cholesterol Skin Mineral salts, water, traces of urea and CO_2	
WK	**DURATION/ TOPIC/ SUB-TOPIC**	**OBJECTIVES / TLM**	**TEACHER-LEARNER ACTIVITY**	**CORE POINTS**	**REMARKS**
	DAY Tuesday **DURATION**	**OBJECTIVES** By the end of the lesson, the student should be able to:	Teacher introduces the lesson by asking students questions on excretion to review their RPK.	**Ureter** Ureters are the tubes that transport urine from the kidneys to the bladder.	1) Draw and Label the parts of the excretory system.

	2hrs **TOPIC** Excretory System **SUB-TOPIC** Excretion	i) Describe the structure of the excretory system of humans. ii) Describe the functions of the urethra, ureter and the bladder. **TLM**	Teacher takes students through the structure of the excretory system. With the aid of drawings and models of the excretory system, the teacher describes the functions of the ureter, urethra and the bladder.	There are two ureters in the human body, one connected to each kidney. **Urethra** The urethra is the tube that allows urine to pass outside the body. The brain signals the bladder muscles to tighten. This squeezes urine out of the bladder. **Bladder** The bladder is a triangular-shaped, hollow organ is located in the lower belly. It is held in place by two ligaments that are attached to other	2) Describe the functions of the ureter, urethra and the bladder.

2		Charts, Models, Drawing & Pictures on the excretory system		organs and the pelvic bones. The bladder's wall relaxes and expand to store urine. They contract and flatten to empty urine through the urethra.	
	DAY Thursday **DURATION** 2hrs **TOPIC** Excretory System **SUB-TOPIC**	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Identify **the** parts of the kidney ii) Explain the **two main** function of the kidney **TLM**	Review the RPK of students using questions Teacher uses the illustration to help students identify the parts of the kidney. With the aid of the illustration on the board, teacher explains the two main functions of the kidney	**<u>Parts of the Kidney</u>** Capsule, medulla, pyramid, cortex, ureter, renal artery, renal vein and pelvis. **<u>Function of the Kidney</u>** i) Excretory Functions The kidneys removed nitrogenous materials, excess water and salts from the body.	1) Draw and Identify the parts of the kidney. 2) Explain the two main

	Kidney and its functions	Charts, Models, Drawing & Pictures illustration on kidney		ii) Homeostatic functions The kidneys balance and regulates the amount and concentration of water to mineral salts in the body. This is referred to as Osmoregulation.	functions of the kidney.
WK	**DURATION/ TOPIC/ SUB-TOPIC**	**OBJECTIVES / TLM**	**TEACHER-LEARNER ACTIVITY**	**CORE POINTS**	**REMARKS**
	DAY Tuesday **DURATION** 2hrs	**OBJECTIVES** By the end of the lesson, the student should be able to:	Teacher introduces the lesson by asking students questions on their RPK.	**Ultrafiltration** Ultrafiltration is the filtration of fluid from the blood in the nephron (Bowman's capsule) under pressure. **Selective re-absorption**	1) With drawings describe the processes involved in the formation of urine

	TOPIC Excretory System **SUB-TOPIC** Kidney	i) Describe the processes involved in the formation of urine by the kidney in humans. ii) Describe the functions of the afferent and efferent arteries, Glomerulus and collecting duct of the nephron. **TLM** Charts, Models, Drawing & Pictures illustration on the nephron	Teacher discusses with students using models and drawings to explain the processes involve in urine formation. With the aid of models and drawings of the nephron, the teacher describes the functions of the afferent and efferent arteries, Glomerulus and collecting duct.	Selective re-absorption is the reabsorption into the blood useful metabolites like glucose and amino acid from the glomerular filtrate into the proximal tubule. **Functions of some Parts of the Nephron** ***Afferent and Efferent Arteries*** They are responsible for the production of pressure for ultrafiltration because of narrow nature of efferent branch than the afferent branch. ***Glomerulus***	by the kidney in humans. 2) Draw and describe the functions of the afferent and efferent arteries, Glomerulus and collecting duct of the nephron.

3				This provides large surface area for filtration of blood that enters the kidney. ***Collecting duct*** It reabsorbs water according to the state of the body under the influence of ADH	
	DAY Thursday **DURATION** 2hrs **TOPIC**	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Identify **the** layers of the skin	Review the RPK of students using questions Teacher uses the drawings and models to help students identify the layers of the skin.	**Layers of the Skin** Epidermis and Dermis. **Function of the Skin** ***i) Protection Functions***. It protects the body tissues and prevent injury to the tissues.	1) Identify the layers of the skin.

	Excretory System **SUB-TOPIC** Kidney and its functions	ii) Explain the functions of the skin **TLM** Chart illustration on the skin	With the aid of the illustration on the chart, teacher explains the functions of the skin.	***ii) Sensory functions*** It is sensitive to touch, pain and temperature (heat and cold). ***iii) Excretory Functions*** It eliminates some urea, salts and water from the blood and excrete them in the form of sweat. ***iv) Homeostatic Functions*** It helps to control our body temperature since the body loses or gains heat directly through the skin.	2) Explain the functions of the skin.
WK	**DURATION/ TOPIC/ SUB-TOPIC**	**OBJECTIVES / TLM**	**TEACHER-LEARNER ACTIVITY**	**CORE POINTS**	**REMARKS**

	DAY Tuesday **DURATION** 2hrs **TOPIC** Excretory System **SUB-TOPIC** Lungs	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Identify the parts of the lungs in humans. ii) The main function of the lungs. **TLM** Charts, Models, Drawing & Pictures on the lungs	Teacher introduces the lesson by asking students questions on their RPK. Teacher discusses with students using models and drawing of the parts of the lungs. With the aid of drawings and models of the lungs, the teacher describes the functions of the lungs.	**<u>Parts of the Lungs</u>** Pharynx, larynx, trachea, alveoli, bronchi, bronchioles, mouth and nostril. **Functions of Lungs** They are responsible for the excretion of gaseous wastes from the body. The main waste gas excreted by the lungs is carbon dioxide, which is a waste product of cellular respiration in cells through the body. Carbon dioxide is diffused from the blood into the air in the tiny sacs called alveoli in the lungs.	1) Draw and identify the parts of the lungs in humans. 2) Describe two functions of the lungs during excretion.

				By expelling carbon dioxide from the blood, the lungs help maintain acid-base homeostasis. Water vapour is also picked up from the lungs and other organs of the respiratory tract as exhaled air passes over their moist linings and the water vapour is excreted along with the carbon dioxide.	
4	**DAY** Thursday **DURATION** 2hrs	**OBJECTIVES** By the end of the lesson, the student should be able to:	Review the RPK of students using questions	**Parts of the Liver** Gallbladder, hepatic duct, cystic duct, spleen, hepatic artery, duodenum, pancreas, stomach and bile duct	1) Identify the parts of the liver.

	TOPIC Excretory System **SUB-TOPIC** Liver and its functions	i) Identify **the** parts of the liver ii) Explain the functions of the liver **TLM** Charts, Models, Drawing & Pictures on the Liver	Teacher uses the models and drawings to help students identify the parts of the liver. With the aid of the models, and drawings of the liver, teacher explains the functions of the liver.	**<u>Function of the Liver</u>** The liver regulates most chemical levels in the blood and excretes a product called bile. This helps carry away waste products from the liver. All the blood leaving the stomach and intestine passes through the liver.	2) Explain the functions of the skin.

APPENDIX VIII

TEACHING NOTES ON EXCRETORY SYSTEM

Excretion

Excretion is the process by which waste metabolic products or substances are removed from the body or cells of living organisms.

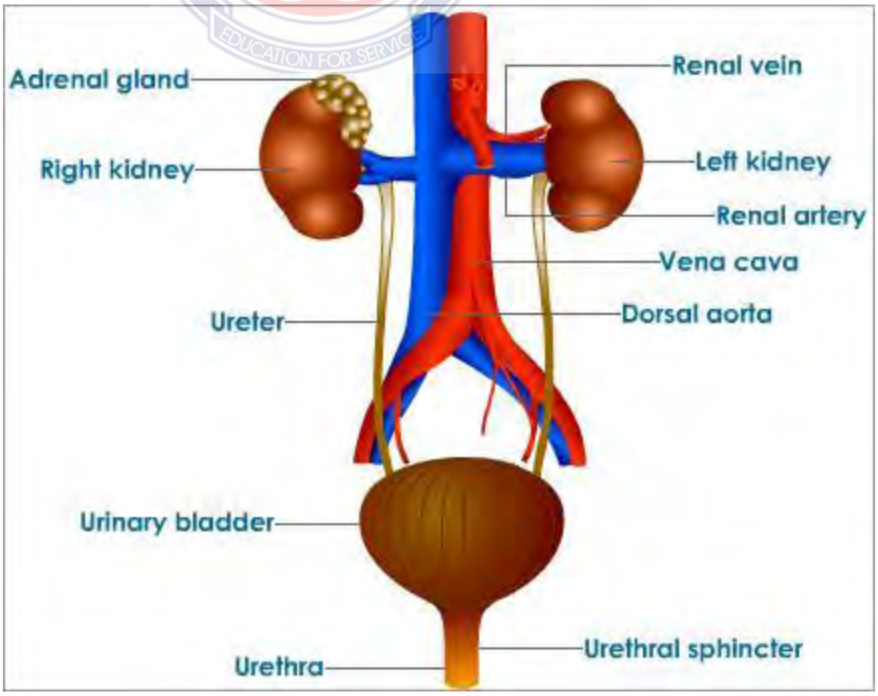
Examples of metabolic products (substances)

Carbon dioxide, excess water, Urea, Mineral salts, Uric acid, cholesterol, Bile pigments and other nitrogenous compounds.

The Excretory organs in mammals

Mammals have four (4) main excretory organs. These are lungs, liver, skin and the kidney.

These special organs with their structures form the excretory system of mammals.



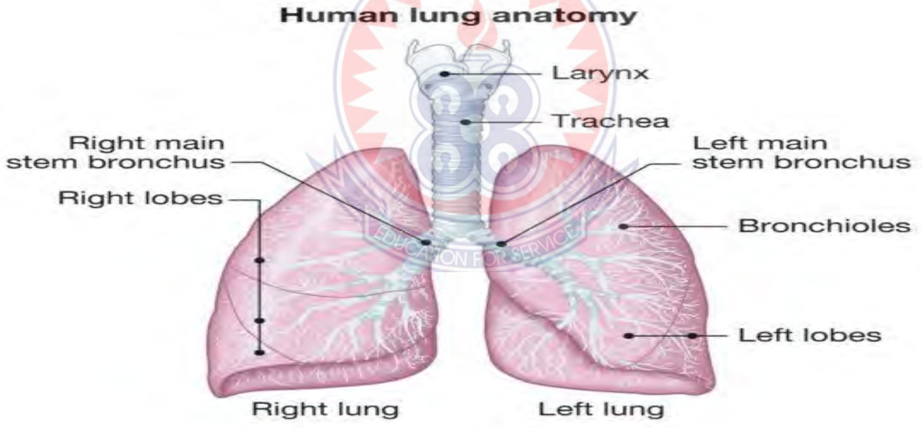
Human Excretory System

Excretory Organs and their associated Excretory Products

Excretory Organ	Associated Excretory Product
Lungs	Carbon dioxide and water
Kidneys	Water, urea, mineral salts, uric acid and other nitrogenous compounds
Liver	Bile pigments, urea and cholesterol
Skin	Mineral salts, water, traces of urea and carbon dioxide

The Structure and Functions of the excretory organs

The Lungs



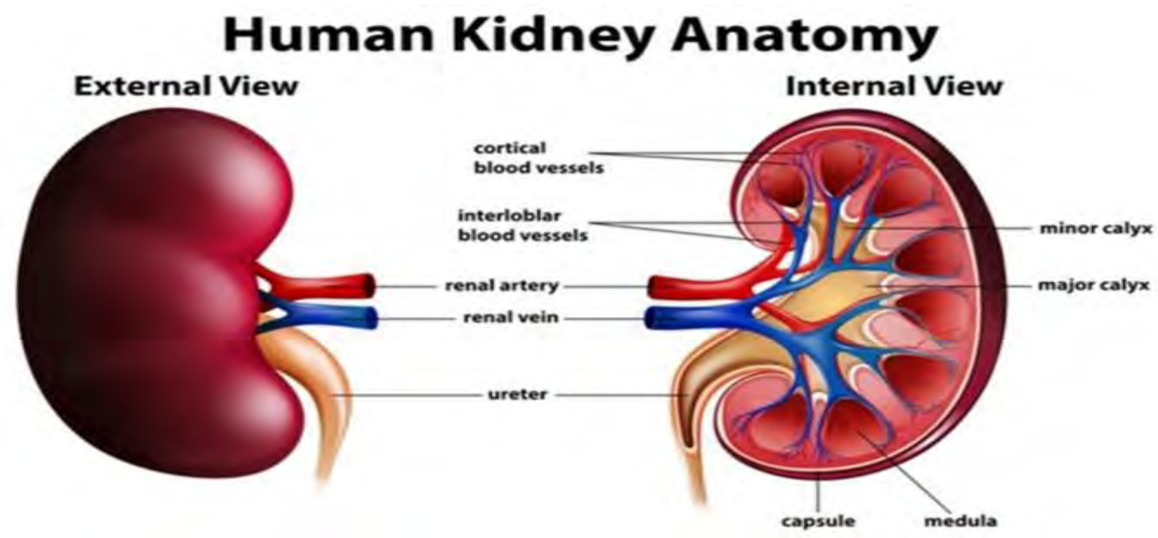
The lungs allowed blood to pick up oxygen and get rid of carbon dioxide. The lungs are able excrete carbon dioxide. Carbon dioxide is carried by the blood into the capillaries and around the alveoli. It passes out of the blood in the alveoli. It is then expelled from the lungs when we breathe out.

The lungs perform two main functions:

- Gaseous exchange (intake of oxygen and output of carbon dioxide and water vapour).

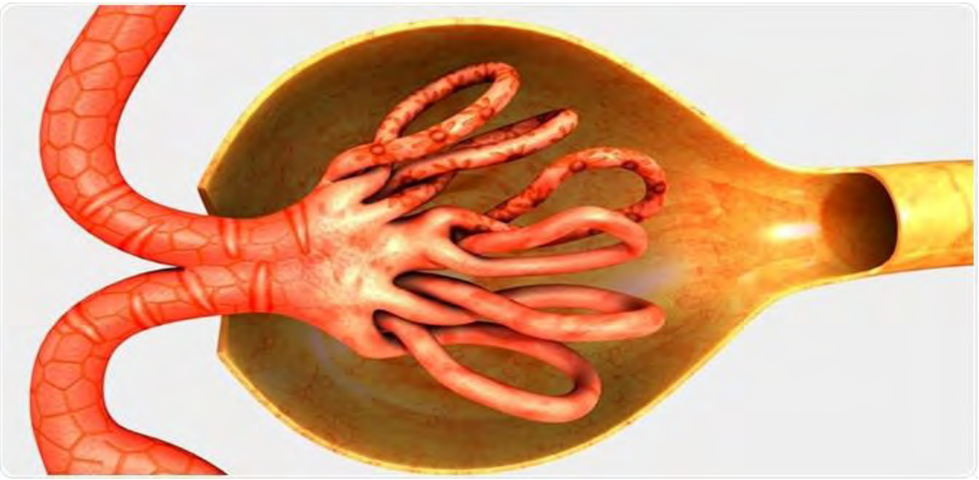
- Excretion of carbon dioxide and water vapour.

The Kidneys



The internal structure of a mammalian kidney has two main regions known as the cortex (a darker outer region) and the medulla (a lighter inner region). A tough layer which surrounds the cortex is called capsule. Each kidney is made up of thousands of tubules called nephrons (urinary or kidney tubules).

A Nephron of the Kidney



Functions of the Kidney

The kidneys carry out two main functions

i. *Excretory functions*

They remove nitrogenous materials, excess water and salts from the body.

The blood entering the kidneys undergoes ultra-filtration in Bowman's capsule to produce glomerular filtrate which moves into the first coiled tube. Glomerular filtrate contains water, urea, mineral salts as well as glucose, vitamins and amino acids. Blood proteins and blood cells are excluded in filtrate because they do not pass through the bowman's capsule. In the proximal tube all glucose, a lot of water and salts are reabsorbed by osmosis. In the distal tubule there is re-absorption of water to maintain appropriate pH level. The remaining part of the filtrate is urine, containing water, urea and salt.

ii. *Homeostatic functions*

The kidneys balance and regulates the amount and the concentration of water to mineral salt in the body. This is referred to as osmoregulation. After formation of urine, there is rise in the osmotic pressure of the blood with very little water in the blood. When this happens, the osmoreceptor in the brain becomes stimulated and causes the release of anti-diuretic hormone (ADH) to be sent to the kidney. ADH then stimulates the re-absorption of water in the tubules of the kidney from the urine. This forces osmotic pressure to go down resulting in concentrated and scanty urine.

As osmotic pressure of blood falls, no ADH is released and less water is reabsorbed from the urine. This causes osmotic pressure to rise with the result that more water is in urine and hence dilute and large quantity of urine is passed.

Formation of Urine by the Kidney

There are two major processes involved in urine formation by the kidney. These are the ultrafiltration and selective reabsorption.

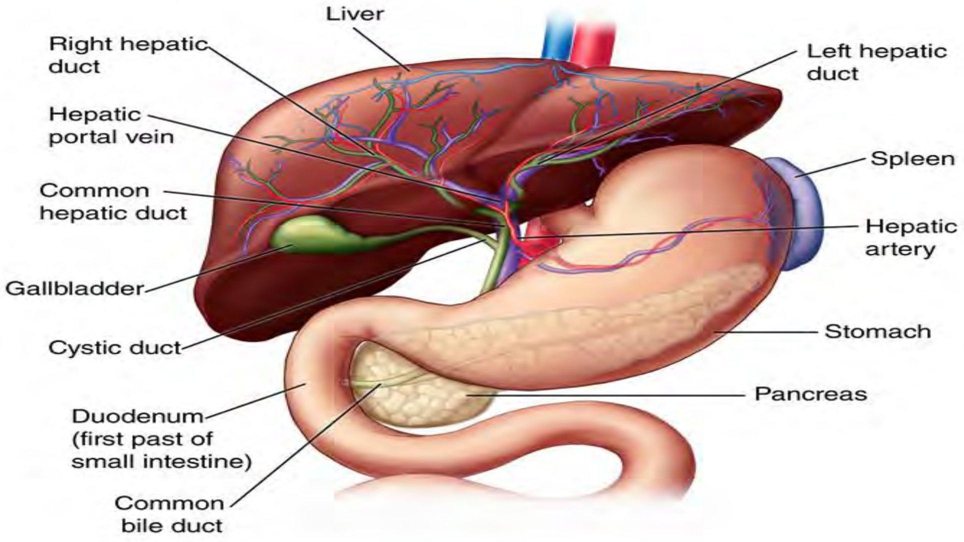
Ultrafiltration

It is the first process involved in the formation of urine. Ultrafiltration is the filtration of fluid from the blood in the nephron / bowman capsule under pressure. Ultrafiltration takes place between the capillaries in the glomerulus and the Bowman's capsule. As a result of the narrow nature of the efferent arteriole as compared to the afferent arteriole, a high pressure is created in the glomerulus. This causes certain substances to filter through the two thin layers of cells separating the cavity of the capsule from the capillaries. Filtered substances include amino acids, glucose, water, mineral salts, vitamins, urea and uric acids. Blood cells and protein are not filtered.

Selective-reabsorption

This is the second step involves the reabsorption into the blood useful metabolites like glucose and amino acids from the glomerular filtrate in the proximal tubule. The re-absorption processes include passive diffusion and active transport. Here, the microvilli of the cells lining the lumen of the tubule provide a large surface area so as to aid re-absorption. A great deal of water is also re-absorbed by osmosis. The concentrated filtrate passes into Loop of Henle and the distal tubule (second convulated tubule) in which re-absorption of salts and water is regulated. If the blood has lower amount of water, may be through excessive sweating, equilibrium may be restored by the tubule absorbing water. On the other hand, the tubule also adjusts the blood pH to between 7.3 and 7.4 by the exchange of ions if there is a rise in acidity or alkalinity of the blood.

THE LIVER



The liver is a major organ only found in vertebrates which performs many essential biological functions such as detoxification of the organism and the synthesis of proteins and biochemicals necessary for digestion and growth. In humans, it is located in the right upper quadrant of the abdomen, below the diaphragm. Its other metabolic roles include carbohydrate metabolism, the production of hormones and substances such as glucose and glycogen, and the decomposition of red blood cells. The liver is an accessory digestive organ that produces bile, an alkaline fluid containing cholesterol and bile acids, which helps the breakdown of fat. The gallbladder, a small pouch that sits just under the liver, stores bile produced by the liver which is later moved to the small intestine to complete digestion. The liver's highly specialized tissue, consisting mostly of hepatocytes, regulates a wide variety of high-volume biochemical reactions, including the synthesis and breakdown of small and complex molecules, many of which are necessary for normal vital functions.

Estimates regarding the organ's total number of functions vary, but is generally cited as being around 500.

Functions of the Liver

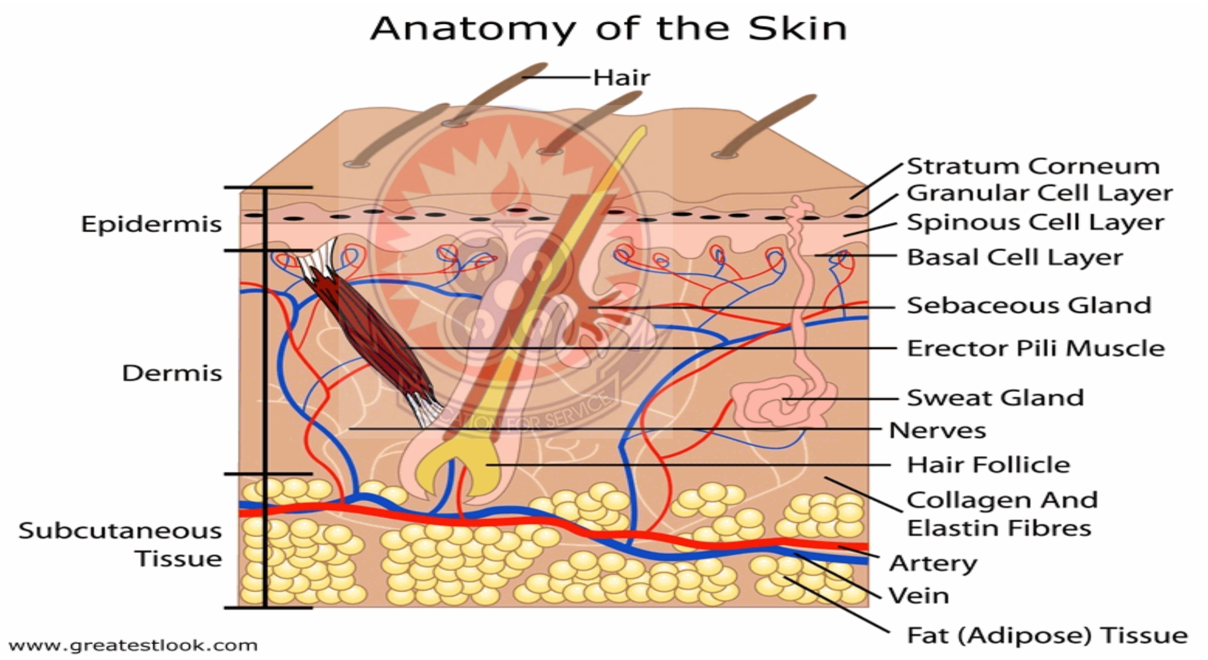
The liver regulates most chemical levels in the blood and excretes a product called bile. This helps carry away waste products from the liver. All the blood leaving the stomach and intestines passes through the liver. The liver processes this blood and breaks down, balances, and creates the nutrients and also metabolizes drugs into forms that are easier to use for the rest of the body or that are nontoxic. More than 500 vital functions have been identified with the liver. Some of the more well-known functions include the following:

- Production of bile, which helps carry away waste and break down fats in the small intestine during digestion
- Production of certain proteins for blood plasma
- Production of cholesterol and special proteins to help carry fats through the body
- Conversion of excess glucose into glycogen for storage (glycogen can later be converted back to glucose for energy) and to balance and make glucose as needed
- Regulation of blood levels of amino acids, which form the building blocks of proteins
- Processing of haemoglobin for use of its iron content (the liver stores iron)
- Conversion of poisonous ammonia to urea (urea is an end product of protein metabolism and is excreted in the urine)
- Clearing the blood of drugs and other poisonous substances
- Regulating blood clotting

- Resisting infections by making immune factors and removing bacteria from the bloodstream
- Clearance of bilirubin, also from red blood cells. If there is an accumulation of bilirubin, the skin and eyes turn yellow.

When the liver has broken down harmful substances, its by-products are excreted into the bile or blood. Bile by-products enter the intestine and leave the body in the form of faeces. Blood by-products are filtered out by the kidneys, and leave the body in the form of urine.

THE SKIN



The mammalian skin is made up of two layers

- Outer or upper layer called **epidermis**
- Inner or lower layer called **dermis**

The **epidermis** consists of three regions

- Cornified or Horny layer: This is an upper, thin region made up of flat and dead cells which continuously flake off.

- Granular layer: This layer is below the upper cornified layer. It is made up of living cells produced by the lower Malpighian layer. These living cells are gradually pushed outwards as new cells accumulate beneath them. They later replace the outer skin as they lose their nuclei and die.
- Malpighian layer: Below the granular is the Malpighian layer which is a continuous layer of one or two cells thick. They divide continually producing new epidermis. Malpighian layer contains **melanin,** a pigment responsible for the skin colour.

The **dermis** lies below the epidermis.

It is a layer of connective tissues with fewer cells and a lot of fibres. The fibres are tough, thus making the skin elastic. The dermis contains blood capillaries, nerves, vessels, sweat glands, hair follicles, adipose cells, erector muscles and sebaceous glands.

Functions of the Skin

Protection function

It protects body tissues in a number of ways. It can withstand some mechanical injuries and also protects the underlying tissues. Protective organs or structures include the horny layer, melanin, sebaceous gland and epidermis. The dermis forms an elastic barrier which stops germs and other disease-causing organisms from entering the body. It also prevents loss of water and keeps essential water inside the body.

Sensory function

It is sensitive to touch, pain and temperature (heat and cold). The skin contains groups of sensory cells (receptors). Some receptors are sensitive to touch, some to pain and others to heat and cold and so protects the body from being harmed. Each receptor is connected to a nerve which carries impulses to the brain. Sensory structure includes the **nerve endings.**

Excretory function

The sweat glands of the skin are able to eliminate some urea, salts and water from the blood and excrete them in the form of sweat. Excretory organs include **sweat glands and sweat pores.**

Homeostatic / Thermoregulatory function

The skin helps control our body temperature since the body loses or gains heat directly through the skin. Warm-blooded animals have various keeping their bodies at a more or less constant temperature.