UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECTS OF GUIDED DISCOVERY STRATEGIES ON STUDENTS` ATTITUDE AND PERFORMANCE IN TWO SELECTED TOPICS IN PRACTICAL BIOLOGY

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DECLARATION

Student's Declaration

I, **EDITH AFARAWOYE AWONONG**, declare that this Thesis, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my original work and that it has not been submitted, either in part or whole, to any institution anywhere for any academic purposes.

SIGNATURE: ……

DATE: ……

Supervisor's Declaration

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

NAME OF SUPERVISOR: DR. JAMES AWUNI AZURE

SIGNATURE: ……

DATE: ……

DEDICATION

This work is dedicated to Cletus Danliar Banseh, Pierry Babachuwe Banseh and Anulam Berenice Banseh who have been my source of inspiration and helped in various ways to make this work a success.

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ABSTRACT

The purpose of this study was to teach students with the guided discovery strategies to enhance their academic performance in biology. The study used guided discovery strategies as intervention to improve the academic performance of biology students at St. Margaret Mary Senior High School in the Greater Accra Region of Ghana. The study employed a quasi-experimental research design. The researcher did biology practical on two selected topics, experiment to show that osmosis occurs in a living tissue, and experiment to show the percentage of air in different types of soil. An intact class of 63 form one science students constituted the sample. Data were collected using test items, questionnaire and interview. Data collected from the study was analysed both quantitatively and qualitatively. The findings of the study showed that the academic performance of the experimental group, that is, students taught using the guided discovery performed better than those in the control group. This is an indication that students taught guided discovery method performed significantly better than those taught with the traditional method. The performance of students improved after the treatment. The implications for teaching and learning are that, guided discovery strategies make science classroom more realistic as students are actively involved. Students also learn to be responsible for their learning.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter discusses the background to the study, statement of the problem, purpose of the study, objectives, and research questions. Furthermore, the chapter looks at the significance of the study, limitations, delimitations and organisation of the study.

1.1Background to the Study

Biology is offered in all senior high schools and it attracts the greatest number of both science-oriented and general arts students. Biology is a practical based subject, which equips students with concepts and skills that are useful in solving the day to day problems of life. The study of biology aims at providing the learner with necessary knowledge with which to control or change the environment for the benefit of an individual, family or community. In general, the importance of biology to humanity can be outlined as follows:

- The learning of Biology helps us to know how to use natural resources more efficiently in industry e. g in bio-technology, food production, building and textile and paper industries.
- The learning of biology helps us to understand changes in the environment and the factors affecting these changes, in order to know how human needs are influenced.
- The learning of biology is important in helping humankind to find effective ways of preventing, treating and curing diseases and home management techniques e.g better methods of food preservation, efficient food preparation, and care of the family.

- The learning of biology is important in helping the improvement of agricultural yields through scientific innovations.

However, it is a common practice that most students choose biology either as one of the science subjects they offer or as the only science subject. Most of these students choose biology not because they have interest in biology but because they see it as the easiest science subject when compared with chemistry or physics. For this reason, they perform poorly in biology examinations. A close look at 2015 -2019 SSCE results confirms that students` performance has been very poor generally and particularly in biology practical , failure is a great problem as it affects the students achievement.

In spite of the importance and usefulness attached to biology, students have reportedly achieved poorly in public examinations in biology. The chief examiner's reports (WAEC, 2012-2021) show that students' achievement in Senior School Certificate Examination (SSCE) May/June in Biology has not been encouraging. The percentage of passes for some years are not good enough especially for candidates that want to study biological sciences and biology based courses. The need for designing instructions that promote better understanding of scientific concepts is very important to the development of science education (NRC, 2000). The performance of students in Biology is a result of poor and ineffective instructional skills and methodologies by Biology teachers. In view of these, teaching of biology requires that biology teachers at the senior secondary school level should have a sound knowledge of the appropriate method of teaching biology as this will improve Students' achievement. One of the challenges in teaching is to create experiences that will involve students and support their own thinking, explanation, evaluation, communication, and application of the scientific models needed to make sense of

these experiences (Afolabi & Akinbobola 2009). According to NRC (2000), the need to design instructions that promote better understanding of scientific concepts.

This research in science education has discovered better methods of teaching science that are not only superior to the traditional method but also have the potential to promote achievement and retention of what is learned and also inculcate positive scientific attitudes in students. Various studies on methodology of science teaching such as inquiry, discovery and process approach have shown that students learn more from science lesson by doing rather than mere observation. The Researcher's interactions with some senior high school science students revealed that students over- depend on teachers for information. Most of the students do not participate in science lessons actively and as such cannot comprehend scientific concepts. They are forced to participate in the lessons for the sake of examinations. In teaching towards understanding of major concepts in biology and achieving conceptual change in students learning outcome, it is first necessary to understand student`s prior knowledge, examine it and then provide opportunities for old and new ideas to be used.

This calls for better instructional methods such as guided discovery strategies. Guided discovery (GD) method of teaching involves guiding students to seek information. Teachers serve as facilitators of learning in which students are encouraged to be responsible, autonomous and construct their own understanding of scientific concepts. Guided discovery approaches allow students to become independent thinkers and are ready to accept responsibilities. Nwagbo (2006) points out that if learners are allowed to discover relationships and solutions to problems and make their own conclusions then, they are better prepared to make wider application

of the materials learned. Guided discovery strategies has positive impact on students' learning outcomes in that it provide students' with investigative and reflective skills that could be applied in other subject areas, build on student prior knowledge and experience, encourage independent learning, enhance students mental efficiency and help them to overcome obstacles, thereby gaining knowledge by themselves. In addition guided discovery strategy provides for individual differences as well as makes the process of learning to be self-sequenced, goal directed, pace self-determined, build initiative, confidence, imagination and creative abilities of students. From the above, the Researcher concluded that guided discovery learning strategies equip students with skills that with enable those to be independent, creative and lifelong learners needed to copy with modern trend of education.

1.2 Statement of the Problem

Teaching is a constantly evolving practice where research is being performed to find the best practices. For the past eight years, the researcher has been a biology teacher at the senior high school and has observed that biology practical lessons are not carried out in most schools (Serwaa-Ampaafo 2017). The teaching of biology in senior high schools generally appears to be through lectures, note-taking, chalkboard illustrations and other teacher-centred methods. These methods do not actively involve the students in problem solving processes as they are predominantly passive. It therefore appears to inhibit the development of students` intuition, initiative, imagination and creative abilities. This leads to poor achievement in practical biology in schools. This was supported by the West Africa Examination Council Chief Examiners Annual Report from 2017 to 2021. A close look at the 2015- 2020 results records confirms that students performers has been very poor generally and particularly in biology practical.

This could be attributed to lack of well-equipped laboratories in some schools, inadequate funds to buy things and specimen for biology practical and lack of qualified biology teachers. Serwaa-Ampaafo (2017) conducted a research on students` performance in practical test and reported that majority of the elective biology students performed poorly in biology practical test. This is because practical biology lesson in a typical Ghanaian classroom is dominated with lecture style of talk and chalk method that has not changed for decades. This teaching method has led to abstractness which makes the students less active and engages them in memorisation. Practical experience in any science subject is crucial for the real understanding of principles and applications of knowledge. Due to several constraining factors ranging from facilities to teachers and learners characteristics and effort, the required practical experiences are not usually possible in most schools. There is a Chinese proverb which states that, I hear I forget, I see I remember, I do I understand". This applies to our situation in Ghana where biology lessons are taught in abstract; students only listen to their teachers but do no practice.

Also, Tordzro, Asamoah and Ofori (2021) conducted a research and their findings of the study revealed that 5% of the students from well -endowed schools, as against 40.5% of those from less -endowed schools, indicated that they had poor attitudes towards Biology practical lessons. It was also reported that practical lessons in Biology, in both well-endowed and less- endowed Senior High Schools were greatly impeded by lack of proper laboratory, lack of laboratory assistants /technicians and inadequacy of practical equipment and materials for practical work.

Biology practical work to students helps them in critical thinking skills, problem-solving skills and engagement of students and these skills together with attitude

towards team work communication and perseverance are fostered in discovery learning.

Practical experience in any science subject is crucial for the real understanding of principles and concepts as students will interact with materials to discover things on their own and have better understanding of theories and concepts. Guided discovery methods are precursor to learning by students as these methods make them participate actively in the act of learning activities. Hence the need to investigate the effects of guided discovery strategies on students' performance in experiment to show that osmosis occurs in a living tissue and experiment to show that soil contains air.

1.3 Purpose of the study

The purpose of the study was to determine the effect of guided discovery strategies on students` attitude and academic performance in some selected topics in practical biology.

1.4 Objectives of the Study

The objectives of the study were to:

1. Examine the effects of guided discovery instructional method on students' academic performance in two selected practical topics in biology.
2. Determine the effects of the use of guided discovery strategies on student`s attitude towards practical work in biology.
3. Examine the challenges teachers face in using the guided discovery strategies in the laboratory.
4. Examine the benefits of practical work to students in their studies.

1.5 Research Questions

The following research questions underpinned the study:

1. What is the effect of guided discovery strategies on student`s academic performance in two selected practical topics?
2. What is the effect of the use of guided discovery strategies on students` attitude towards practical work in Biology?
3. What is the challenges biology teachers' face when using guided discovery strategies in conducting practical work?
4. What are the benefits of practical work to students in their studies?

Null Hypothesis

There is no significant difference in academic performance between students taught biology using guided discovery method and their counterparts taught using the traditional lecture method.

1.6 Significance of the Study

Theoretically, the Piagets' theory of cognitive development explains that when a child recognises cognitive conflict, it is called the process of resolving conflict `equilibration". The findings and recommendations of this study may serve as useful guidelines for teachers, students, school administrators and educational researchers. With regard to the teachers, the outcome of the study may serve as guide for them to in cooperate guided discovery instructional approach which leads to self-learning into their teaching processes.

The research would help science teachers to realize that their role in teaching and learning science is not to transmit information but to serve as facilitators for learning which includes creating and managing meaningful and impactful learning experiences. To the students, the use of guided discovery approach and self-learning

would make them to be self-independent, discipline, able to take initiatives and plan their own studies. This would enhance students' academic performance in class exercises, tests, assignments and external examinations in biology. The students would also acquire lifelong learning skills needed for solving challenges. The study would help educational curriculum designers to place more emphasis on scientific inquiry skills when developing science curriculum. The study will help educational stakeholders to play their part of equipping secondary schools with the necessary equipment for the teaching of biology by discovery method.

1.7 Delimitations

Dusick (2011) stated that delimitations are characteristics selected by the researcher to define the boundaries of the study. He further explained that it involves delineating properly the boundaries of the study, that is, what will be covered and what will not be covered in the study in question. It is a way of trying to bring the problem into sharp focus. In the light of the above, the following were the delimitations of the study:

There are several methods of teaching science but guided discovery strategies has been selected on the basis of current practices where there is the need for students to be independent in order to cope with the influx of technological advancement in this modern age. The study was restricted to St. Margaret Mary Senior High School in the Greater Accra Region. This was due to proximity and accessibility of the research subjects and also as a teacher in the school. The study was also restricted to SHS1 because adequate time was needed to prepare them and monitor their performance with time before they write the final examination. The study focused on guided

discovery method of instruction on practical biology. Finally, curriculum content was limited to some selected practical topics.

1.8 Limitations

Simon and Goes (2013) point out that limitations are potential weaknesses in research study and are out of the researcher's control. They are the shortcomings, conditions or influences that cannot be controlled by the researcher that place restrictions on the methodology and conclusions. The study was limited to two schools in the in the district. Also not all forms of guided discovery strategies were employed in the teaching and learning processes. In this study, there was some minimum guidance provided by the researcher. Another limitation was related to the absenteeism on the part of some of the students. Some students absented themselves from school due to truancy at the time of intervention and this may introduce error and the results of the study would be affected. Another limitation was that, the sample was obtained from one particular year group so the results cannot be applied to all schools within the district.

1.9 Organisation of the Study

This thesis is organized in five chapters. Chapter one deals with introduction to the study. It includes background to the study, statement of the problem, purpose of the study, objectives, research questions and significance of the study. It also covers limitations and delimitations. Chapter two deals with literature review. It looks at the concept of guided discovery, the importance of questions in guided discovery science lessons, the role of the teacher in guided discovery lessons and the impact of guided discovery method in science lessons. Chapter three discusses the methodology of the study. It explains the choice of the research method and experimental design and

explained how the population and sampling technique. It also covered the instruments used for data collection, validity and reliability of the research instruments. Chapter four focuses on the analysis of the data and discussion of the findings while chapter five covers the summary of findings, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The chapter reviews related literature on the effect of guided discovery instructional strategy which lead to self-learning on students' academic performance. The topical issues under which literature was reviewed include the features of guided discovery and the importance of questions in guided discovery science lesson. Other areas looked at were role of the teacher in guided discovery lessons, the impact of guided discovery method in science lesson. The chapter further discussed theoretical framework and conceptual model of the study.

2.1 The Concept of Guided Discovery (GD)

Discovery learning takes place in problem solving situations where the learner draws his or her own experience from or performing experiments as suggested by the Grauer School, Learn by Discovery (Grauer, 2016). Discovery method of teaching is an instructional strategy that is useful in teaching biology because it is an activity designed in such a way that students performed certain mental processes in an attempt to find a lasting solution to a problem. Discovery method can be of two types, guided discovery and unguided discovery.

According to Sekyere (2013) there are two types of guided discovery: inductive and deductive. The inductive method according to Sekyere (2013) leads students to discover what is to be established through questions and answers and experiments. He further explains that the teacher questions students and leads them to make the generalisation and abstraction.

However, the deductive method according to Sekyere (2013) makes a statement or fact about something and students are led to prove the validity of the statement through questions and answers, and experiment. This study applies inductive method because it has an advantage over deductive method in that students do not easily forget their findings or discoveries. Guided discovery has some features to follow during lessons The researcher used the guided discovery method because the researcher devises series of statements that guided the learners in making series of discoveries. The researcher also initiated a stimulus and the learner reacts by engaging in inactive inquiry and discovers the appropriate response.

Guided discovery is one of those teaching methods that employ exploration, manipulation and experimentation to find out new ideas: it is a problem solving oriented method (Akuma, 2008). Guided discovery instructional strategy, is characterized by convergent thinking. The instructor devises a series of statements or questions that guide the learner, step by logical step, making series of discoveries that leads to a single predetermined goal. In other words, the teacher initiates a stimulus and the learner reacts by engaging inactive inquiry thereby discovering the appropriate response. Extensive review of the literature by Dejong and Jooling (2003) showed that generally speaking, guided simulation discovery leads to better results than non-guided ones. It aided better understanding of concepts and of course better training for the the discovery process itself (Dejong & Jooling, 2003). According to Okoye (2004) and Nwagbo (2004), during the early 70`s , the rational for science teaching shifted as discovery strategy was adopted worldwide. This was because students tended to memorized facts and concepts, most of which they did not understand. This resulted in lack of retention and application of concepts.

The guided discovery strategy is activity oriented and involves practical demonstration, discussion and experimentation. During such instruction, the students employ the processes of science like observation, classification, investigation and critical interpretation of findings. In biology, it is possible for guided discovery strategy of teaching to be enhancing students` performance. This is because of the activity oriented nature of the guided discovery strategy (Okoye, Momoh, Aigbomain, & Okecha, 2008).

According to Eggen and Kanchak (2001) guided discovery approach of teaching is a form of problem based instruction which emphasizes on students' active involvement in the learning. Guided discovery method is a teaching technique that encourages students to take a more active role in the learning process by answering a series of questions or solving problems designed to introduce a general concept (Mayer, 2003). Guided discovery method is a teaching method in which the principal content of what is to be learned is not given but must be discovered by the learners.

This method involves guiding students to seek information .It has been observed that science teachers play important role in the implementation of guided discovery method, which faces many difficulties especially during the implementation process. Chang(2007) listed some of these obstacles often experienced during implementation of guided discovery method in a study with biology teachers. They are crowded class, insufficient time, scarcity of effective research materials, scarcity of teaching materials etc.

Moreover, Chang (2007) is of the opinion that guided discovery method is an approach to inquiry. The teacher provides illustrative materials for students to study on their own. Leading questions are then asked by the teacher to enable students think

and provide conclusions through the adoption of the processes of science. Nwagbo (2006) points out that if learners are allowed to discover relationships and solutions to problems and make their own conclusions then, they are better prepared to make wider application of the materials learned. It is the intention of the researcher that activity based science will allow learners to explore the environment and discover nature. The teacher plays the role of a research person who guides the learners to sources of information. The most important feature of this method is that it enables both the teacher and learners to be researchers and problem solvers.

Furthermore it has some positive influence on students academics by making them proactive, developing their understanding of the nature of science. This teaching method increases retention of material learnt because the students organize the new information and integrate it with information that has already been stored (Gallenstien, 2004). From the above views, the researcher concluds that guided discovery allows students to take the lead in their own learning experiences. The teacher serves as a facilitator or a resource person whose role is to guide, motivate, stimulate, clarify, explained, and makes it possible for the learners to mutually agree upon goals. The idea is that students are more likely to remember concepts they discover on their own than those forced on them. In a nutshell, guided discovery is defined as an instructional method based on leading questions and problem-forming that guide students to obtain knowledge and discover relations and concepts by getting involved in the classroom interaction where the researcher helps them to be more active and more responsible for their learning.

2.2 Features of Guided Discovery

Westwood (2008) identifies the following as features of guided discovery. These are: students are required to investigate a topic or problem by active means, obtain relevant information, interpret causes and effects and arrive at conclusions. It is more effective when the process is carefully structured and students have prerequisite Knowledge and skills on the topic to be treated. Guided discovery is enhanced by various tools. According to Westwood (2008) one of these tools is simulation. In Westwood's view, simulation happens when the teacher provides students with examples and hints that help them to understand certain concepts. Reichert (2005) identifies scaffolds as one of the features of guided discovery. To Reichert (2005) scaffolds mean the necessary support and guidance provided by the teacher to the students as they engage in learning activities in order to reach the discovery in the form of conclusions and principles.

Mayer (2004) points out that, guided discovery can be a very time-consuming method, often taking much longer for information to be acquired than would occur with direct teaching. Jo (2010) explains that the discovery method does not always work. The class size, the ages of the students, or the amount of material that must be covered, may make it inadvisable. But, Jo (2010) is also of the view that when conditions are right, the discovery method can ignite students; enthusiasm for mathematics and science as no other method, and that it can give them the confidence and the power to independently discover, question, analyses, and conquer, new ideas. He therefore suggests that the materials must be carefully planned in advance and monitored to prevent chaos as students begin to investigate the intended knowledge. The importance of questions in guided discovery is discussed below.

2.3 The Importance of Questions in Guided Discovery science Lesson

Dillon (2000) mentions that guided discovery allow teachers to employ good coaching skills as they determine how best to guide the students to understand or apply new learning where the main tools of assessment are questions. So the aim of questions is not to test but to guide the students and direct their attention to the important points in the lesson. Kidman (2001) points out that the teacher asks questions which require the students to think, read, study, ponder and reason.

According to Kidman (2001), when the students respond, the teacher expands, develops, enlarges, and illustrates the point. The teacher is accountable to keep the class on track toward specific objectives of the lesson through questions. They explained that questioning is the entry into problem formulation in inquiry; promote participatory learning, good communication skills, and confidence building in students' learning process. Thornbury (2004) states that teacher must be clever in the art of asking meaningful questions. This will give students the opportunity to practice problem-solving and will help them to become more capable of solving problems that arise in learning sessions.

Thornbury (2004) further explained that the use of low-order and high-order questions is necessary during learning lessons and that high-order questions provide students more opportunities for self-evaluation. In his view one good strategy of engaging students in science lesson is by prompting them to answer questions or ask questions is an effective way of engaging them. This would then help the teacher to resolve misconceptions and understanding. On the score of the above, it is important to sum-up that leading questions are important because they activate and keep students alive all the time, check and give feedback which helps build new knowledge.

2.4 The Role of the Teacher in Guided Discovery

Nowadays, people are advocating that teaching and learning process should be student-centred. Despite that, the teacher still plays a great role in the process of interaction whether it is between the teacher and the students, among students, or the students and the classroom environment. Hardy, Jonen, Moller and Stern (2006) argue that students will often have misconceptions (wrong previous concepts students have about something) and do not know they have them. It becomes the teacher`s job to draw these out and make them visible to the students. They are not left on their own to explore and discover ideas, but are guided through well-design activities and questions that can prompt them to build the necessary knowledge which will be designed by the teacher. Hardy et al (2006) further disclosed that without guidance, students will be unable to relate their discovery activity to their misconception and thus give up. In a science lesson, clarifying concepts is very essential for understanding. According to them, if the teacher gives the students no guidance during the activity, they may solve the problem wrongly.

There are also students who are completely lost and have no prior knowledge let alone misconceptions about the particular idea that they must discover. Mayer (2004) claims that to hold students interest, the teacher can allow the students to take part in choosing the purpose of the activity. In fact, to have a class discussion that is carefully facilitated by the teacher regarding, the purpose of guided discovery activities can yield wonderful results. In Mayer (2004), the key is to provide a context that students can operate within and give them a goal or a purpose for their activity. As long as the purpose holds, according to him, the students' interest will be driven enough to continue with the discovery process. In the light of what is mentioned above, it will be instructive to summarize the role of the teacher in three points: clarifying the wrong

concepts for the students, framing well activities and questions which lead students to discovery and giving necessary support and help.

2.5 The impact of guided discovery method on students ` performance and attitude

Students learn better when they discover ideas on their own. In guided discovery learning, students confront problems and teachers assist those finding solutions. In guided discovery, learners have access to prompts and domain knowledge from experts. They are not left on their own to explore and discover ideas, but are guided through well-designed activities and questions that can prompt them to build the necessary knowledge. It helps students to understand concepts in science, biology inquirying skills and perception of science by doing sciences. The guided discovery increases student participation during lessons. Teaching and learning materials are provided and students discover ideas by interacting with the materials. It also fosters collaboration between learners. Learners who engage in guided discovery are more likely to feel empowered and self-confident.

Guided discovery also supports active engagement of the learners in the learning process. Guided discovery learning also makes students curious since they will learn things on their own. Using the guided discovery strategies in science lessons also make students to develop problem solving and creative skills. It also makes students responsible for their own mistakes and results. All these help students to learn and understand concepts better which helps students to remember things that they discovered themselves. Guided discovery method therefore promotes learning through discovery, which eventually leads to the development of higher quality cognitive skills which in effect enhances problem solving skills in students. Guided discovery

approach also help students build on their prior knowledge while giving them ownership of the problem-solving process. In this approach, they can test their ideas against alternative perspectives and develop a contextual understanding of concepts.

2.6 Challenges in the use of guided discovery for practical work in biology

The use of guided discovery strategies in teaching practical biology may have the potential to confuse the students if no initial framework is available. The use of guided discovery for practical lessons is also time consuming since students will follow the steps given to them to perform the experiment to discover new ideas and concepts on their own and no time is usually allocated for biology practical on the school time table and it is usually the normal time that is used for the practical lessons and it is not enough for practical work. Since students are also made to discover things for themselves, there should be enough equipment so that each student can use but most senior high schools do not have enough equipment which makes it difficult to use the guided discovery for practical work in biology. in the process of performing experiments they may break a lot of apparatus when performing the experiments.

Another challenge of using guided discovery strategies in practical biology is the large number of students offering biology or large class size. Because biology students are usually many in Ghanaian senior high schools, it makes it difficult for teachers to organise practical lessons for them especially using the guided discovery strategies where students will be given the steps for them to follow and discover new ideas for themselves with the guidance of the teacher. And because of the larger number of students, it is not easy for the teacher to go round to monitor and assist all the students. And every student should be provided with the equipment to use for the practical. Some equipment are also difficult to work with. Most senior high schools in

Ghana do not have modern laboratory equipment and the old ones are difficult to work with and this makes it difficult to carry out practical lessons especially using the guided discovery strategies because students will not be able to use them on their own to discover new ideas.

2.7 Theoretical Framework

According to Khan (2010), theoretical framework of a study is the structure that holds and supports the theory of a research work. The author further disclosed that it serves as the lens that a researcher uses to examine a particular aspect of his or her subject field. A good theoretical framework assures the reader that the type of investigation researchers propose is not based on their personal instincts or guesses but rather informed by established theories and empirical facts obtained from credible studies (Trochim, 2006). The theoretical perspective that guided this study is constructivist learning theory. The theories of John Dewey, Jean Piaget, Lev Vygotsky, and Jerome Bruner provide the theoretical basis for application of constructivist theory in the classroom (Kearsley, 2001). The cognitive developmental view is largely based on the theories of Piaget and Vygotsky (Bjorklund, 2000).

Piaget`s theory of cognitive development proposes that the basis of all learning is the child`s own activity as they interacts with their physical and social environment. Piaget identified four stages of mental development as the child progresses from infancy to maturity which include: sensory-motor stage, the pre-operational stage, concrete operational stage and the formed operational stage. The Piaget theory implies that certain periods are critical in the child mental development and this have to be taken into consideration when planning the biology curriculum. Before a new topic or concept is introduced to a child, the teacher should make sure that the child

has mastered the prerequisites for learning. One of the implication s of Piaget`s theory for biology teaching is that, the teacher should be conscious of the developmental level of the learners and accordingly adapt his instruction to the learners capabilities. Piaget`s theory is also associated with the concept of `discovery learning` in which students are invited to explore carefully planned activities and experiences that are designed to help them realise key observations and ideas. In other words, students should be led from concrete actions to abstract mental conceptualizations as this will repair the misconceptions of students come to class with and bring about conceptual change. Piaget also indicated that heredity and the child`s environment play a prominent role in the cognitive development of the child. The work of Piaget and his contemporaries are based on the premises that when the individual reacts to changes in the environment, socio-cognitive conflicts occur that bring about cognitive instability. This then stimulates to restore equilibrium and hence cognitive development (Bjorklund, 2000).

Lev Vygotsky emphasised the impact of cultural and social influences on cognitive development, particularly the interaction of children with other people in cognitive development (Kearsley, 2001). Vygotsky`s social development theory asserts that a child`s cognitive development and learning ability can be guided and mediated by their social interactions. His theory states that learning is a crucially social process as opposed to an independent journey of discovery.

Vygotsky described the difference between what children can do unaided and what they can achieve with a little help from peers, teachers and parents as the zone of proximal development. (Mcleod, 2012).

Dewey believed that children were naturally motivated to actively learn and that education only serves to make more learning possible (Berding, 2000). Dewey believed that human beings learn through a `hands-on` approach. This places Dewey in the educational philosophy of pragmatism. Pragmatists believe that reality must be experienced. This means that students must interact with their environment in order to adapt and learn. Dewey theory recommends an interdisciplinary curriculum, or a curriculum that focuses on connecting multiple subjects where students can freely walk in and out of the classrooms. In this way, they pursue their own interest, and build their own method for acquiring and applying specific knowledge. Dewey`s urged teachers to remember that the child`s own instinct and powers furnish the material and give the starting point for all education. Kearsely (2001) reported that "Bruner's constructivist theory is based upon the study of cognition. Bruner identifies four significant aspects of effective teaching and learning: attitude towards learning, knowledge presented in a way that accommodates the student`s learning ability, material presented in effective sequences and carefully considered and paced rewards and punishments. In Bruner`s theory, learners go from a tangible, action-oriented stage of learning to a symbolic and abstract stage of learning. By using this theory, learners can build new knowledge upon knowledge they`ve previously learned. This can lead to better understanding of what students are learning. For Bruner, the purpose of education is not to impart knowledge, but instead to facilitate a child`s thinking and problem-solving skills which can then be transferred to a range of situations. A major theme in this theory is that learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge. Bruner`s learning theory has direct implications for teaching practices. Some of these implications are:

- Instruction must be appropriate to the level of the learners.
- The teachers must revisit the material to enhance their knowledge.
- The material must be presented in a sequence giving the learners the opportunity to acquire and construct knowledge and transform and transfer his learning.
- Students should be involved in using their prior experiences and structures to learn new knowledge.
- Help students categorize new information to be able to see similarities and differences between them.
- Teachers should assist learners in building their knowledge.
- Teachers should provide feedback that is directed towards intrinsic motivation.

The Researcher then grounded the conceptual framework into four concepts: the teacher' role, the learner's role, primary source and manipulative materials and self-learning as shown in Figure

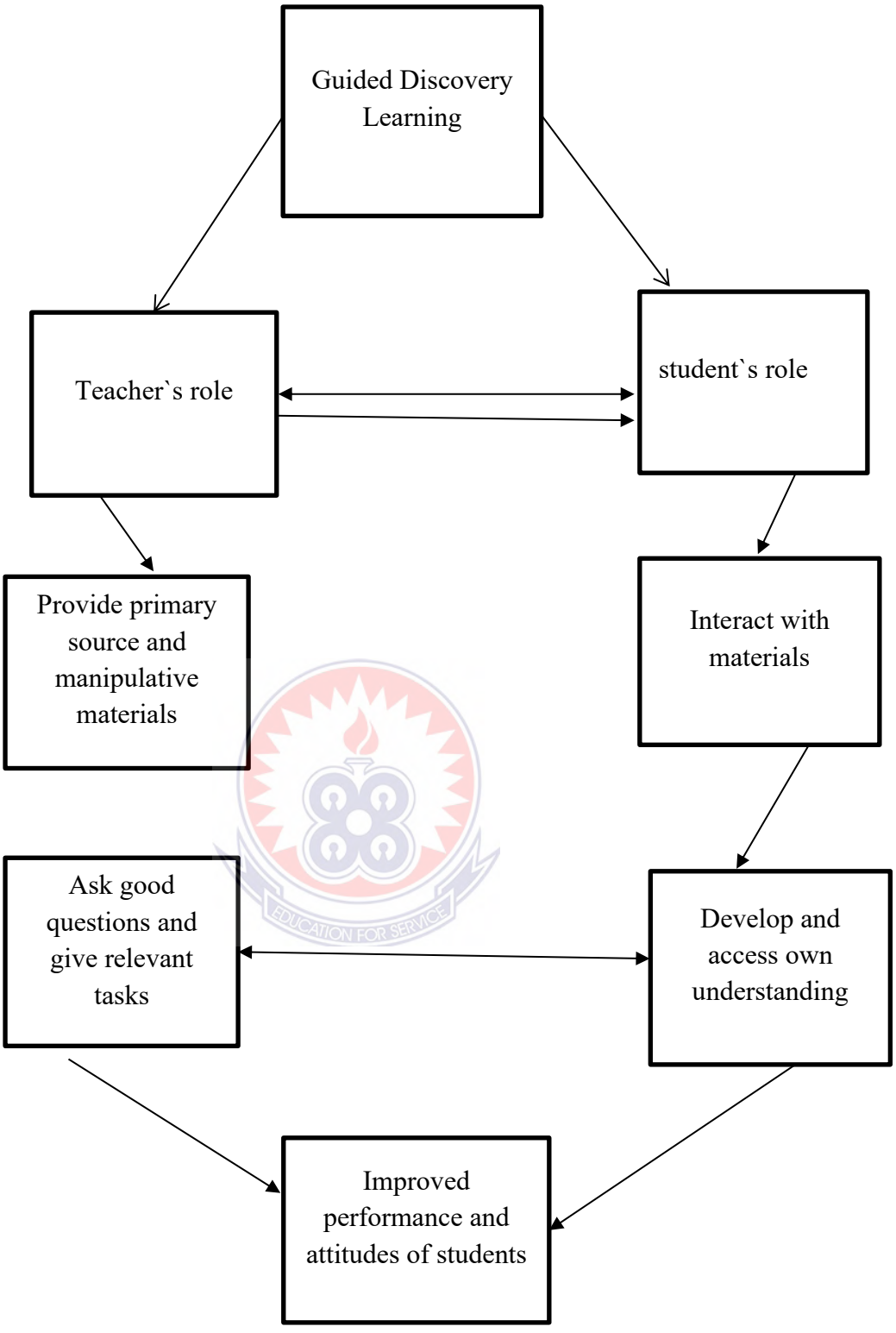


Figure 1: Conceptual model of the study (Edith Awonong 2023)

The model was adapted from Krah (2015). In this model, the teacher and learner interact to bring about meaningful learning. The teacher acts as a facilitator who provides instructional guides and manipulative materials. Manipulative materials are concrete objects that allow learners to explore an idea in an active hand-on approach. The learners follow the instructional guides which are the primary source and interact with the manipulative materials and carries out activities. In the process, the teacher asks facilitating questions which stimulate and help the learner to think and which are relevant to the assignment or task given. However, students who find the task difficult to do may negotiate with the teacher for change. The learner develops and assesses his or her own understanding and this leads to self-learning.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter deals with the research methodology employed in the study. It explains the choice of the research method and experimental design. It further explained how the population and sample were selected and then gave reasons for the choice of a particular sampling technique. Other areas covered include instruments used for data collection, validity and reliability of the research instruments and how the data collected were analysed to determine the effectiveness of the teaching approaches used.

3.1 Research Design

The study is quasi- experimental pre-test, post- test non-equivalent control group research design. The groups chosen were assigned out of convenience rather than through randomization into control and experimental groups. Two intact non-equivalent control groups were used. The study adopted a mixed –method approach for data collection. Two intact form one science classes of St. Margaret Mary SHTS were engaged. One science class was used as the experimental group and another was used as the control group. The study adopted a mix-method approach for data collection.

Quasi- experimental research is similar to experimental research in that there is manipulation of an independent variable. It differs from experimental research because either there is no control group, no random selection and no active manipulation. Quasi- experiment is an empirical interventional study used to estimate the casual impact of an intervention on target population without random assignment.

3.2 Research Population

A population, according to Punch (2006) is the target group of people about whom a researcher wants to develop knowledge. Similarly, Creswell (2008) is of the view that population is a group of individuals or objects who has the same characteristics. Creswell further explains that a population defines the limits within which research findings are applicable and that a population could be large or small and a researcher needs to decide what group to use for the study. In research, there are two sorts of populations to consider: the target population and accessible population (Castillo 2009). According to Castillo (2009), the accessible or readily available population is the population that researchers can easily reach, work with and apply their findings to target population.

In this study, the target population comprised all science students of St. Margaret Mary Senior High School in Dansoman in the Greater Accra Region of Ghana.The target population comprised about 320 general science students. The accessible population was first year biology students in St. Margaret Mary Senior High School. The choice of first year biology students was because they have learnt what osmosis and soil is in junior secondary school Integrated science and are likely to be more receptive to the teaching strategies as they are not under pressure of preparing for external examination.

3.3 Sample and Sampling Technique

Sampling, according to Amoani (2005), is the procedure whereby elements or people are chosen from a population to represent the characteristics of that population. In this study, purposive sampling was used to select the sample for the study. This was done to collect in-depth information from the right respondents. The sample for the study

was first year biology students. The sample size was 63 students and out of this 35 of them were boys and the remaining 28 were girls. In a typical school situation, classes cannot be disrupted or re-organised for research purposes, therefore in such a case, it was better to use intact groups that are already organised. Two intact classes were chosen, one was assigned as the experimental group and the other as the control group. The experimental group was made up of 30 students and the control group was made up of 33 students.

3.4 Research Instruments

Research instruments are tools used to collect data to answer the research questions. Zohrabi (2013) points out that there are various ways of collecting data. According to him some of them are questionnaire, interview, classroom observation and test. The questionnaire, test and interview were the instruments that the researcher used in collecting data for this study.

3.4.1 Questionnaire

According to Jack and Norman (2003), a questionnaire is a written document that has a set of questions given to respondents or used by an interviewer to ask questions and record answers .The authors pointed out that there are two forms of questionnaire,

close-ended and the open-ended. The closed-ended questionnaire was used for the research. Questionnaire is the most frequently used instrument or tool in educational research for obtaining the data beyond the physical reach of the researcher which for example may be sent or mailed to people who are thousands of miles away.

A structured questionnaire was used for the study (Appendix A). The questionnaire was structured based on the research question that desired to know the attitudes of

students towards guided discovery strategies. The questionnaire on attitude requires the respondents to tick the appropriate response that best describes their opinion about the statement provided. The questionnaire had 15 items. The respondent choices were limited to the set of opinions. The questionnaire was composed of three sections. The first section was concerned with the bio data of the respondent. This contained information on sex and class. The second section was concerned with the benefits of carrying out practical`s during biology lessons. The third was concerned with the attitude of students during practical lessons in biology.

3.4.2 Interview guide

The interview guides are like questionnaires. The researcher poses the questions instead of the respondents reading the items by themselves. An unstructured interview schedule where the researcher writes the respondent` answers as they speak was used to find out the challenges teachers face in using the guided discovery strategies in teaching practical biology. (Appendix B)

3.4.3 Test

Test or test instrument is a set of questions for measuring a sample of an individual's behaviour such as multiple choice, performance test, etc. In a pre-test -post-test design, the dependent variable is measured once before the treatment is implemented and once after it is implemented. Pretest and posttest is a research design in which the same assessment measures are given to participants both before and after they have received a treatment or been exposed to a condition. The pre-test was given to the students at the beginning of the course to determine their initial understanding and the post-test was conducted just after the learners have finished performing the experiments. Both the pre-test and post-test questions were set on an experiment to

show that soil contains air and the experiment to show that osmosis occurs in a living tissue. Both the pre-test and post-test questions were multiple choice items and fill in items (Appendix C). The marks scored from each test are then compared using a t-test.

3.5 Validity of the Instruments

Creswell (2008) states that validity means the individual's scores from an instrument make sense, are meaningful, and enable a researcher to draw good conclusions from the sample being studied, and that validity seeks to determine whether the instrument actually measures what it is intended/designs to measure.

In this study, the face and content validities of the instruments were validated by my colleague teachers to check whether the questions were clear and were at the level of the students before giving it to my supervisor to assess the instruments that I had designed.

Prolonged engagement of the students was used to measure the credibility of the interview conducted. The researcher spent 10 to 20 minutes with each respondent during the interview. Credibility also refers to the confidence in how well data and processes of analysis address the intended focus. Prolonged engagement refers to spending extended time with respondents in their everyday world in order to gain a better understanding of behavior (Given,2008). According to Barusch, Gringeri and George(2011), prolonged engagement helps a researcher to identify and question distortions in the data, and essentially come to see and understand a setting as insiders see and understand it.

3.6 Reliability of the research instruments

Reliability refers to whether or not you get the same answer by using an instrument to measure something more than once. In simple terms, research reliability is the degree to which research method produce stable and consistent results.

The researcher used a pilot test to determine the suitability of the instruments. To ensure there was no ambiguity in the questions and to enhance the reliability of the instrument, the test questions and questionnaire was pilot tested using a small sample of the students who were not involved in the study. Test- retest reliability was used to assess the degree to which test scores are consistent from one test administration to the next. The purpose of the pilot testing was to identify any difficulties in responding to the questions in the pretest, posttest and questionnaires. The Cronbach`s alpha reliability statistic was used to assess the internal consistency of the test. The Cronbach alpha internal consistency reliability coefficient for the test using data from the pilot test was found to be 0.78 and this was considered significantly reliable for the study. The Cronbach`s alpha reliability statistic was used to assess the internal consistency of the questionnaire. The Cronbach alpha internal consistency reliability coefficient for the questionnaire using data from the pilot test was found to be 0.76 and this was considered significantly reliable for the study (Baidoo, 2015).

3.7 Data Collection Procedure

In this study data was collected with the aid of the research instruments. The data was collected from the pre-test and post-test written by both the experimental and control group. The study was conducted within four weeks. The same pre-test were administered to both students in the experimental and control group before employing the guided discovery strategies for the experimental group.

This was followed by a two-week instruction for the experimental group using guided discovery strategies and the control group using the traditional approach. While the experimental group received their practical lessons through guided discovery strategies, the control group received their practical lessons through the traditional method.

The post-test was administered to both the control and experimental group in the fourth week to check for any differences in the performance of the two groups after the implementation of the treatment. Cohen, Manion and Morrison(2013) indicated that the period between the pre-test and post-test should not be made too long, since the situational factors may change, and also not too short that the participants will remember the first test. In view of this, the post-test was administered a week after the treatment.

3.7.1 Pre-treatment Activities

The researcher carried out the following activities to help her to know the effects of guided discovery strategies on students` performance in practical biology in two selected topics.

The researcher asked the students questions by reviewing the students` relevant previous knowledge on the two selected topics.

.Pre-test questions were administered to the two groups, science classes on a pre-determined day. An allocated time of forty minutes was given to the students to finish answering the questions individually. After which the papers were taken from them.

3.7.2 Treatment Activities

The researcher introduced the lesson by reviewing the students` relevant previous knowledge through question and answer technique. This stage is very essential to arouse the students` attention and help in bridging the gap in learning by activating students` prior knowledge and in taking in the new material. The students` followed the instructional guides, interacted with the manipulative materials, carried out activities independently and recorded their findings. However, students who found the task difficult to do negotiated with the teacher for change.

A period of 120 minutes was designed for instructional time within a week for both the control and experimental group. The control group were taught with the traditional method by the researcher and the areas addressed were definition of osmosis, factors affecting osmosis, experiment to show that osmosis occurs in a living tissue. Other areas included definition of soil, constituents of soil, composition of soil air, importance of soil air, factors affecting the amount of air in the soil and experiment to show that soil contains air.

For the experimental group, their first lesson was divided into two sessions, and the students performed the experiment. The lesson plan design is shown in Table 1.

Table 1: Allocated areas in each session

Session 1	Session 2	Session 3
Definition of Osmosis	Experiment to demonstrate that osmosis occurs in a living tissue. Factors affecting the rate of osmosis.	Observations and conclusion

Session 1

This session was designed by the researcher to help the students to understand the meaning of osmosis and know the factors that affect the rate of osmosis. The researcher explained that osmosis is the movement of water molecules from a dilute solution into a concentrated solution across a -partially permeable membrane.

The researcher further explained that the factors that affect the rate of osmosis are concentration gradient, temperature and nature of the cell membrane.

Session 2

Session 2 of the treatment activities was done in another biology lesson. This lesson was designed by the researcher in such a way that the apparatus/materials were set up in the lab and the method/steps were given to the participants to follow to carry out the experiment. The researcher gave the following apparatus and steps for the participants to use:

Apparatus:

Petri dishes, distilled water, concentrated salts /sugar solution, yam and Knife.

Method

i. Prepare two slices of yam with holes in them and label them A and B. Add a concentrated sugar or salt solution into the hole of yam to serve as the test experiment.
ii. Add distilled water to yam B to serve as the control.
iii. Mount each of the two yams in a petri-dish containing distilled water.
iv. Leave the set up to stand for some time and observe the level of liquid in each yam.

The researcher gave these steps to the students to follow to perform the experiment on their own with the guidance of the researcher and explained concepts to students as they performed the experiment on their own. After performing the experiment, the researcher asked their students to write their observations.

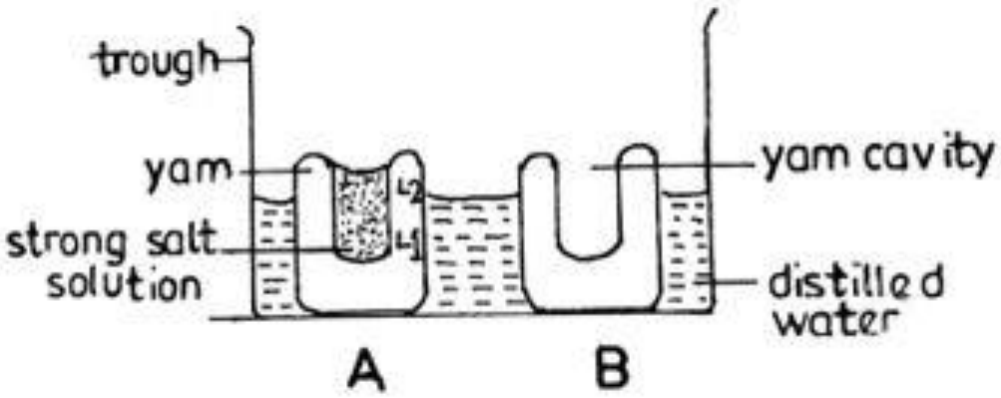


Figure 2: Diagram to show that osmosis occurs in a living tissue.

Observation

Level of liquid in the hole of yam A rises whilst B remains the same. The rise in the level of liquid in A is due to the movement of water molecules from the outside of the tissue. This occurs as a result of a concentration gradient between liquid in the yam hole and the petri disc and water molecules move from the petri disc across the yam which serves as a partially permeable membrane .The level of liquid in yam B remains the same because there is no movement of water since there is no concentration gradient between the liquids.

Conclusion

Osmosis occurs in a living tissue.

Lesson two

Table 2: Allocated Areas in each session

Session 1	Session 2	Session 3
Definition of soil Constituents of soil Composition of soil air.	Importance of soil air. Factors affecting the amount of air in the soil	Experiment to find the percentage of soil air content.

Session 1

This session was designed by the researcher to help the students to understand the meaning of soil and to also know the various constituents of soil. The researcher also explains the composition of soil air. The researcher explained that soil is a mixture of organic and inorganic materials which forms an ecosystem of living organisms and provides materials for plants growth.

The researcher also stated the various constituents of soil as humus, living organisms, soil particles, mineral salts, air and water. The researcher also stated that air in the soil is made up of oxygen, carbon dioxide and nitrogen.

Session 2

This session was designed by the researcher to help students to understand the importance of soil air and also the factors that affect the amount of air in the soil. The researcher explained that the importance of soil air are :

1. Used for respiration by soil organisms and roots of plants.
2. Provides atmospheric nitrogen to form nitrates.
3. Makes the soil porous.

The researcher explained that the factors that affect the amount of air in the soil are:

1. Soil particles: Larger soil particles have large air spaces.
2. Soil water: Water fills air spaces in the soil. Amount of air increases as water in the soil decreases. Waterlogged soils have low amount of air.
3. Temperature: As temperature increases, soil water evaporates and amount of air increases in the soil.

Session 3

This session took place in another biology lesson. The lesson was designed by the researcher in a way that the apparatus and materials were set up in the biology lab for the students to do the practicals. The researcher also gave the steps to students to follow and perform the experiment whilst the researcher goes round to assist them when the need arises. Students read the instructions carefully and performed the practical.

Apparatus

Beakers, measuring cylinders, water and samples of soil.

Method/Steps

i. Determine and record the volume of a tin container by filling it with water and then pouring it into a measuring cylinder (V1).
ii. Tightly fill the container with soil and add more soil until it is impossible to press further.
iii. The volume of the soil is given as the volume of the container determined earlier (V1).Empty the soil into a 500cm3 measuring cylinder.
iv. Add sufficient amount of water into the the measuring cylinder to cover the soil sample.

v. Read and record the volume of the content of the soil and water (V2)

vi. Stir the mixture gently until no air bubbles are seen.

vii. Read and record the final volume /level of the mixture (V3)

viii. Obtain the volume of air in the soil by subtracting the final volume from the initial volume of the mixture(V2-V3)

Percentage of air in the sample of soil

$$= \frac{\text{volume of air in the soil sample}}{\text{Volume of original soil}} \times 100$$

$$= \frac{V2 - V3}{V1} \times 100$$

Observation

The larger the soil particles, the greater the percentage of air in the soil.

Conclusion

Sandy soil has the greatest percentage of air in the soil.

After students have finished doing the two practicals, questionnaires were given to participants in the experimental group to fill. This was to find out the benefits of carrying out practicals during biology lessons.

3.7.3 Post treatment activities

At this stage, the learners were made to answer the evaluation questions which are the post-test questions and the teacher takes the scripts to mark.

3.8 Data Analysis

Data analysis is the process of simplifying data in order to make it comprehensive (Jack & Norman, 2003). According to Bogdan and Bilklen (2003) data analysis refers

to the process of systematically searching and arranging the interview transcripts, find notes and other materials that are accumulated to produce findings.

The data collected from both pre-test and post-test exercises were analysed using descriptive statistics; t-test was used for the hypothesis testing to find if there was a significance difference or not between the academic achievements of students who were taught using guided discovery strategies and students who were using the traditional approach. A p-value which is the significance (p) value is compared to the prior alpha level (level of significance for the statistic) and determination is made as to reject or retain the null hypothesis (Hair, Black, Babin & Anderson, 2010). A p-value of 0.05 or less is considered significant while p-values above 0.05 are considered not significant.

The questionnaire was analysed based on the responses of the respondents on the effects of guided discovery strategies on students attitude towards practical work in biology. These attitudes were found from the analysis of responses of respondents from the questionnaire. The data was presented in frequency and percentages. The interviews on challenges biology teachers face by using guided discovery strategies was analysed based on the responses of the respondents during the oral interview conducted by the researcher and the responses were written down.

Ethical Considerations

There is the need for ethical considerations in every research that involves people. The following ethical issues were observed when conducting this research: Informed consent, confidentiality, anonymity, discontinuance and respect.

Informed consent

Informed consent seeks to incorporate the rights of autonomous individuals through self-determination. Individuals can make informed decisions in order to participate in the research voluntarily, only if they have information on the possible risk and benefits of the research before the research begins (Fouka & Mantzorou, 2011). The head mistress of the school and the participants were informed about the purpose of the research, the expected duration and the procedures of the research.

Confidentiality

Confidentiality refers to the data gathered. It is the management of private information by the researcher in order to protect the subject's identity (Maclean & Poole, 2010). Participants in research have the right to expect that the information they provide would be treated confidentially and if published will not be identifiable as theirs (Jeridah, 2019). The researcher informed the participants about the methods which will be used to protect anonymity and confidentiality

Discontinuance

Participant's right to decline to participate or to withdraw from their research was made clear to the participants. The participants were told of their freedom to withdraw at any time without giving any reason or being penalized. The researcher ensured that the participants knew their rights to withdraw. The participants had the right to withdraw and to require that their own data including recordings, be destroyed.

Anonymity

Making data anonymous means that contributors` names are not disclosed in order to protect participant's identity. Anonymity is protected when participant's identity cannot be with personal response (Fouka & Mantzorou, 2011). All research data

collected remained confidential and the identity of the participants was protected throughout the study. No student name has been mentioned or was published in any reports of this study. The researcher took many precautions as possible to protect anonymity and gave an advice of any special action the participants should take to avoid risk.

Respect

The principle of respect requires the researcher to avoid discrimination against colleagues or learners on basis of sex, race, gender, ethnicity or other factors that are not related to their scientific competence and integrity .In this study, all students taking part were treated equally irrespective of their gender, social, economic and religious differences.

3.9 Chapter Summary

This chapter described the research methodology which included the study area, the design, population, sampling, and data collection procedure and data analysis. The study employed a mixed method approach. Data was collected from pre-test, post-test, interview and questionnaire. The data was generated from these sources were analysed using quantitative and qualitative procedures. The validity and reliability of the instruments were also discussed as well as the pre-treatment and treatment activities. The ethical considerations discussed included respect, informed consent, discontinuance, anonymity and confidentiality.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0. Overview

This chapter presents the analysis of data findings of the study obtained from the pre-test, post-test, interview and questionnaire from the experimental group and the control group. The analysis and discussions were in line of the research questions. Descriptive statistics of the test scores were calculated to determine the difference between the variables of the two groups. The descriptive statistics included frequency of the number of boys and girls who participated in the study, means and standard deviations. An independent t-test was further applied to see whether a statistically significant difference existed among the mean values at a 0.05 alpha level.

4.1 Demographic characteristics of the participants

The participants were 63 in all, 28 of the students representing 44.4% were girls and 35 of the students representing 55.6% were boys. This implies that the study was dominated by boys but the dominance of the boys in the study is not supposed to skew the results of the study. The average age of the participants was 15 years. The number of science teachers who were interviewed were six in all, three of them were males and the other three were females. Three of the teachers taught biology, one taught physics and the other two taught chemistry at the time of the study. The average age of the six teachers was 37yrs. Two of the biology teachers had been teaching for more than twenty years and the third biology teacher had been teaching for four years. The physics teacher had been teaching for five years and the two chemistry teachers had also been teaching for the past seven and nine years respectively.

4.2 Presentation of the results by research questions

4.2.1 Research Question One:

What is the effect of guided discovery strategies on student`s academic performance in two selected practical topics?

The first research question sought to find the effects of guided discovery strategies on students` academic performance in two selected practical topics. This section presents the t-test analysis between the post-test scores of the experimental group and the control group. The reason was to find the effects of guided discovery strategies on students` performance in the experimental group in learning practical biology as against the control group. The results of the t-test analysis in Table 3 showed that the standard deviations of the pre-test scores for experimental and control groups were 8.59 and 9.19 respectively. The means of the pre-test scores for the experimental and control group were 55.83 and 57.06 respectively. The mean of the control group was slightly higher than the mean of the experimental group but the small difference is not statistically significant (t=-0.05, p=0.59). The results showed that the p-value was greater than the alpha value, 0.05(p>0.05). This indicates that the students in the experimental and control group were at the same level of understanding at the beginning before the treatment was employed.

Table 3: t-test results of the experimental and control groups for pre-test scores (significant at p<0.05)

Groups	N	df	M	SD	t	P
Experimental group	30	61	55.83	8.59	-0.05	0.59
Control group	33	-	57.06	9.19	-	-

The results of the t-test analysis in Table 4 showed that the p-value was 0.00 which was less than the alpha level 0.05. This shows that there was statistically significant difference between the post-test scores of the experimental group and control group. The mean of the post-test scores for the experimental group was 69.27 and the mean of the control group was 59.76. This indicates that the mean of the experimental group was higher than that of the control group. This also showed that the academic performance of the students in the experimental group increased when they were taught using the guided discovery strategies.

The participants were 63 in all, 33 students in the experimental group and 30 students in the control group.

HO1: There is no statistical significant difference between the pre-test scores of students who were taught using guided discovery strategies and those taught using traditional method.

A t-test was performed on the pre-test and post-test results of both the experimental and control group to see whether a statistically significant difference existed among the mean values.

Table 4: t-test results of the Experimental and Control groups of the post-test scores (significant at p<0.05)

Groups	N	df	M	SD	t	P
Experimental group	30	61	69.27	10.58	3.43	0.00
Control group	33		59.76	11.32	-	-

The t-test was used to analyse this comparison, it showed that the t-statistic was 3.43 and the p-value was 0.00. The p-value was less than 0.05 alpha values and this shows that there was a statistically significant difference in the post-test scores between the experimental group and the control group after the treatment.

Based on the data provided in Table 4, it could be concluded that the strategy used in teaching the experimental group enhanced the understanding of the learners and they performed better than those in the control group that were taught using the traditional method. The null hypothesis was rejected as there was a statistically significant difference between the academic performance of students who were taught using the guided discovery strategies and those who were taught using the traditional method.

The mean of the control group from the post test scores was 59.76 and the mean of the experimental group was 69.27. The mean of the experimental group was greater than the mean of the control group and the results indicated that the experimental group which have been taken through guided discovery strategies performed better in the post-test because of the treatment.

4.2.2 Research Question Two

What are the effects of guided discovery strategies on students` attitude towards practical work in Biology.

The second research question sought to find the attitudes of biology students towards the use of guided discovery strategies by teachers for teaching and learning. These attitudes were found from the analysis of responses of respondents from the questionnaire given. The attitudes looked at were the attitudes of students during practical lessons in biology and the benefits of carrying out practical during biology

lessons. The results of the analysis were presented in frequency and percentages. Table 5 presents the results of the analysis of the responses on attitude of students towards practical lessons in biology.

Table 5: Percentage frequency distribution of students responses on the effect of guided discovery strategies on their attitude towards practical work in Biology.

D = Strongly disagree/ disagree NS = Not true(Unaware) A= Strongly Agree/Agree

Statement	A	%	D	%	NS	%
1. I see biology practical lessons to be very interesting.	21	70.0	5	16.7	4	13.3
2. Most of us do not pay attention during practical Lessons.	17	56.7	7	23.3	6	20.0
3. I participate fully during practical lessons.	17	56.7	7	23.3	6	20.0
4. Practical lessons help me to interact with teaching and learning materials to understand the theory.	26	86.7	3	10.0	1	3.3
5. Practical work may give me wrong answers Which could have implications for my learning for examination.	8	26.7	16	53.3	6	20.0

The results from Table 5 revealed that the students had some attitudes when it came to practical work during biology practical lessons.

From Table 5, 21 students representing 70% of the students agreed that they see biology practical lessons to be more interesting when taught using guided discovery

strategies than practical work done using the traditional lecture method and only five students which represent 16.7% of the students disagreed to the assertion and just four students representing 13.3% of the students were indecisive or were not sure of their responses. The results also showed that 17 students which represent 56.7% of the students agreed that most students do not pay attention during practical lessons. However, seven students which make 23.3% of them disagree with this statement and six students representing 20% of the students were not sure about their responses. With regards to the statement, I participate fully during practical lessons, seventeen students representing 56.7% of them were in agreement with the statement while seven students making 23.3% of them disagreed to the statement and just six students representing 20% of the students were not sure of their responses. The results also showed twenty-six of the students representing 86.7% agreed that practical lessons help students to interact with teaching and learning materials to understand the theory better. This statement was however disagreed upon by three students representing 10% of the students and only one student making 3.3% of the students was not sure of his or her response.

Out of the thirty students representing 100%, who responded to the statement practical work might give students wrong answers which could have implications for their learning for examination, sixteen students representing 53% of them disagreed with the statement and eight students representing 26.7% of them agreed to the assertion and only six students representing 20% of the students were not sure about their responses meaning they did not know whether practical work will have implications for their learning for exams or not.

4.2.3 Research Question Three

What is the challenges biology teachers face by using guided discovery strategies in conducting practical work in the lab.

The third research question sought to find the challenges biology teacher's face when using guided discovery strategies in conducting practical work in the lab. These challenges were found out by interviewing the teachers. The interview was unstructured and done orally whiles the responses from the respondents were written down. Six science teachers were interviewed and during the interview session. The researcher gave codes from T1-T6 to the teachers for easy identification.

In an interview with respondent T1, he had this to say on what are the challenges Biology teachers face when using guided discovery strategies in conducting practical work in the lab.

> *The challenge I face when using guided discovery strategies in conducting practical work in the lab is that, it is time consuming. Sometimes students cannot finish their practical work.*

The statement by T1 shows that the students need to be given enough time so that they can do the practical to discover new ideas for themselves. The teacher also needs enough time to prepare the guidelines or steps or the written materials for the students to follow and do the practical. The respondent explained that students use all the time allocated for the practical and still don`t finish since there is not enough time set aside for practical work but the normal instructional time.

T2 responded as follows:

> *The challenge I face when using guided discovery strategies in conducting practical work in the lab is lack of equipment or inadequate equipment.*

The respondent stated that, most biology labs do not have enough equipment which makes it difficult for teachers to conduct practical using guided discovery strategies. This is because once students will be doing the practical on their own by following the given instructions, and there should be enough equipment so that every student can have access to them to be able to do the practical. However, this is not the case since the laboratory is devoid of most equipment.

T3 gave this as her response when she was interviewed on the challenges teachers face when using guided discovery strategies in conducting practical in the lab.

> *The challenge I face when using guided discovery strategies in conducting practical in lab is that, biology students are too numerous to manage for practical. This is so because Home Economics students are included.*

The respondent said that the numbers of students who study biology in her school are too many because it is not only the science students who do biology now but also the home economics students too. This makes it difficult for the teacher to manage the practical because the guided discovery method is not considered more convenient especially with larger classes and laboratory technicians do not assist teachers in planning practical works. This makes it very difficult for the teacher to conduct the practical because of the large number of students.

Respondent T4 said:

My challenge is that, students are not particularly interested in practical classes. The respondent explained that, most biology students especially the home economics students do not have interest in practical lessons and it is even worst when using the guided discovery strategies where they will have to work on their own to discover new ideas. This makes it very difficult to for me to do practical.

T5 gave this as her response when he was interviewed:

The challenge I face is that some equipment are difficult to work with.

The respondent said that, her biology lab is not a modern laboratory so most of the equipment are old and out moded which makes some of the equipment difficult to work with. He said this makes it very difficult to do practical using the guided discovery strategies because most of the students can not work with the equipment. The respondent also said that some of the biology teachers do not even know how to use some of the equipment because they have not been trained on how to use them.

T6 also gave his response when he was interviewed:

There is lack of funds for purchasing specimens for practical lessons. The respondent emphasized that most biology teachers usually have issues with heads of senior high school when it comes to getting specimens for practical lessons because they heads always complain of lack of funds especially this time of free senior high school. This makes it difficult for teachers to conduct practical lessons especially using the guided discovery strategies which may even require more material because they students will be working on their own.

4.2.4 Research Question Four

What are the benefits of practical work to students in their studies?

The fourth research question sought to find the benefits of practical work (guided discovery activities) to students in their studies. These benefits were gotten from the analysis of responses of respondents to the questionnaire given. It looked at the benefits of practical work to students in their studies .Results of the analysis were presented in frequency and percentages.

Table 6 presents the analysis of the responses on the benefits of practical work(guided discovery activities) to students in their studies.

Table 6: Percentage frequencies on students` responses of the benefits of carrying out practical during Biology lessons.

Statement	A	%	D	%	NS	%
1. The aim of practical work during biology lessons is to improve our understanding.	27	90.0	0	0	3	10.0
2. Doing practical`s during biology lessons helps us to develop the skills needed in Problem solving.	30	100	0	0	0	0
3. Practical work in biology will promote the Understanding of the nature of science.	29	96.7	0	0	1	3.3
4. Practical lessons build our interest in biology.	26	86.7	0	0	4	13.3
5. Carrying out practical during biology lessons makes us to pay attention in class.	28	93.3	2	6.7	0	0
6. Practical lessons helps us to discover new concepts on our own.	28	93.3	1	3.3	1	3.3
7. Practical lessons helps us to Understand some topics better than teaching us with the lecture method.	28	96.7	0	0	1	3.3
8. Students will not understand some topics in biology without carrying out practical on them.	26	86.7	2	6.7	2	6.7
9. Practical lessons add fun to learning.	2	6.7	4	13.3	24	80.0
10. Practical lessons usually build our interest and motivate us to learn.	29	96.6	1	3.3	0	0

A= strongly agree/agree D= strongly disagree/disagree NS=not sure

From Table 6, twenty-seven students representing about 90% of the students generally agreed that the aim of practical work during biology lessons is to improve students` understanding more than the traditional method of teaching while only three students representing 10% of the students were not sure and none of the students disagreed with the assertion. The results also showed that 100% of the students agreed that doing practical during biology lessons helps to develop the skills of students in problem solving. All the thirty students making 100% of the students agreed that practical lessons actually help to develop their skills in problem solving.

With regards to the statement, practical work in biology will promote the understanding of the nature of science, 96.7% of the students were in agreement to the statement while 3.3% of the students were not sure. These percentages showed that almost all the students were in agreement with the statement. Additionally, 86.7% of the students agreed that practical lessons in biology builds students` interest in biology and 13.3% of the students were uncertain about the response. The responses showed that most of the students agreed that practical works in biology helps to build the interest of the students in biology.

Considering whether carrying out practical work during biology lessons makes students to pay attention in class, 93.3% of the students were in agreement to this statement and 6.7% of the students disagreed with the statement. The responses showed that majority of the students agreed to the assertion. The results also revealed that 93.3% of the students agreed that practical lessons helps students to discover new concepts on their own while 3.3% of the students disagreed with the statement and 3.3% also were not sure of their responses.

In terms of whether practical lessons in biology helps students to understand some topics better than teaching with the traditional method, 96.7% of the students were in agreement to the statement and 3.3% of the students were uncertain. The analysis of the responses showed that greater percentage of the students are in agreement to the assertion. The results also showed that 86.7% of the students agreed to the statement students will not understand some topics in biology without doing practical on such topics. In addition to that, 13.3% of the students disagreed to the assertion and 3.3% of the students were unsure. The analysis also showed that a greater percentage of the students were not certain whether practical lessons adds fun to learning and 13.3% of the students disagreed with the statement and 6.7% of the students agreed to the assertion.

Out of the total number of students who responded to the statement practical lessons usually builds our interest and motivate us to learn more, 96.7% of the students agreed to the statement while 3.3% of them disagreed.

4.3 Discussion of results in Relation to Research Questions

The findings are in consonance with the results of researchers in guided discovery strategy. Onanuga (2004) concluded that the use of discovery method caused the students who are exposed to it to perform better than students exposed to the traditional method of teaching. The findings are also in agreement to Ugwanyi (2008), who noted that the guided discovery method of instruction is more effective than the commonly used expository methods in biology. The students are more likely to remember concepts they discover on their own. It could be concluded that the use of guided discovery strategies helped the form one science students to understand the

topic better. This explains why the academic performance of the experimental group improved more than the control group in the post-test scores.

4.3.1 Research Question 1:

What are the effects of guided discovery strategies on students academic performance in two selected practical topics in biology.

From the results of the students in Table 3 in the pre-test exercise before the treatment, it was evident that most of the students had poor understanding on the experiment to show that soil contains air and experiment to show that osmosis occurs in a living tissue. Also, most of them could not state the factors affecting the rate of osmosis. This made the students not to do well in the pre-test exercise. Also, from the analysis of the results in Table 3, it was noticed that most students could state the factors that affect the rate of osmosis but they could not explain how those factors can affect osmosis. It also showed that they students could not state the factors affecting the amount of air in the soil. This showed that the students did not perform well in the pre-test exercise. The mean of the pre-test scores for the experimental group was 55.83 and the mean of the control group was 57.06. The mean for the control group was slightly higher than the mean of the experimental group but the small difference is not statistically significant.

From the analysis of the post-test results in Table 4, it was evident that after the treatment, most of the students performed very well in the post-test exercise. They students got the questions that they couldnot answer in the pre-test exercise correct and this was because of the treatment. Table 4 shows that the statistical difference in the means of the post-test scores of the experimental group and control group. The means of the post-test scores for the experimental and control groups were 69.27 and

59.76 respectively. This shows that the mean of the experimental group was higher than that of the control group in the post-test scores. However, the t-test was used to analyse this comparison, it showed that the t-statistic was 3.43 and the p-value was 0.00. The p-value was less than 0.05 alpha values and this that there was a statistically significant difference in the post-test scores between the experimental group and the control group after the treatment. This means that, the guided discovery strategies helped the students and it reflected in their performance because most of them scored higher marks. The results also showed that after the treatment, the students could now state and explain the factors affecting the rate of osmosis. Olutade (2009) with respect to teaching method stressed that teaching method is important in the impartation of knowledge in teaching –learning processes and the type adopted determines to a great extent the students assimilate.

4.3.2 Research Question Two:

What is the attitude of biology students towards the use of guided discovery strategies by teachers for teaching and learning.

This section presents the analysis of responses from the questionnaire given. This was to look at the attitudes of students during practical lessons in biology and the benefits of carrying out practical during biology lessons. From the analysis of the students responses of the questionnaire in Table 5, it was found that majority of the students were in agreement with the statement that I see biology practical lessons to be more interesting. About half of the students also agreed that, most students do not actually pay attention during practical lessons and only seven students representing 23% of the students disagree with the statement. About half of the students also agreed that students participate fully during practical lessons whiles seven students disagreed with

the statement and six students representing 20% of the students were not sure of their responses. A greater percentage, 26 students representing 86% of the students also agreed that practical lessons in biology helps them to interact with teaching and learning materials to understand the theory and only three students making 10% of the students disagreed with statement and only one student was not sure of her response. Fifty percent of the students disagreed that practical work might give them wrong answers which could have implications for their learning for examination and 26% of the students agreed to the statement and only 20% of them were not sure of their responses.

In line with these findings, Cimer (2007) highlighted teachers` styles, techniques and methods of teaching may also be factors that affect students learning in biology.

4.3.3 Research Question Three:

What are the challenges biology teachers face by using guided discovery strategies in conducting practical work in the lab.

From the responses of the teachers in the interview, it was evident that most biology teachers had challenges when using guided discovery strategies in conducting practical in the lab. From the responses of the teachers from the interview, the following challenges were identified by the teachers:

1. Most teachers said it is time consuming.
2. Lack of equipment.
3. Large number of students in biology classes.
4. Most of the biology students do not have interest in practical lessons.
5. Most equipment in the biology lab is difficult to work with.

6. Lack of funds to buy specimen for biology practical.

4.3.4 Research Question Four:

What are the benefits of practical work (guided discovery activities) to students in their studies.

This question looked at the benefits of practical work (guided discovery activities) to students in their studies. From the analysis of Table 6, it showed that a very high percentage of the students agreed to the assertion that the aim of practical work during biology lessons is to improve students understanding. Majority of the students were also in agreement with the statement that doing practical during biology lessons helps to develop their skills in problem solving. A higher percentage of the students also agreed that practical lessons help them to understand some topics better than teaching them with the lecture method. A greater percentage (86.7%) of the students also agreed that practical lessons build their interest in biology. The responses also showed that 93% of the students agreed that practical lessons helps students to discover new concepts on their own and only one student representing 3.3% of the students disagreed with the statement. On whether students will not understand some topics in biology without practical twenty-six students representing 86% agreed to the statement and two students making 6.7% of the students were not sure of the statement. From the analysis of the responds from the respondents, it was clear that practical work helps students to discover new ideas and improve their understanding. The responses also proved that practical work also helps students to develop skills needed in problem solving.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

The chapter presents the summary of the findings of the study. It also includes recommendations and suggestions for further studies.

The following research questions guided the study:

1. What is the effect of guided discovery strategies on student`s academic performance in two selected practical topics?
2. What is the attitude of biology students towards the use of guided discovery strategies by teachers for teaching and learning?
3. What are the challenges biology teacher's face by using guided discovery strategies in conducting practical work in the laboratory?
4. What are the benefits of practical work to students in their studies.

The study also tested the following hypothesis:

HO1: There is no statistically significant difference between the pre-test scores of the students who were taught using the guided discovery strategies and those taught using the traditional method.

HO2: There is no statistically significant difference between the post-test scores of students who were taught using guided discovery strategies and those taught using the traditional method.

5.1 Summary of Main Findings

The purpose of the study was to find out the effects of guided discovery strategies Senior High School science students` attitude and performance in practical biology. The study addressed the research questions and hypothesis stated by adopting the quasi-experimental design. In all, 63 science students were selected for the study through purposive sampling. The instruments used for collecting data were pre-test, post-test, interview and a structured questionnaire. The data was also presented in a frequency table. The descriptive statistic that was also used to analyse the data were the mean, standard deviation, variance and percentages. T-test was also used to estimate the statistical significant difference between the academic performance of the experimental group and the control group.

The first research question sought to find out the effects of guided discovery strategies on students' academic performance in two selected practical topics. The analysis of the pre-test scores that is presented in Table 3 showed that most of the students had poor performance in both the experimental and control groups because most of them scored below 50% which was a poor performance. The analysis of the post-test results in Table 4 was however used to find out the effects of guided discovery strategies in two selected topics in practical biology. The analysis on Table 4 showed that the post-test scores of both the experimental and control groups. The scores from the Table 4 showed that the experimental group which were taken through the guided discovery strategies performed very well after the treatment as compared to the post-test scores of the control group. The results however proved that the experimental group performed better because of the treatment. The results showed that the guided discovery strategies helped to improve the academic performance of the students.

The null hypothesis 1 stated that there is no statistical significant difference between the pre-test scores of students who were taught using guided discovery strategies and those taught using the traditional method. This null hypothesis failed to be rejected as Table 3 revealed that the students in the experimental group and the control group were at the same level of understanding before the treatment was employed since the p-value after the T-test analysis was 0.59 which was greater than the alpha value, at 0.05. After the pre-test, treatment was given to the experimental group after which post-test was conducted for both. The results of the post-test revealed that the experimental group out perform their colleagues in the control group. Therefore, the null hypothesis that there is no statistically significant difference between the post-test scores of students who were taught using guided discovery strategies and those taught using the traditional method was rejected because the findings of the study revealed that the experimental group that was taught using the guided discovery strategies performed better after the treatment than the control group that was taught using the traditional method and this was because of the treatment given.

The second research question sought to find the attitude of biology students towards the use of guided discovery strategies by teachers for teaching and learning. The responses from the questionnaire showed that using guided discovery strategies in practical biology deepened students` understanding more than the traditional method of instruction and it also made complex concepts simple. The use of guided discovery strategies in teaching and learning biology practical makes the subject interesting and made students to interact with the learning materials to discover new concepts on their own. The responses also showed that guided discovery strategies also held the students` attention, added fun to the learning and made students` to discover things on their own.

The third research question sought to find the challenges biology teacher's face by using guided discovery strategies in conducting practical work in the laboratory. These were the responses from the unstructured interview with some science teachers. The teachers said doing practical's using the guided discovery strategies in the laboratory is time consuming because there is no time allocation for biology practicals on the school time table so the normal teaching period is used. Another challenge from that the respondents gave was lack of equipment or inadequate equipment. The teachers said when using the guided discovery strategies, every student should have access to the equipment since they have to interact with the materials to discover new ideas. The respondents also gave lack of funds as one of the challenges. The respondent said, teachers always need money to buy specimen for the practical's but heads of schools always complain that there is no money especially this time of free senior high school. Another teacher also said his main challenge when conducting practical using guide discovery strategies is that, biology students are too numerous to manage during practical's especially now that home economics students also offer biology. Biology teachers face a number of challenges when they use guided discovery strategies in teaching Biology practical.

The fourth research question sought to find out the benefits of carrying out practicals during biology lessons. The responses from the questionnaire revealed that , most of the students agreed that carrying out practical during biology lessons helps students to understand concepts and theories better. About 90% of the students agreed that carrying out practical during biology lessons helps to improve the students understanding and also to develop the skills needed in problem solving. A greater percentage of the students also agreed that practical work in biology will help build their interest in biology. Majority of the students also agreed that, practical work will

help students to understand some topics better than teaching them with the traditional method. Most of the students also agreed that practical work add fun to learning. The responses also showed that practical lessons usually build students` interest and motivate them to learn.

5.2 Conclusions

Based on the findings, the results indicated that there is a significant main effect of the treatment on students` academic performance in biology when guided discovery strategy is used on the experimental group in teaching selected topics. This indicates that guided discovery strategies are capable of improving students` academic performance in biology. The study also concluded that guided discovery strategies used during practical work helped the students to discover new ideas for themselves and also helped to make practical lessons more interesting and motivate them to learn and interact with the teaching and learning materials to understand the concepts being studied. The findings of the study also indicated that teachers face a lot of challenges when using guided discovery strategies in conducting practical in biology.

5.3 Recommendations

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

- Science teachers especially biology teachers should incorporate guided discovery strategies in teaching most topics in biology for the better understanding of students because the use of guided discovery strategies in the study of Biology affect student performance on the biology concepts taught.
- Facilities and suitable learning environment should be provided to allow students to use guided discovery strategies in their learning.

- The heads of Senior High Schools should try to allocate some enough time on the school time table for practical lessons because practical lessons will help students to understand concepts better.
- The government should build modern well equipped laboratories in all Senior High Schools to promote the teaching and learning of science.
- Curriculum designers for Senior High Schools should include the use of guided discovery strategies as an instructional approach for teaching complicated topics in the science curriculum.
- The Ghana Education Service directorate should organize in-service training and workshops for Senior High School science teachers in the various topics in practical's.
- Students with special needs might need different strategies to keep them on track.

5.4 Suggestions for further studies

The findings of the study showed that guided discovery strategies can improve students` practical performance. It is therefore suggested that biology teachers should use guided discovery strategies in practical work to reinforce the theory lessons.

This study examined improvement of school academic performance in biology the effects of guided discovery strategies at SHS level in Ablekuma west Municipal in the Greater Accra region of Ghana. Further studies should be conducted to investigate the effectiveness of guided discovery strategies in urban, rural, suburban schools and for high, average and low achievers.

REFERENCES

AbdRayl, M. S., Mansor, N. A., Othman, Z., & Lyndon, N. (2013). Inculcation of Science process skills in science classrooms. *Journal of Asian Social Science, 8*(9), 54- 55.

Adkisson,C., & McCoy, L. (2006). A study of teachers' perceptions of high school Mathematics instructional methods. In L. P. McCoy (Ed.), *Studies in teaching: Research Digest. Winston-Salem, NC*: Wake Forest University.

Afolabi, F., & Akinbobola, A. O. (2009). Constructivist problem based learning Technique and the academic achievement of physics student with low ability Level in Nigerian secondary schools. *Eurasian Journal of Physics & Chemistry Education*, 1, 45-51.

Akerson, V. L., Hanson, D. L., & Cullen, T. A. (2007). The influence of guided Inquiry and explicit instruction on K-6 teachers' views of nature of science. *Journal of Science Teacher Education, 18*(5), 751-772.

Akinbobola, A. O. (2009). Enhancing students' attitude towards Nigerian Senior Secondary School Physics through the use of cooperative, competitive and Individualistic learning strategies. *Australian Journal of Teacher Education, 34*(1), 166-167.

Akinmoyewa, J. O. (2003). Effects of cooperative, competitive and individualistic use of self-instructional package on Learners' Achievement in Biology. *Journal of Education and Society, 1*(2), 133-141.

Akuma, N. (2008). Effects of Guided Discovery Method on senior secondary students, Interest in Map Work. *African Journal of Educational Research*.12, 2:111-116.

Amedahe, F. K. (2002). *Fundamentals of educational research methods*. Cape Coast: University of Cape Coast.

Amoani, K. (2005). *Research methodology and review*. Accra: Pentecost Press.

Anderson, T., & Fretzin, L. (2004). *Programmed instruction*. Retrieved July 14th, 2015 from http://lrs.ed.uiuc.edu/students/fretzin/epl1q2programmed.htm.

Annum, G. (2015). *Research instruments for data collection*. Retrieved on July 19th, From campus.educadium.com. /newmdiart/file.../ugraResearch/…/resinstr

Ary, J. & Razaviet, B. (2001). *Research in education*. London: Wadswork Group.

Baidoo M. K. (2015). *A comparative analysis of the effects of the 3-year and 4-year SHS policies on students' performance.* Unpublished Dissertation, University of Education, Winneba.

Barrett, P. (2011). *Assessing the reliability of rating data*. Retrieved on 20th July, 2015 from http://www.pbarrett.net/techpapers/rater.pdf

Barusch, A., Gringeri, C., & George, M. (2011). Rigor in qualitative social work research: A review of strategies used in published articles. *Social work research*, *35*(1), 11-19.

Berding, J. W. A. (2000). *John Dewey's participatory philosophy of education: Education, experience and curriculum*. Retrieved on 12th June 2015 from http://www.socsci.kun.nl/ped/whp/histeduc/misc/dewey01.html

Bergman, M.M.(Ed.) (2008). *Advances in Mixed Methods Research*. Continuum.

Bernard, H. R. (2002). *Research methods in anthropology:* Qualitative and Quantitative methods (3rd Ed.). Walnut Creek, California: Alta Mira Press.

Bjorklund, D. F. (2000). *Children's thinking: Developmental function and individual Differences* (third Ed.). Belmont: Wadsworth/Thomson Learning.

Bogdan, R. C., & Bilklen, S. K. (2003). *Qualitative research for education: An Introduction to theory and methods (4th Ed.)*. Boston: Allyn & Bacon.

Bryman, A. (2012). *Social research methods (4th* Ed.). Oxford University press.

Castillo, J.J. (2009). *Research population*. Retrieved on 23rd November, 2015 from http://www.experiment-resources.com/res earch-population.html

Cepni, S. (2010). *Introduction to Research and Studies Project.* Trabzon: Celepler Printing.

Chang, H., Quintana, C., & Krajcik, J. (2007). *The impact of animation-mediated practice on middle school students' understanding of chemistry concepts*. Retrieved from www.ukessays.com

Cimer, A. (2007). Effective teaching in science: A review of literature. *Journal of Turkish science education*, *4*(1), 20-44.

Cohen, L., Manion, L., & Morrison, K. (2008). *Research methods in education*. New York: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education*. Routledge, Taylor and Francis Group: London.

Colley, K. E. (2006). Understanding ecology content knowledge and acquiring Science process skills through project based instruction. *Science Activities, 43*(1), 26-33.

Cooper, H. M. (2007). *Battle over homework*: *Common ground for administrators, Teachers, and parents (3rd* Ed.). Thousand Oaks, CA: Corwin Press

Cooper, H., Robinson, J. C., & Patall, E. A. (2006). Does homework improve Academic achievement? A synthesis of research, 1987–2003. *Review of Educational Research, 76*(1), 1–62.

Creswell, J. W., & Plano Clark, V.L. (2011).*Designing and Conducting Mixed methods Approaches*. Sage Publications.

Creswell, J. W. (2008). *Educational research: planning, conducting, and evaluating Quantitative and qualitative research* (3rd ed.). New Jersey: Upper Saddle River.

Creswell, J.W. & Plano Clark, V.L.(2018).*Designing and Conducting Mixed Methods Research* (3rded.).Sage Publications.

Dejong, T. & Van Joolingen, W. (2003). *Scientific Discovery Learning* with *Computer Simulations of Conceptual Domains*. *Review of Educational Research*, 63, 2:179-201.

Dillon, J. (2000). *Classroom questions and discussions*. Norwood, NJ: Ablex .

Dusick, D. M. (2011). *Writing the delimitations*. Retrieved July 25, 2014 from http://bold-ed.com/delimitations.htm.

Eggen, P.,& Kauchak, D.(2010). *Educational psychology*. Windows on classrooms (5th ed.). Upper Saddle River, NJ: Prentice Hall

Erenosho, S. Y. (2009*). Teaching science in seconding schools: A Methodology Handbook.* Ibadan: Polygraphics Ventures Limited.

Ferrance, E. (2000). *Action research –education theme, national and Island Regional Educational Laboratory, Brown University.* Retrieved July 14, 2015 from Website URL:http://www.alliance.brown.edu/pubs/themes_ed/act_research.pdf

Fouka, G., & Mantzorou, M. (2011). What are the ethical issues in conducting research? Is there a conflict between the research ethics and the nature of nursing? *Health Science Journal, 5*(1), 3-14.

Fraenkel, J. R., & Wallen, N. E. (2000). *How to design and evaluate research in Education* (4th Ed.). New York: McGraw-Hill, Inc.

Gallenstein, N. L. (2004). Creative discover through classification of teaching Children mathematics. *The Mathematics Educator 11*, 103-104.

Gay, L, R, & Airasian, P. (2000). *Educational research*: *competencies for analysis And application*. Upper Saddle River, NJ: Prentice-Hall.

Given, L. M. (Ed.). (2008). *The Sage encyclopedia of qualitative research methods*. Sage publications.

Gravetter, J. F., & Forzano, L. B. (2006). *Research methods for the behavioural Science (second Ed.).* Belmont, USA: Thomson Wader.

Hair, J. F., Black, W. C., Babin, B. J.,& Anderson, R. E. (2010). *Multivariate data analysis (7TH ed.)*, NJ: Prentice Hall.

Hardy, I., Jonen, A., Möller, K., & Stern, E. (2006). Effects of instructional support within constructivist learning environments for elementary school students' understanding of" floating and sinking.". *Journal of Educational Psychology*, *98*(2), 307.

Heale, R., & Twycross, A. (2015).Validity and Reliability in Quantitative studies. *Evidence Based Nurs, 18*(4), 66-67.

Jack, F. R., & Norman, E. W. (2003). *How to design and evaluate research in education* (5th ed.). Boston: McGraw Hill Publishers.

Jeridah, L. M. (2019). *The effect of jigsaw method on grade 12 learners' performance in reaction rate in Maleboho Central Circuit.* University of Limpopo: Published Dissertation.

Jo, R.(2010). *The Logic of discovery of grounded theory*: Saga. Retrieved May 17th, 2015 from http://srmo.sage pub.com/../nio.xml

Kearsley, E. P., & Wainwright, P. J. (2001*). The effect of high fly ash content on the compressive strength of foamed concrete*. *Cement and concrete research*, *31*(1), 105-112.

Kearsley, G. (2001). *Constructivist theory*: *Theory into practice*. Jacksonville, FL: Jacksonville State University.

Khan, R.E.(2010). *Developing the theoretical and social framework, Lecture* J199. Retrieved June 20th, 2015 from http://www.scibd.com/patrisya 123/documents

Khanzode, V. V. (2004*). Research methodology - Techniques and trends*. New Delhi: APH publishing cooperation.

Kidman, L. (2001). *Developing decision makers. An empowerment approach to Appoaching Christ church.* New Zealand: Innovative Print Communications Ltd.

Krah P. K. *(*2015*). Guided discovery and self learning strategies.* UEW Publications.

Krah, N. M., Narayanan, S. M., Yugawa, D. E., Straley, J. A., Wright, C. V., MacDonald, R. J., & Murtaugh, L. C. (2019). *Prevention and reversion of pancreatic tumorigenesis through a differentiation-based mechanism*. *Developmental cell*, *50*(6), 744-754.

Kumekpor, T. K. B (2002*). Research methods and techniques of social research.* Accra: Son Life Press & Services.

Labaree, D. F. (2011). Consuming the public school. *Educational Theory, 61*,381-394.

MacLean, M., & Poole, G. (2010). An introduction to ethical considerations for novices to research in teaching and learning in Canada. *Canadian Journal for the Scholarship of Teaching and Learning*, *1*(2), 7.

Mayer, R .E. (2003). *Learning and instruction*. Upper Saddle River: Pearson Education Inc.

Mayer*,* R*. (*2004*).* Should There Be A Three-Strike Rule Against Pure Discovery *Learning? The Case for Guided Methods of instruction. American Psychologist.* 59 *(1*), 14-19*.*

McLeod, S.A.(2012). *Zone of proximal Development*. Retrieved on 10th May, 2015 from www.simple psychology.org/zone-of-priximal Development.html

Merriam, S. B. (2001*). Qualitative research and case study application in education.* San Francisco, California: Jossey- Bass Publishers.

Mills, G. E. (2000). *Action research: A guide for the teacher researcher*. Columbus: Prentice Hall.

Mogari, D. (2003). A relationship between attitude and achievement in Euclidean Geometry of grade 10 pupils. *African Journal of Research in Mathematics, Science and Technology Education, 7*, 63-72.

Mohajan, H. (2017).Two criteria for good measurement in research: validity and reliability. Annals of Spiru Haret University. *Economics Series, 17*(4), 59-82.

National Research Council. (2000*). National science education standards.* Washington, D.C.: National Academy Press.

Nwagbo, C. (2004). The Relative Efficiency of Guided Inquiry and Expository Methods on Achievements in Biology Students of Different Levels of Scientific Literacy. *Journal of STAN*.36, 1&2:43-51.

Nwagbo, C. (2005). The Relative Efficacy of Guided Discovery Inquiry and Expository Methods of Different Levels of Scientific Literacy. *Journal of Science Teachers Association of Nigeria*(JSTAN).

Nwagbo, C. (2006). Effects of two teaching methods on the achievement in and Attitude to biology of students of different levels of scientific literacy. *International Journal of Educational Research, 45*, 216-229.

Okoye, N.S. *(*2004*).* Factors Affecting Teaching and Learning. The Teacher, Subject Matter and Environmental Dimension in Ughamadu, K.A and Okoye, N.S.*(*Eds*)* *Principles, Methods and Strategies for Effective Teaching.* Agbor *KMENSUO* Educational publishers.

Okoye, N.S. Momoh, S.O., Aigbomian, D.O. and Okecha, R.E. (2008). *Teachers Quality*, *Instructional Strategies and Students Performance in Secondary School Science.Journal of Instructional Psychology*.

Olatoye, R. O., & Adekoya, Y. M. (2010). Effect of project based, demonstration and Lecture teaching strategies on senior secondary students' in an aspect of Agricultural science. *International Journal of Educational Research and Technology,* 1(1), 19-20.

Onanuga, P.A.*(*2004*). Differential Effects of Guided Discovery and Conventional Methods of Secondary School Students Achievement in Agricultural Science, African Journal of Educational Research.* 7,1 &2.

Parson, R. D., & Brown, K. S. (2002*). Teacher as a reflective practitioner and action Researcher.* Belmont, Calif: Wadsworth &Thomson learning.

Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education*: *theory*, *research*, *And applications* (2nd Ed.). Upper Saddle River, NJ: Prentice Hall Merrill.

Popoola, A. A. (2002). *Effect of Heuristic problem solving and programmed Instructional strategies on senior secondary school students' learning Outcomes in mathematics and science in Ekiti State, Nigeria*. Unpublished Ph.D. Thesis, University of Ibadan.

Punch, K. F. (2006*). Developing Effective Research Proposals* (2nd ed.). London: Sage Publication.

Reichert, R. (2005). *Scientific discovery learning with computer simulations of Conceptual domains of learning*. Retrieved on May 14, 2015 from www.elearning-reviews.org/publications/270 HTML Dillon, j. (2000)

Riasat, A. (2005). *Development and effectiveness of modular teaching in Biology at Secondary level*. Retrieved on July 14, 2015 from http://eprints.hec.gov.pk/495/1/376.html.htm

Robson, C. (2002). *Real World Research* (second ed.). Singapore: Best-Set Tyesetter Ltd.

Rwodzi, F. R.M., & Mukundu, C, C. K. (2013). Project approach as an alternative to Regular laboratory practical work in the teaching and learning of Biology in Rural secondary schools in Zimbabwe. *International Journal of Education and Information Studies*, 3(1), 13-20.

Saat, R. M. (2004). The acquisition of integrated science process skills in a web – Based learning environment. *Research in Science Teaching and Technological Education, 22*(1), 23 – 40.

Sekyere, E. A. (2013). *Teachers' guide on topical issues for promotion and selection Interviews and general professional update* (pp. 92-93). Kumasi: Afosek Educational Consult.

Serwaa-Ampaafo, E. (2017). *Investigating the performance of senior high school students in biology practical work:* University of Cape Coast Publication.

Sidhu, K. S. (2007). *Methods of research in education*. New Delhi: Sterling Publishers.

Taraban, R. (2007). Effect of active learning experiences. *Journal of Research and Science Teaching, 44* (7), 960-979.

Thornbury, S. (2004). Big words, small grammar. *English Teaching Professional*, *31*, 10-11.

Trochim W. M. K. (2006). *Research methods knowledge based*. Retrieved June 20, http://www.socialresearchmethods.net/kb/design.php.

Ugwanyi, J. A. (2008). Effect of guided discovery achievement in physics in selected Secondary schools. *Nigeria Journal of Technical Education, 15*(1) 167- 171.

Ugwanyi, J.A. *(*2008*). Effect of Guided Discovery Achievement in Physics in Selected Secondary Schools in Nsukka, Enugu State, Nigeria. Nigeria Journal of technical education. 15.*

Walsh, J., & Sattes, B. D. (2005*). Quality questioning: Research-Based practice to Engage every learner.* Thousand Oaks, CA: Corwin press.

Wellington, J. (2000). *Educational research: Contemporary issues and practical Approaches* .London: Continuum.

West African Examinations Council (2014). *Chief Examiners Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2012). *Chief Examiners Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2013). *Chief Examiners Report on Senior Secondary Certificate Examination.* Accra*;* Wisdom press.

West African Examinations Council (2015). *Chief Examiners Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2016). *Chief Examiners Report on Senior Secondary Certificate Examination.* Accra; Wisdom press.

West African Examinations Council (2017). *Chief Examiners Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2018). *Chief Examiners Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2019). *Chief Examiners Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2020). *Chief Examiners Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2021). *Chief Examination Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

West African Examinations Council (2022). *Chief Examination Report on Senior Secondary Certificate Examination*. Accra; Wisdom press.

Westwood, P. (2008*). Direct Instruction (DI), what teachers need to know about Teaching methods?* Victoria: ACER press.

Yusuf, M. O., & Afolabi, A. O. (2010). Effects of computer assisted instruction on Secondary school students' performance in biology. *The Turkish Online Journal of Educational Technology*, 17, 144-203.

Zohrabi, M. (2013). Mixed method researcher: Instruments, validity, reliability and reporting findings. *Theory and Practice in Language Studies, 3*(2), 254-262.

APPENDIX A

PRE-TEST AND POST-TEST SCORES (IN PERCENTAGES) AND RESULTS OF STUDENTS` PERFORMANCE IN THE PRE-TEST AND POST-TEST

Table 7: Pre- test scores (in percentages) for Experimental Group and Control Group.

Learner Number Control Group:	Experimental Group: Scores for Each learner (%)	Control Group: Score for each learner (%)	Learner Number Control Group:	Experimental Number Group: Scores for Each learner (%)	Control Group: Score for each learner (%)
1	38	39	19	32	41
2	35	44	20	17	37
3	35	50	21	23	29
4	44	56	22	53	48
5	41	46	23	38	51
6	35	18	24	38	53
7	32	56	25	41	38
8	26	34	26	21	38
9	53	41	27	34	34
10	41	32	28	36	38
11	41	35	29	17	36
12	41	47	30	27	35
13	35	41	31	41	31
14	38	37	32	37	30
15	41	32	33	-	39
16	41	35	34	-	
17	38	27	35	-	
18	41	54	36	-	

Table 8: Post- test scores (in percentages) for Experimental Group and Control Group.

Learner Number Control Group:	Experimental Group: Scores for Each learner (%)	Control Group: Score for each learner (%)	Learner Group: Scores for each learner (%)	Experimental Number Group: Scores for Each learner (%)	Control Group: Score for each learner (%)
1	59	56	19	69	61
2	63	48	20	66	57
3	60	47	21	55	79
4	68	45	22.	72	68
5	69	70	23	74	71
6	84	64	24	78	73
7	90	46	25	66	88
8	56	51	26	79	58
9	58	42	27	63	54
10	71	59	28	48	58
11	79	63	29	80	56
12	95	53	30	78	55
13	61	79	31	-	51
14	72	76	32	-	50
15	56	57	33	-	59
16	70	57	34	-	-
17	61	47	35	-	-
18	68	74	36	-	-

Table 9: Results of students` performance in the pre- test presented as Figures and Percentages

Question Number	Total Number Of students	Number of student with correct Answers	Percentage (%)	Number of students with wrong answers	Percentage (%)
1	63	44	70	19	30
2	63	33	53	30	47
3	63	28	44	35	56
4	63	35	56	28	44
5	63	3	5	60	95
6	63	39	62	24	38
7	63	4	7	59	93
8	63	24	38	39	62
9	63	18	29	45	71
10	63	23	37	40	63
11	63	22	35	41	65
12	63	29	46	34	54
13	63	10	16	53	84
14	63	24	38	39	62
15	63	24	38	39	62
16	63	26	42	37	58
17	63	22	45	41	65
18	63	23	37	40	63
19	63	14	22	49	78
20	63	31	49	32	51
21	63	46	73	17	27
22	63	46	73	17	27
23	63	32	51	31	49
24	63	16	25	47	75
25	63	40	63	23	37

Table 10: Results of students` performance in the post- test presented as Figures and Percentages

Question Number	Total Number Of students	Number of student with correct Answers	Percentage (%)	Number of students with wrong answers	Percentage (%)
1	63	54	86	9	14
2	63	49	78	14	22
3	63	42	67	21	33
4	63	43	68	20	32
5.	63	36	57	27	43
6.	63	47	75	16	25
7.	63	38	60	25	40
8.	63	39	62	24	38
9.	63	52	83	11	17
10.	63	36	57	27	43
11	63	46	73	17	27
12	63	38	60	25	40
13.	63	24	38	39	62
14.	63	52	83	11	17
15.	63	36	57	27	43
16.	63	43	68	20	32
17	63	60	95	3	5
18	63	46	73	17	27
19.	63	24	38	39	62
20.	63	45	71	18	29
21.	63	48	76	15	24
22.	63	47	73	16	27
23.	63	51	81	12	19
24.	63	57	90	6	10
25	63	45	71	18	29

APPENDIX B:

PRE -TEST QUESTIONS FOR STUDENTS

UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1.Which of the following types of soil contains the greater percentage of air?

A. sandy B. loamy C. silt D. clay

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as ……

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

4. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

5. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

C. movement of solute molecules from a region of lower concentration of solvent molecules.

D. movement of solvent molecules from a dilute solution into a concentrated solution.

6. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen D. sulphur

7. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

8. In which of the following yam tissues will osmosis occur?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

9.The following are all factors affecting the amount of air in the soil except……

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

12. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

15. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants.

B. major source of nitrogen

C. reduces soil acidity

D. it promotes the activities of microbes and other soil organisms

16. Which of these does not require energy?

A. Gravity B. Passive transport C. osmosis D. active transport

17. What is the name of the membranes that allow certain materials to pass through them?

A. Osmosis B. Selectively membrane C. Diffusion D. Impermeable

18. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil.

D. By drying the soil

19. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

20. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are
   a. ……
   b. ……
   c. ……
2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a
   ……
3. The factors affecting the amount of air in the soil are
   a……
   b……
   c……

4.What are the importance of soil air?

(a)……
……
……

(b)……
……
……

(c)……
……
……
……
……

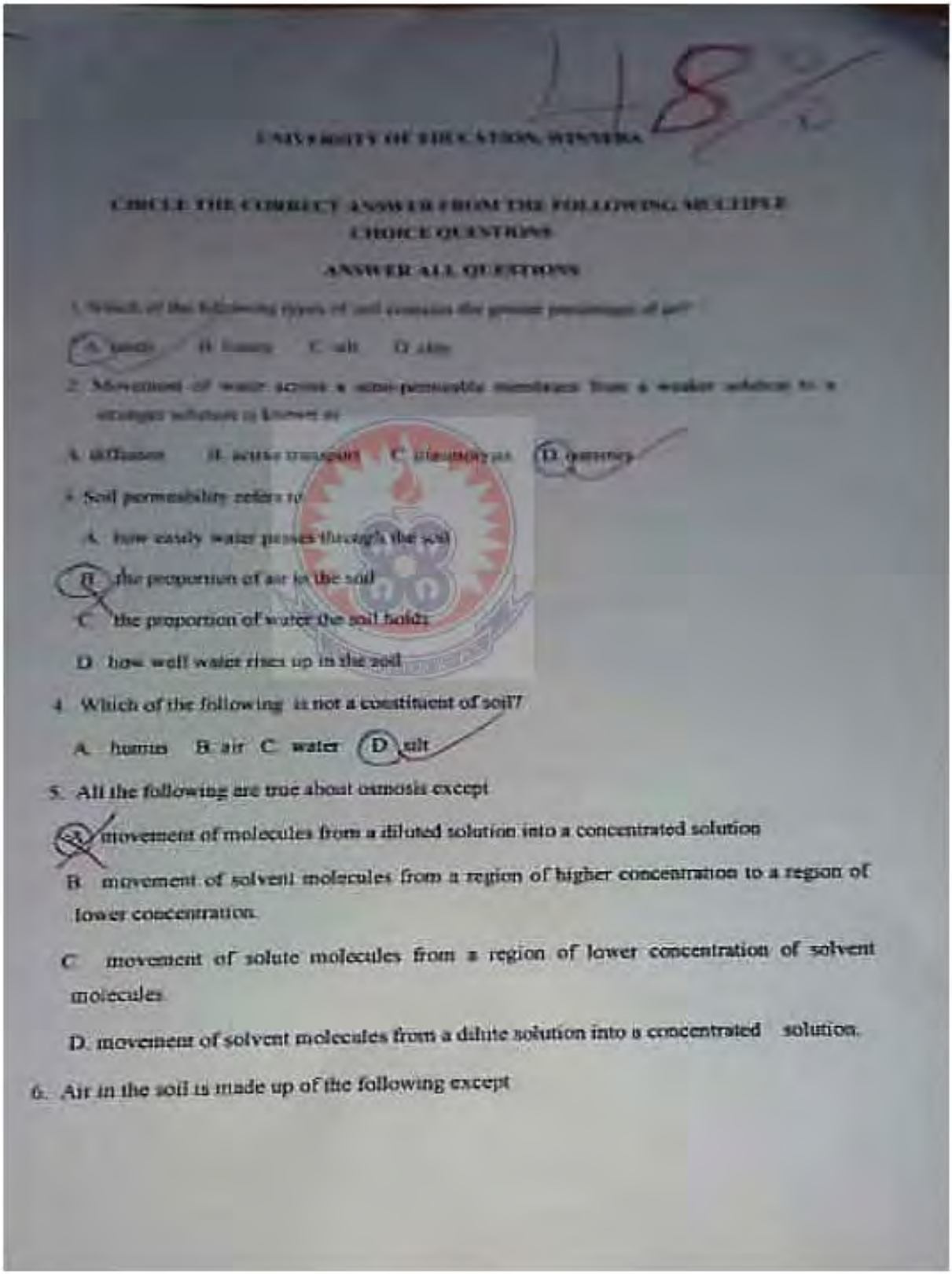
5. Which of the soil samples have large air spaces?

……

APPENDIX C:

PRE-TEST RESULTS FOR STUDENTS

STUDENT 'A':



UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. Which of the following types of soil contains the greatest percentage of air?

A. sandy B. loamy C. silt D. clay

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

4. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

5. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

C. movement of solute molecules from a region of lower concentration of solvent molecules

D. movement of solvent molecules from a dilute solution into a concentrated solution.

6. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen (D.) sulphur

7. [illegible] of the soil can be improved by the presence of the following except

(A.) termites B. earthworms C. grasshoppers D. millipedes

8. In which of the following ways maize will minerals occur?

(A.) boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

9. The following are all factors affecting the amount of air in the soil except

A. soil particles B. concentration gradient C. soil water (D.) temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

(B.) absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

24/60

11. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning (D.) ploughing

12. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient (C.) permeability D. size of the particles

13. Osmotic pressure or pure water is

A. 0 B. 1 (C.) 10 D. 20

14. Osmosis cannot take place in a

(A.) pig's bladder B. cellophane paper C. transparent polythene D. parchment

paper

15. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants

B. major source of nitrogen

C. [illegible] soil acidity

D. it promotes the activities of microbes and other soil organisms

16. Which of these does not require energy?

A. Osmosis B. Passive transport C. osmosis D. active transport

17. What is the name of the membranes that allow certain materials to pass through them?

A. Osmosis B. Selectively membrane C. Diffusion D. Impermeable

18. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil

D. By drying the soil

19. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

20. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting ... are

a. Temperature ✓

b. Concentration gradient ✓

c. Particle size ✓

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a

Semi - permeable membrane ✓

3. The factors affecting the amount of air in the soil are

a. Soil particle ✓

b. Soil moisture ✓

c. ? ?

24/42

4. What are the importance of soil air?

(a) Need for respiration by organisms in the soil ✓

(b)

(c)

5. Which of the soil samples have large air spaces?

Sandy soil ✓

24 + 24 = 48

STUDENT 'B':

34%

UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. Which of the following types of soil contains the greater percentage of air?

(A. sandy) B. loamy C. silt D. clay

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as .....

A. diffusion (B. active transport) C. plasmolysis D. osmosis

3. Soil permeability refers to

A. how easily water passes through the soil

(B. the proportion of air in the soil)

C. the proportion of water the soil holds

D. how well water rises up in the soil

4. Which of the following is not a constituent of soil?

(A. humus) B. air C. water D. silt

5. All the following are true about osmosis except

(A. movement of molecules from a diluted solution into a concentrated solution)

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

C. movement of solute molecules from a region of lower concentration of solvent molecules

D. movement of solvent molecules from a dilute solution into a concentrated solution

6. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen D. sulphur

7. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

8. In which of the following ways humans will consume yams?

A. Boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

9. The following are all factors affecting the amount of air in the soil except

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

12. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

15. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants

B. major source of nitrogen

C. reduces soil acidity

D. it promotes the activities of microbes and other soil organisms

16. Which of these does not require energy?

A. Gravity B. Passive transport C. osmosis D. active transport

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A. Osmosis B. Selectively membrane C. Diffusion D. Impermeable

18. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil

D. By drying the soil

19. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

20. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

12/60

12 + 22 = 34

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are;

a. Permeability ✓

b. Concentration gradient ✓

c. Size of the particles ✗

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a

Semi- permeable membrane ✓

3. The factors affecting the amount of air in the soil are

a. Temperature ✓

b. Time Soil particles ✓

c. Season climate ~~can~~ soil water ✓

4. What are the importance of soil air?

(a). It protects the activities of microbes and other soil organism. ✓

(b). It is used by for respiration by soil organisms and roots of plants. ✓

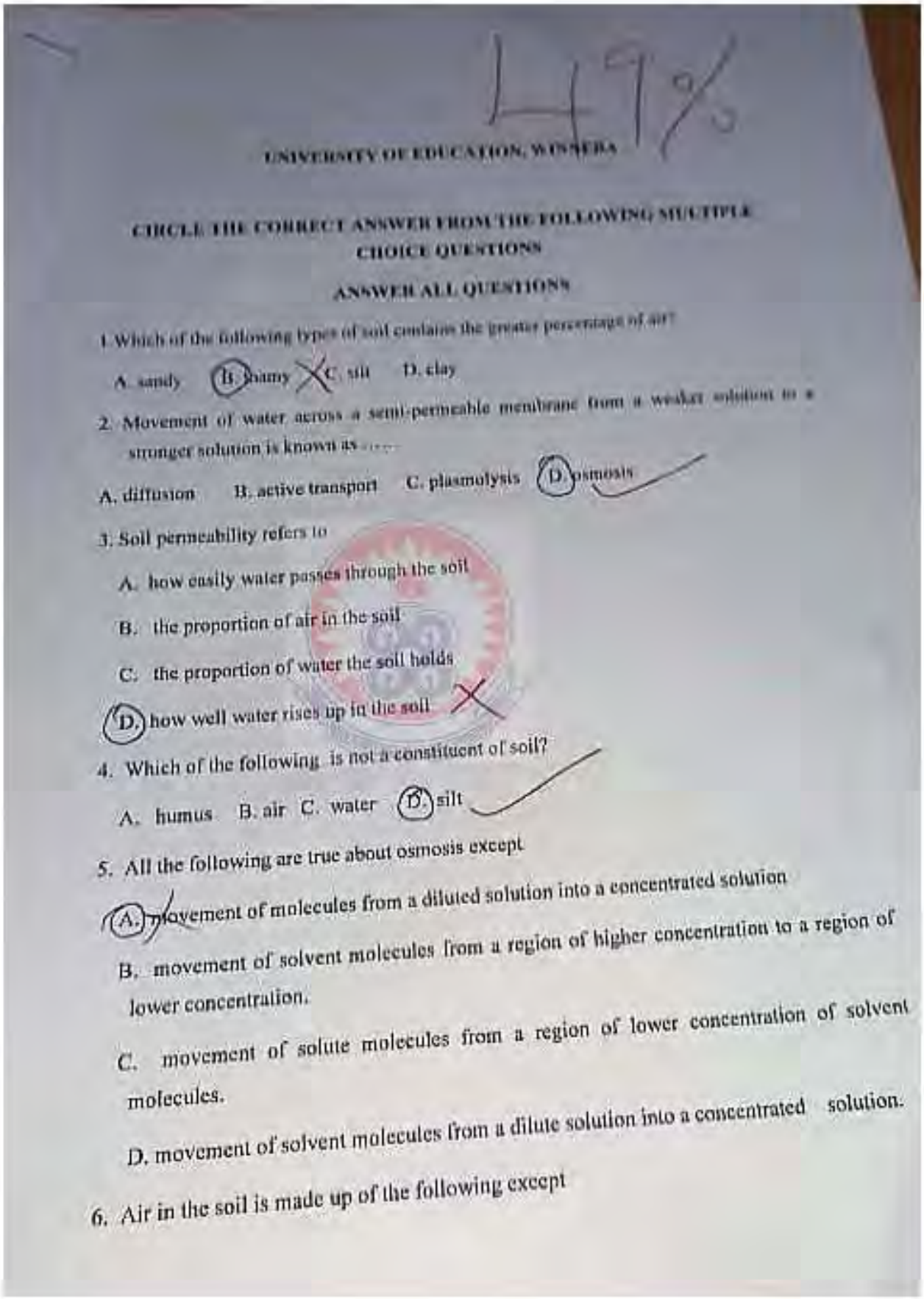
(c). It reduces soil acidity. ✓

5. Which of the soil samples have large air spaces?

clay sample. ✓

22/40

STUDENT 'C'



UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. Which of the following types of soil contains the greater percentage of air?

A. sandy B. loamy C. silt D. clay

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as .....

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

4. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

5. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

C. movement of solute molecules from a region of lower concentration of solvent molecules.

D. movement of solvent molecules from a dilute solution into a concentrated solution.

6. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen D. sulphur

7. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

8. In which of the following yam tissues will osmosis occur?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

9. The following are all factors affecting the amount of air in the soil except.....

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

12. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

15. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants

B. major source of nitrogen

C. reduces soil acidity

(D) it promotes the activities of microbes and other soil organisms

16. Which of these does not require energy?

A. Gravity B. Passive transport C. osmosis (D) active transport

17. What is the name of the membranes that allow certain materials to pass through them?

A. Osmosis B. Selectively membrane C. Diffusion (D.) Impermeable

18. How is air removed from n sample of soil?

A. By heating the soil sample

B. By burning the soil sample

(C) By adding water about three times the volume of the soil into the soil.

D. By drying the soil

19. Which of the following factors does not affect soil formation

A. climate B. organisms C. time (D.) concentration

20. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution (D) Knife

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are

a. Temperature ✓

b. Concentration gradient ✓

c. Permeability ✓

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a

Semi-Permeable membrane ✓

3. The factors affecting the amount of air in the soil are

a. Temperature ✓

b. Organisms ✓

c. Soil water ✓

4. What are the importance of soil air?

(a) It makes the soil fertile for Plant growth ✓

(b) It is used for respiration by soil organisms and roots of plants ✓

(c) ?

5. Which of the soil samples have large air spaces?

Sandy Soil ✓

25/40

STUDENT 'D'

UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. Which of the following types of soil contains the greater percentage of air?

A. sandy B. loamy C. silt D. clay

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as .....

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

4. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

5. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

C. movement of solute molecules from a region of lower concentration of solvent molecules.

D. movement of solvent molecules from a dilute solution into a concentrated solution.

6. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen D. sulphur

7. [illegible]

A. [illegible] B. [illegible] C. [illegible] D. [illegible]

8. In which of the following [illegible] tissues will [illegible]?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

9. The following are all factors affecting the amount of air in the soil except____

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

12. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

13. Osmotic pressure of pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

15. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants.

B. major source of nitrogen

C. reduces soil acidity

D. it promotes the activities of microbes and other soil organisms

16. Which of these does not require energy?

A. Convey B. Passive transport C. osmosis D. active transport

17. What is the name of the membranes that allow certain materials to pass through them?

A. Osmosis B. Selectively membrane C. Diffusion D. Impermeable

18. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil.

D. By drying the soil

36/60

19. Which of the following factors does not affect soil formation

A. climate B. organisms C. None D. concentration

20. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are

a. Concentration gradient

b. Permeability of the membrane

c. Temperature

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a

Semi-permeable membrane

3. The factors affecting the amount of air in the soil are

a. Soil particles

b. soil water

c. Temperature

4. What are the importance of soil air?

(a). It helps to make soil porus

(b). It is used for respiration by soil organism and roots of plant

(c). ~~Oxygen~~ Soil air helps in the germination of seed.

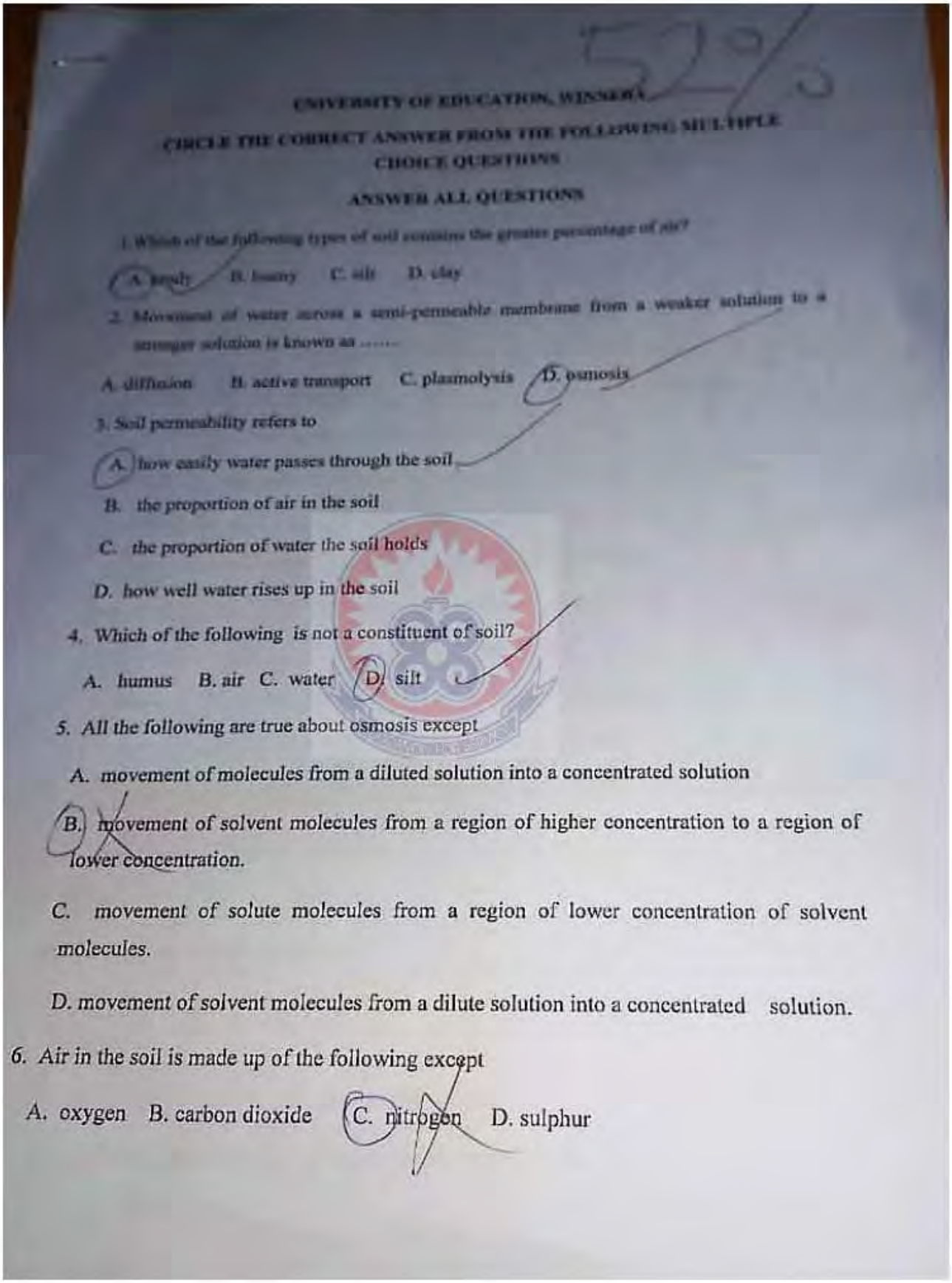
5. Which of the soil samples have large air spaces?

Sandy soil.

12/20

12+8+2+48

STUDENT'E'



UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. Which of the following types of soil contains the greater percentage of air?

A. loam B. loamy C. silt D. clay

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as .....

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

4. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

5. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

C. movement of solute molecules from a region of lower concentration of solvent molecules.

D. movement of solvent molecules from a dilute solution into a concentrated solution.

6. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen D. sulphur

7. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

8. In which of the following yam tissues will osmosis occur?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

9. The following are all factors affecting the amount of air in the soil except.....

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

12. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

15. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants.

B. major source of nitrogen

C. reduces soil acidity

D. it promotes the activities of microbes and other soil organisms

16. Which of these does not require energy?

A. Gravity B. Passive transport C. osmosis D. active transport

17. What is the name of the membranes that allow certain materials to pass through them?

A. Osmosis B. Selectively membrane C. Diffusion D. Impermeable

18. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil.

D. By drying the soil

19. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

20. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

45/60

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are

a. Concentration.

b. Temperature.

c. Permeability.

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a

Semi-permeable membrane.

3. The factors affecting the amount of air in the soil are

a. Size of the particles.

b. Climate.

c.

4. What are the importance of soil air?

(a). Soil air helps organisms in the soil to respire.

(b). It is the major sources of nitrogen to the soil.

(c). It makes soil porous.

5. Which of the soil samples have large air spaces?

Sandy soil.

7 + 45 2 52

APPENDIX D

POST-TEST QUESTIONS FOR STUDENTS

UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as ……

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

4.Which of the following types of soil contains the greatest percentage of air?

A. sandy B. loamy C. silt D. clay

5. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil.

D. By drying the soil

6. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

7. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants.

B. major source of nitrogen

C. reduces soil acidity

D. it promotes the activities of microbes and other soil organisms

8. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

9.The following are all factors affecting the amount of air in the soil except……

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

12. In which of the following yam tissues will osmosis occur?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

15. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

16. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

C. movement of solute molecules from a region of lower concentration of solvent molecules.

D. movement of solvent molecules from a dilute solution into a concentrated solution.

17. What is the name of the membranes that allow certain materials to pass through them?

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19. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen D. sulphur

20. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are
   d. ……
   e. ……
   ……
2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across
   a……
   ……

3. The factors affecting the amount of air in the soil are

   a……

   b……

   c……

4.What are the importance of soil air?

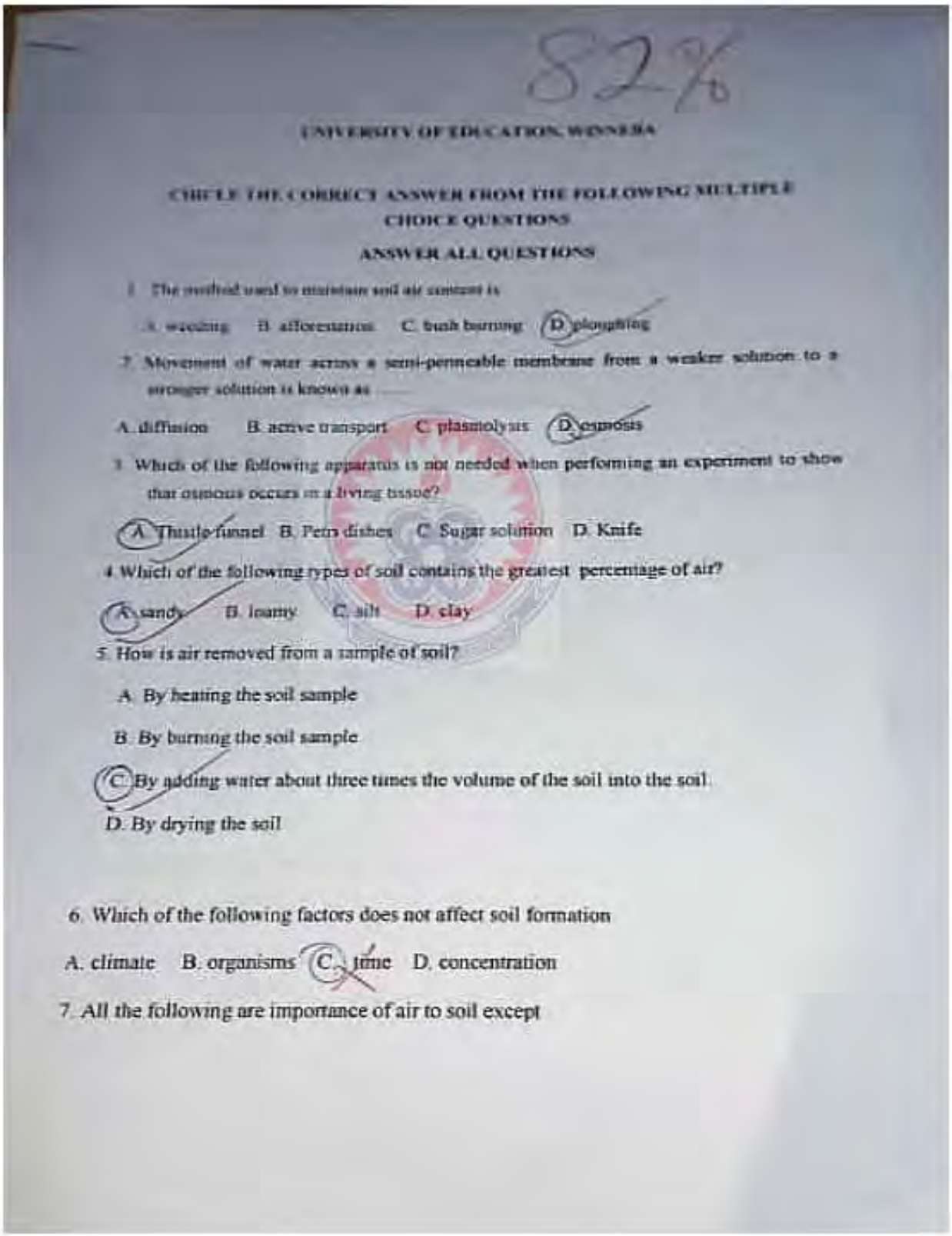
(a)……
……
……
(b)……
……
……
(c)……
……
……
……
……

5. Which of the soil samples have large air spaces?
……
……

APPENDIX E:

POS-TEST RESULTS FOR STUDENTS

STUDENT 'A':



82%

UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

4. Which of the following types of soil contains the greatest percentage of air?

A. sandy B. loamy C. silt D. clay

5. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil

D. By drying the soil

6. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

7. All the following are importance of air to soil except

A. [illegible]

B. [illegible]

C. reduces soil acidity

D. promotes the activities of microbes and other soil organisms

8. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

9. The following are all factors affecting the amount of air in the soil except

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

12. In which of the following yam tissues will osmosis occur?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

45/60

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

37+45 = 82

15. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silk

16. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration

C. movement of solute molecules from a region of lower concentration of solvent molecules

D. movement of solvent molecules from a dilute solution into a concentrated solution

17. What is the name of the membranes that allow certain materials to pass through them?

A. Osmosis B. Selectively membrane C. Diffusion D. Impermeable

18. Which of these does not require energy?

A. Gravity B. Passive transport C. osmosis D. active transport

19. Air in the soil is made up of the following except

A. oxygen B. carbon dioxide C. nitrogen D. sulphur

20. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

SECTION II (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are

a. temperature

b. concentration gradient

c. permeability of membrane

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a

semi-permeable membrane

3. The factors affecting the amount of air in the soil are

a. Soil water

b. Soil particles

c. Temperature

4. What are the importance of soil air?

(a) Reduce soil acidity

(b) Major source of nitrogen.

(c) Use for respiration by soil organisms and roots of plant.

5. Which of the soil samples have large air spaces?

Sandy soil

37/40

4

STUDENT 'B':

UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as .....

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

4. Which of the following types of soil contains the greatest percentage of air?

A. sandy B. loamy C. silt D. clay

5. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil.

D. By drying the soil

6. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

7. All the following are importance of air to soil except

A. used for respiration by soil organisms and roots of plants

B. major source of nitrogen

C. reduces soil acidity

D. it promotes the activities of microbes and other soil organisms

8. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

9. The following are all factors affecting the amount of air in the soil except

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

12. In which of the following yam tissues will osmosis occur?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

51/60

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchme

paper

15. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

16. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration.

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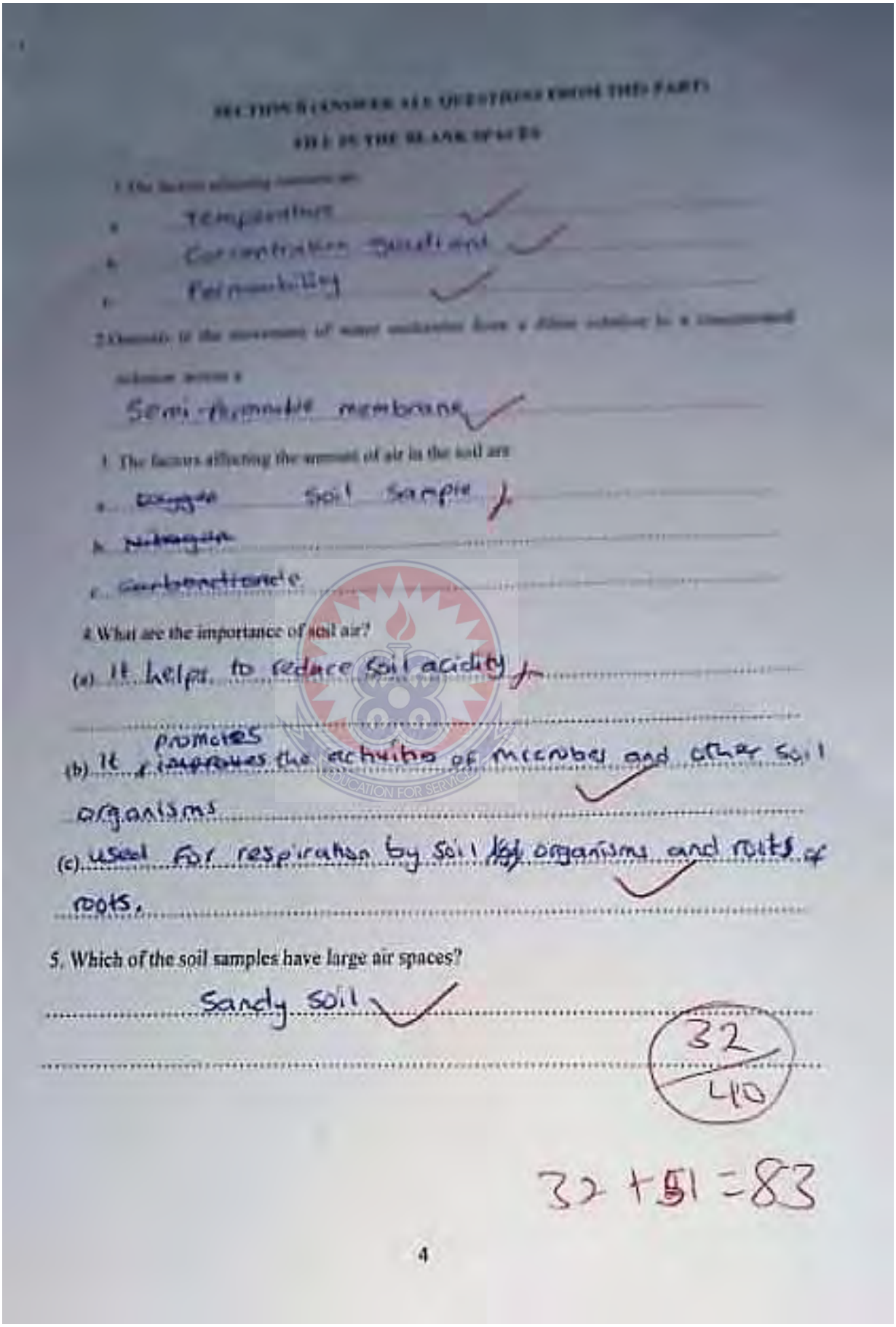
20. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil



SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)
USE IN THE BLANK SPACES

1. The factors affecting osmosis are
   a. Temperature ✓
   b. Concentration gradient ✓
   c. Permeability ✓

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a
   Semi-permeable membrane ✓

3. The factors affecting the amount of air in the soil are
   a. ~~oxygen~~ Soil Sample ✓
   b. ~~nitrogen~~
   c. ~~Carbondioxide~~

4. What are the importance of soil air?
   (a) It helps to reduce soil acidity ✓
   (b) It promotes / improves the activities of microbes and other soil organisms ✓
   (c) used for respiration by soil ~~life~~ organisms and roots of roots. ✓

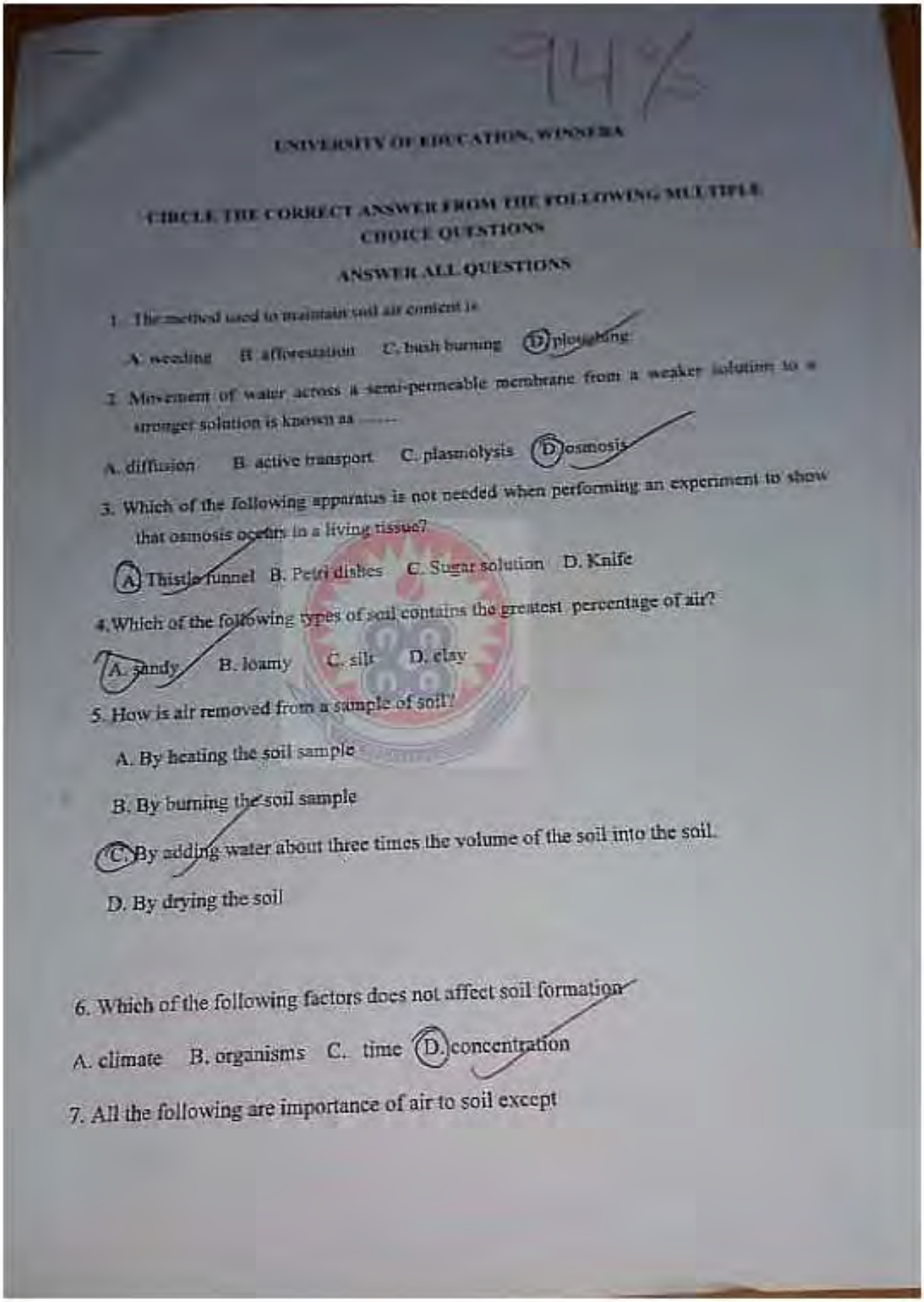
5. Which of the soil samples have large air spaces?
   Sandy soil ✓

32/40

32 + 51 = 83

4

STUDENT 'C'



94%

UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

1. The method used to maintain soil air content is

A. weeding B. afforestation C. bush burning D. ploughing

2. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as ……

A. diffusion B. active transport C. plasmolysis D. osmosis

3. Which of the following apparatus is not needed when performing an experiment to show that osmosis occurs in a living tissue?

A. Thistle funnel B. Petri dishes C. Sugar solution D. Knife

4. Which of the following types of soil contains the greatest percentage of air?

A. sandy B. loamy C. silt D. clay

5. How is air removed from a sample of soil?

A. By heating the soil sample

B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil.

D. By drying the soil

6. Which of the following factors does not affect soil formation

A. climate B. organisms C. time D. concentration

7. All the following are importance of air to soil except

A. [illegible]

B. [illegible]

C. reduces soil acidity

D. it promotes the activities of microbes and other soil organisms

8. All the following are factors affecting the rate of osmosis except

A. temperature B. concentration gradient C. permeability D. size of the particles

9. The following are all factors affecting the amount of air in the soil except

A. soil particles B. concentration gradient C. soil water D. temperature

10. Which of the following is an example of osmosis?

A. absorption of products of digestion through the villi in the ileum into the blood

B. absorption of water by root hairs of plants from the soil

C. absorption of some mineral salts in the soil by root hairs of plants

D. movement of oxygen from maternal blood into the placenta

11. Aeration of the soil can be improved by the presence of the following except

A. beetles B. earthworms C. grasshoppers D. millipedes

12. In which of the following yam tissues will osmosis occur?

A. boiled and peeled

B. raw and peeled

C. boiled and unpeeled

D. roasted and peeled

13. Osmotic pressure or pure water is

A. 0 B. 1 C. 10 D. 20

14. Osmosis cannot take place in a

A. pig's bladder B. cellophane paper C. transparent polythene D. parchment paper

57/60

15. Which of the following is not a constituent of soil?

A. humus B. air C. water D. silt

16. All the following are true about osmosis except

A. movement of molecules from a diluted solution into a concentrated solution

B. movement of solvent molecules from a region of higher concentration to a region of lower concentration

C. movement of solute molecules from a region of lower concentration of solvent molecules

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17. What is the name of the membranes that allow certain materials to pass through them?

A. Osmosis B. Selectively membrane C. Diffusion D. Impermeable

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20. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

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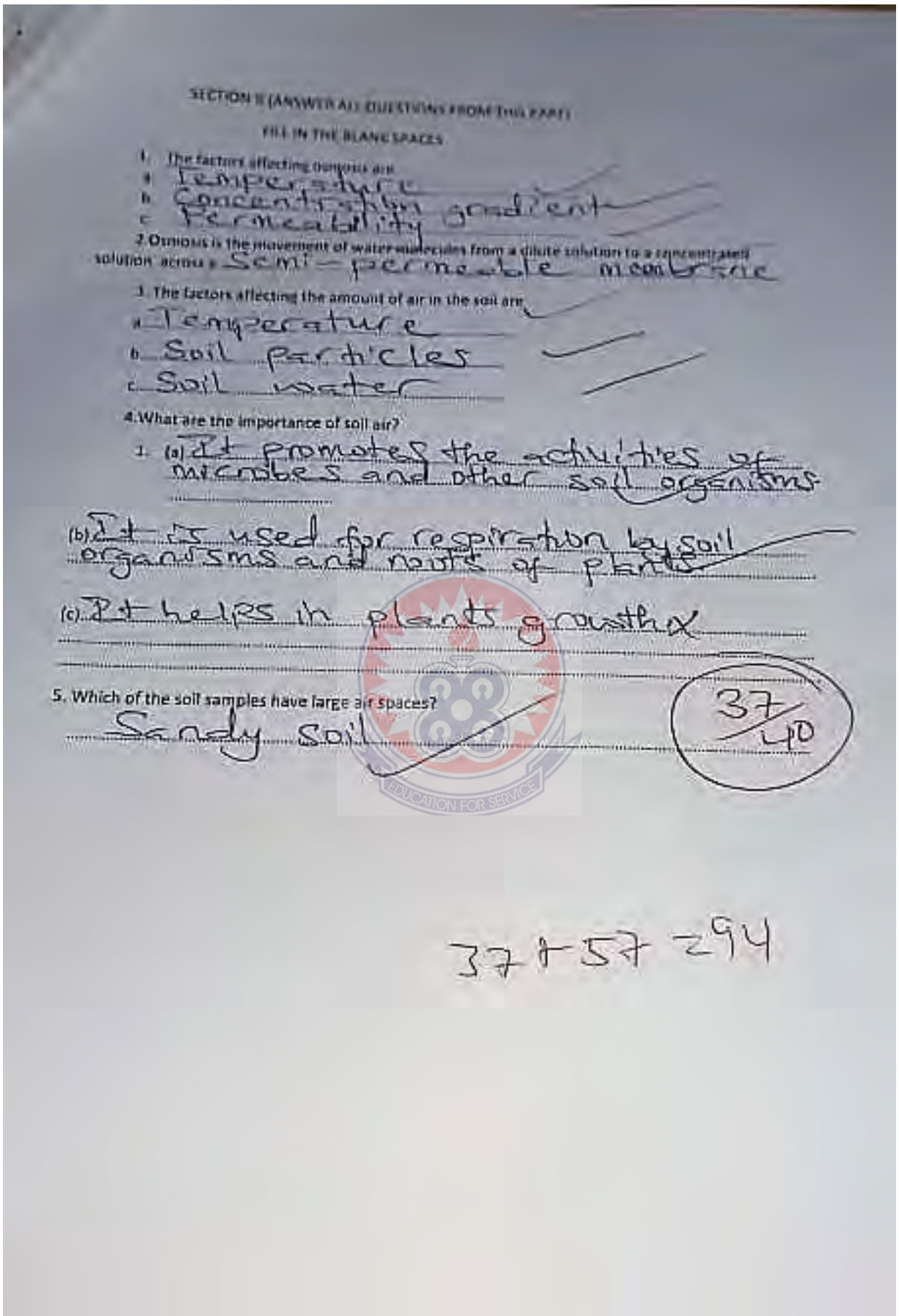
D. how well water rises up in the soil



SECTION II (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are
   a. Temperature
   b. Concentration gradient
   c. Permeability

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a Semi-permeable membrane

3. The factors affecting the amount of air in the soil are
   a. Temperature
   b. Soil particles
   c. Soil water

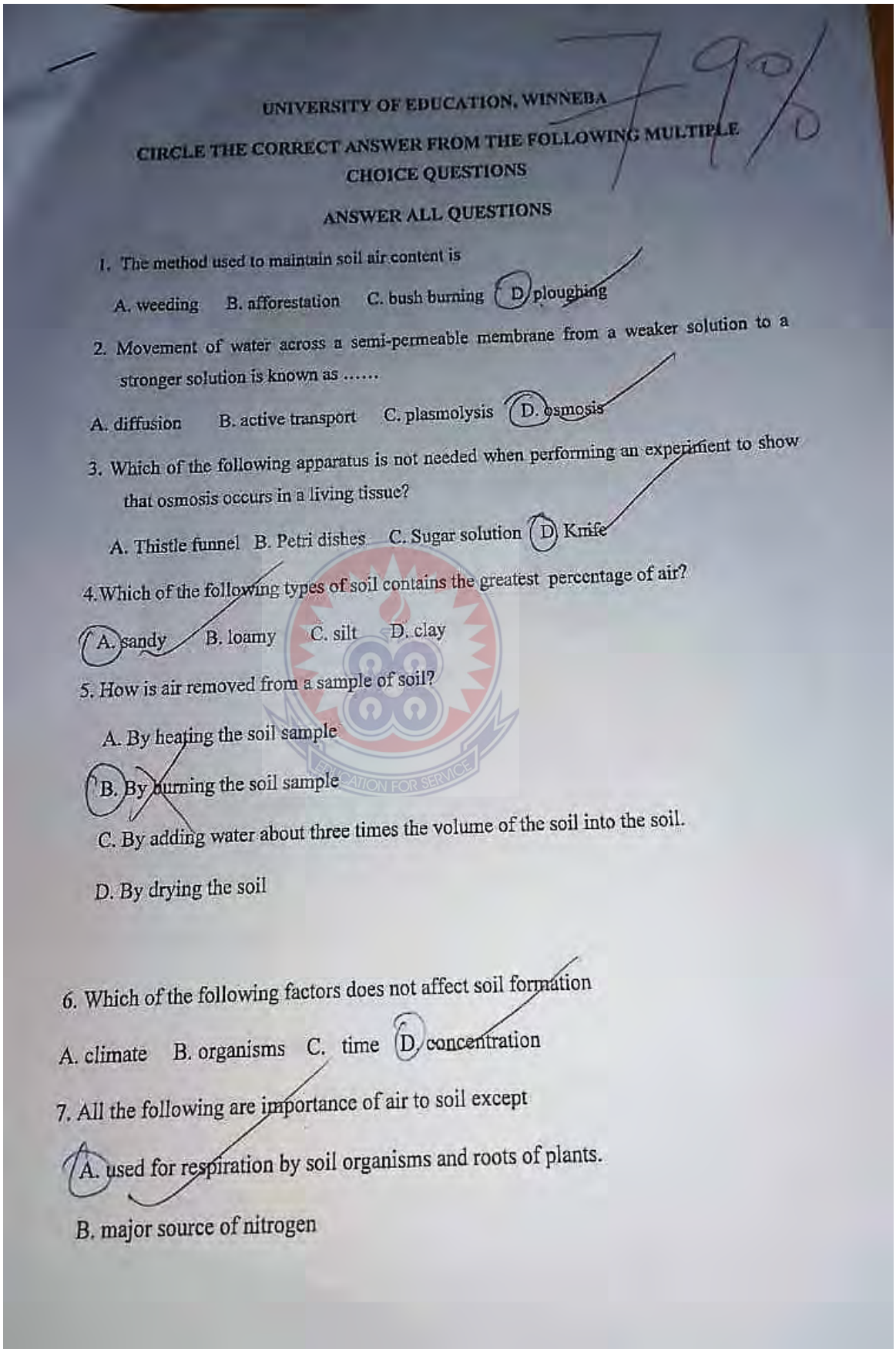
4. What are the importance of soil air?
   1. (a) It promotes the activities of microbes and other soil organisms
   (b) It is used for respiration by soil organisms and roots of plants
   (c) It helps in plants growth

5. Which of the soil samples have large air spaces?
   Sandy soil

37/40

37 + 57 = 94

STUDENT 'D'



UNIVERSITY OF EDUCATION, WINNEBA

CIRCLE THE CORRECT ANSWER FROM THE FOLLOWING MULTIPLE CHOICE QUESTIONS

ANSWER ALL QUESTIONS

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B. By burning the soil sample

C. By adding water about three times the volume of the soil into the soil.

D. By drying the soil

6. Which of the following factors does not affect soil formation

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B. major source of nitrogen

D. It promotes the activities of microbes and other soil organisms

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A. 0 B. 1 C. 10 D. 20

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A. oxygen B. carbon dioxide C. nitrogen D. sulphur

20. Soil permeability refers to

A. how easily water passes through the soil

B. the proportion of air in the soil

C. the proportion of water the soil holds

D. how well water rises up in the soil

51

60

51 + 28 = 79

SECTION B (ANSWER ALL QUESTIONS FROM THIS PART)

FILL IN THE BLANK SPACES

1. The factors affecting osmosis are

a. Concentration gradient.

b. Permeability of membrane.

c. Temperature.

3

2. Osmosis is the movement of water molecules from a dilute solution to a concentrated solution across a

semi - permeable membrane

2

3. The factors affecting the amount of air in the soil are

a. Soil water

b. Soil particles.

c. Temperature.

3

4. What are the importance of soil air?

(a). It is used for respiration by soil organism.

(b). It helps to make the soil porous.

2

(c). Oxygen is required for the decomposition of dead plants and animals for humus.

3

5. Which of the soil samples have large air spaces?

Sandy Soil.

2

28/30

4

APPENDIX F

QUESTIONNAIRE

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

MASTERS OF PHILOSOPHY IN SCIENCE EDUCATION (BIOLOGY)

Dear respondent,

This questionnaire seeks to find out attitudes of students towards biology practical lesson. Please as much as possible, kindly complete this questionnaire as accurately and honestly as you can. Any information gathered will be treated confidential.

SECTION A – Background Information

Instructions: Please kindly tick the brackets provided for the question appropriately the response that best answers it. Please provide written answer where applicable.

1. Gender Female( ) Male ( )
2. Class ……..

SECTION B : Benefits of carrying out practical's during biology lessons.

Instructions: This section presents some statements on the benefits/effects of carrying out practical during biology lessons. You are expected to indicate your knowledge about the statements by ticking the number in the boxes provided below the option that best describe your responses.

Keys: 1-Strongly disagree (very untrue) 2-Disagree (untrue) 3- Not true (unaware) 4- Agree (true) 5- Strongly agree (very true).

Benefits of carrying out practicals during biology lessons.

Responses

Benefits/effects of carrying out practicals during biology lessons.	**Response**	**Response**	**Response**	**Response**	**Response**
1. The aim of practical work during biology lessons is to improve our understanding.	**1**	**2**	**3**	**4**	**5**
2. Doing practical`s during biology lessons helps us to develop the skills needed in problem solving.	**1**	**2**	**3**	**4**	**5**
3. Practical work in biology will promote the understanding of the nature of science.	**1**	**2**	**3**	**4**	**5**
4. Practical lessons builds our interest in biology.	**1**	**2**	**3**	**4**	**5**
5. Carrying out practicals during biology lessons makes us to pay attention in class.	**1**	**2**	**3**	**4**	**5**
6. Practical lessons helps us to discover new concepts on our own.	**1**	**2**	**3**	**4**	**5**
7. Practical lessons in biology helps us to understand some topics better than teaching us with the lecture method.	**1**	**2**	**3**	**4**	**5**
8. We will not understand some topics in biology without carrying out practicals on such topics.	**1**	**2**	**3**	**4**	**5**
9. Practical lessons add fun to learning.	**1**	**2**	**3**	**4**	**5**
10. Practical lessons usually builds our interest and motivate us to learn more.	**1**	**2**	**3**	**4**	**5**

SECTION C: The attitude of students during practical lessons in biology.

Instructions: This section presents statements that looks at students attitude during practical lessons.Respondents are required to tick the appropriate response that best describes their agreement or disagreement to the statements provided.

Keys:1-Strongly disagree**(**very true**)** 2-Disagree(untrue) 3-Not sure(unaware) 4-Agree(true) 5-Strongly agree(very true)

11. I see biology practical lessons to be very interesting.	1	2	3	4	5
12. Most of us don't pay attention during practical lessons.	1	2	3	4	5
13. I participate fully during practical lessons.	1	2	3	4	5
14. Practical lessons helps me to interact with teaching and learning materials to understand the theory.	1	2	3	4	5
15. Practical work may give me wrong answers which could have implications for their learning for examination. .	1	2	3	4	5

Thank you for your cooperation.

Testing of Null Hypothesis

Ho: There is no statistically significant difference between the academic achievements of the experimental group and the control group.

H1: There is a statistically significant difference between the academic achievements of the experimental group and the control group.