UNIVERSITY OF EDUCATION, WINNEBA

USING DIFFERENTIATED INSTRUCTION TO IMPROVE SHS STUDENTS' PERFORMANCE OF CELL DIVISION

ERIC ASARE JUNIOR

MASTER OF PHILOSOPHY

2022

UNIVERSITY OF EDUCATION, WINNEBA

USING DIFFERENTIATED INSTRUCTION TO IMPROVE SHS STUDENTS' PERFORMANCE OF CELL DIVISION

ERIC ASARE JUNIOR
(202144902)

A thesis in the Department of Science Education,
Faculty of Science Education submitted to the school of
Graduate Studies in partial fulfillment
of the requirements for the award of the degree of
Master of Philosophy
(Science Education)
in the University of Education, Winneba

DECEMBER, 2022

DECLARATION

Student's Declaration

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

Signature………………………………

Date…………...……………………….

Supervisor's Declaration

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

Name of supervisor: DR. ERNEST I. D. NGMAN-WARA

Signature………………………….

Date…………...……………..

DEDICATION

I dedicate this piece of work to all who supported me.

ACKNOWLEDGEMENT

First and foremost, my greatest thanksgiving goes to the Almighty God (Eternal Rock of Ages, I call Him) for His enormous grace and mercy in providing the requisite strength needed to successfully undertake this study. My sincere appreciation also goes to my supervisor for his guidance in completing this study. I am also highly indebted to my mum, dad and siblings for their enormous support in seeing me through this programme. To all who laboured with me for the success of this work, I say God richly bless you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DI	Differentiated Instruction
STMEs	Science Technology Mathematics and Engineering
DSHS	Delcam Senior High School
GES	Ghana Education Service
TLMs	Teaching and Learning Materials
SKMT	Students Knowledge on Mitosis Test
SAMT	Students Assessment on Mitosis Test
ITBS	Iowa Tests for Basic Skills

ABSTRACT

This study used Differentiated Instructional to improve students‘ performance of cell division among Senior High School Form Three (SHS 3) students of the Delcam Senior High School in the Adentan Municipality of the Greater Accra Region of Ghana. Quasi-experimental research design was used. The sampling technique was census. The instrument for data collection was the tests (pre-test and pre-test). Student‘s census was taken of all science students in form three. A Pre-test (Student Knowledge on Mitosis Test) was conducted to identify students‘ misconceptions related to the subject. The researcher taught the students using differentiated instruction. A post-test was administered to the sample. The pre-test elicited several alternate concepts from the students. This was to prove that students of Delcam SHS have alternate concepts in cell division (mitosis). The means of the pre-test and post-test were compared using the paired t-test. The differentiated instruction used was able to improve the performance of Students at the intervention stage. The post-test (Student Assessment on Mitosis Test) had 80% pass rate whiles the pre-test had 5% pass rate. There was a significant difference between the post-test and pre-test scores [$t= 11.906$: $p<0.05$]. There was no significant difference between the scores of the male and female students in the post-test [$t=1.4$; $P>0.05$]. From the research, gender had no effect on differentiated instruction. The study concluded that differentiated instruction improves students‘ performance in cell division (mitosis). Since the findings of the study showed that students exposed to the differentiated instructional in cooperative learning settings performed better in such learning settings, students should be encouraged to develop social interaction in the use differentiated instruction. This implies that biology teachers should model their instructions to enforce student-student interaction in differentiated instruction class.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents the background to the study, which leads to the statement of the problem. It continues to the purpose of the study, as well as the research objectives. The research questions (questions that guided the study) and the educational significance of the study formed part of this chapter. The chapter ends with the delimitation, limitation of the study and the organization of the study.

1.1 Background to the Study

Experience gathered by the Researcher as a biology teacher and a biology examiner for the West African Examinations Council (WAEC) at the Senior High School (SHS) level, suggests that most students perform poorly in biology because they have a difficulty with learning some biology concepts. This may be because biology is taught abstractly, making some of the concepts seem complex and confusing and therefore difficult for students.

Previous studies have shown that students have difficulty learning concepts related to the process of cell division (Saka, Cerrah, Akdeniz & Ayas, 2006). Cell division forms the basis of genetic, reproductive, growth, developmental and molecular biology. As a matter of fact, majority of the students or teachers considered topics such as gene, DNA, chromosome, and cell division as difficult to learn (Oztas, Ozay, & Oztas, 2003). Th``e reasons for these opinions include students‘ inability to differentiate between doubling (replication), pairing (Synapsis), and separating (disjunction), as well as determining whether or not these processes occur in mitosis, meiosis, or both. Other causes of those ideas include a lack of understanding of basic terms confusing chromatids with chromosomes, or replicated chromosomes with unreplicated chromosomes among others. (Saka, et. al, 2006). This is a concern for instructors because cell division processes are key to understanding growth, development, reproduction and genetics (Chinchi, Yue, & Torres, 2004).

Studies on problem solving related to genetics found that students had misconceptions about the stages of meiosis (Chinchi, et. al., 2004). Accurate organization of many concepts in cell biology is dependent on the degree of understanding cell division (Flores, Tovar, & Gallegos, 2003).

Clark and Mathis (2000) indicated that students experience difficulties, particularly in distinguishing chromatids, chromosomes, and homologous parts of chromosomes during the cell division process. Their study concluded that these difficulties in chromosome structure and behaviour could readily be identified and eliminated through models. Altiboz (2004) examined the level of understanding and misconceptions of Grade 9 students regarding mitosis and meiosis. His study concluded that students experience difficulties in understanding fundamental concepts, such as DNA, chromosome, chromatid, homologous chromosomes, haploid and diploid cells, and the relationships between such concepts, and possess some misconceptions. Saka et al. (2006) have shown that science student teachers have misconceptions, particularly regarding the concepts of gene and chromosome, in accordance with their findings obtained from written responses and drawings. Chin (2012) studied the concepts of students regarding cell division and growth. Conclusions of their study revealed that students generally focus on the increase occurring with number of the cells, as a result of cell division and disregard the growth occurring in the cells.

Riemeier and Gropengießer (2008) analysed the difficulties in learning as experienced by the 9th grade students regarding cell division, and their conceptual understandings within teaching experiments. They have shown that well planned teaching activities for the cell biology might enhance the conceptual development process and might contribute to the conceptual learning by the students. It is evident from the literature that misconceptions related to cell division processes lead to a series of problems for the biology teaching. These challenges are not easy to solve because of the differences among students and size of the class.

Every student differs in his approach towards studies, even inside a single classroom, the thought process, the perception towards the content being delivered, emotional stability, the sequence of instruction being delivered each and every thing related to the instruction. Not every student learns from the same resource, the same process and same sequence, each of us is different in nature; time and again it has been proved that one size doesn‘t fit all, neither clothes, nor shoes and so does the differences apply to instruction as well. The contents in the textbook and the learning objectives are standardized for single class students, but it depends on the teacher to modify the presentation of content, the sequence in which they are delivered, the type of assessments for each learner or a group of learners.

Mixed ability or "heterogeneous" classes consist of students of different levels of skillfulness or proficiency. Such terms are deceptive as homogenous classes can't occur and there aren't two students who are similar (Ur, 1991).

So, in classes of mixed ability, students might differ in many ways. They might react to teaching techniques and instructions taught differently. There are no classrooms that have two students similar in everything. Mixed ability classes are found in every school where students come from diverse backgrounds and have different background knowledge or skills which confirms what is mentioned above that students are not similar.

According to Fisher (2001, Pg. 23), "All children are born with potential and we cannot be sure of the learning limits of any child." So, for peers to accomplish their full potential, teachers should help them to work according to their efforts by guiding them to the right track. So, learning obstacles might be eliminated by guiding and helping them to develop their abilities.

Teachers should know that a mixed ability classroom has students with different levels of proficiency and have various strengths and weaknesses. Also, it consists of different abilities, learning styles, and learning profiles. (Ireson and Hallam, 2001) So, the teacher has to respond to the needs of students according to their abilities, learning styles, and preferences in mixed ability classrooms in order for those peers to develop and exhibit their full potential.

The literature showed also that such discrepancies affect the level of achievement of students academically. However, there are two main levels of student's achievement: low achievers and high achievers and also in some instances average achievers

In schools, high achievers are those that attain high marks. Also, they do the work or task demanded from them in a proficient way. They are very organized and behave well in classroom and share effectively in classroom instruction or discussion. As noted by researchers and educators who described students whose academic achievement is high as gifted learners, creative learners, advanced learners or high achievers. However, there are differences between these terms especially between high achievers, gifted learners, and creative thinkers. Studies by educators and researchers differentiated them in an attempt to enable teachers to understand the needs of their peers better.

Advanced learners or high achievers are in need to advance their abilities and skills. Therefore, teachers must assist them in this case. Therefore, such teachers should work on promoting their growth with tasks that fit them and are challenging at the same time. Otherwise, learners might lose interest during the educational process and tends to achieve less. The effect will be a failure in developing or achieving their full potential.

Low achievers are referred in most researches as "underachievers" or " slow learners". Underachievement is the difference between the pupil's academic capability and his real performance in school (Reis & Mc Coach, 2000). Therefore, the underachiever is the person who doesn't succeed in arriving to the expected level of performance or doesn't perform as expected.

Teacher-centred instructional strategy refers to teaching techniques in which learning activities are centred on the teacher (Baeten, Dochy, Struyven, Parmentier, & Vanderbruggen, 2016). In this strategy, the teacher is the ultimate authority figure and students viewed as without knowledge of the instructional content and are expected to passively absorb knowledge. The teacher, in front of the students, profess knowledge through direct instruction with an aim that upon assessment, students will post good results based on what the teacher instructed them on. In this strategy, objectively scored tests and assessments are indicators of learning (van de Kuilen, Altinyelken, Voogt, & Nzabalirwa, 2019). Examples of teacher-centred instructional strategies include teacher talks commonly known as lecturing, class demonstrations, giving assignments and homework, memorising, and reviewing (Baeten et al., 2016). Other methods include reviewing, questioning and class discussions. Students are often expected to take notes based on the knowledge professed in class. The teacher controls every learning experience by subjectively designing class activities (Di Biase, 2019).

Advantages of the teacher-centred instructional strategies are that it is suitable for large classes where it is practically impossible to cater to the learning needs of individual students. Historically, teacher-centred instructional strategies have been applied for its main advantages in cases where the main aim of education has been the transfer of knowledge. Teacher-centred instructional strategies are the most common instructional strategies and especially in resource-limited environments (Starkey, 2019). However, teacher-centred instructional strategies have been criticised for an inability to spur learner attitude change, which in part, is one of the objectives of learning. The other major dilemma of the strategy is the lack of sources and resources. This is especially true, given the fact that all knowledge is expected from one source (Di Biase, 2019) In applying teacher-centred instructional methods, rigid administration, planning and management hinder innovativeness and knowledge exploration.

Learner-centred instructional strategies are based on learning responsibilities and facilitative nature of the teacher (Olayinka, 2016). The main aim of the strategies is to make students attain skills to explore their learning features so as to allow students to learn how to learn in the process (Starkey, 2019). Prominent features of learner-centred instructional methods include collaborative learning, critical thinking and connecting information to previous knowledge. For this reason, the strategies have been referred to as interactive learning. The learning process, as such, involves facilitating the presentation of questions for small group work. It may also present an opportunity for the use of media and student fieldwork involvement. The strategies are grouped in broad methods, including inquiry-based learning, case-based learning, problem-based learning, project-based learning, discovery learning, and just-in-time teaching (Starkey, 2019).

The advantages of the strategies are diverse. Proponents applaud the strategies for the fact that they enable diverse learning styles and at the same time, encourage the active involvement of all students while facilitating individual improvement of weaknesses (Starkey, 2019). The strategies provide an opportunity for students to ask questions, lead conversations and define problems. In this way, the strategies aid the connection of students‘ world with classroom learning pursuits. It has also been argued that when learners are facilitated to share experiences through group discussions, application of acquired knowledge and skills is enhanced (Starkey, 2019). The strategies, however, are not without blame. Critics of the strategies argue that since they encourage students‘ participation and thus discussions and talking among students, they present a chaotic classroom. The student-centred teacher also has the disadvantage of having to manage all students‘ activities at once, which in a real sense, is a tall order when students are working on different stages of the same project. Moreover, evidence has alluded that some students may miss important facts since the strategies do not allow instructors to deliver instruction at once for all students. Finally, in cases where students‘ preference to work alone is evidenced, group work becomes most inappropriate (Starkey, 2019).

Pedder (2006) identifies unique teaching challenges in large classrooms that have a negative impact on academic achievement. Elements associated with negative impacts on learning in large classrooms include reduced teaching time and an increased need for administration, organization and time spent on disciplinary matters. His research also shows that interactions between students and teachers lead to improved school performance, especially for underperforming students. This is because as class size increases direct interactions with the teacher decrease. These student-teacher interactions also increase teachers' understanding of individual student needs and their ability to offer accurate, personalized instruction, which is often sacrificed in larger classroom settings (Pedder, 2006). The challenge in today's large classrooms (Blatchford, 2011), is how can one teacher address the learning needs of every student?

With Pedder's description of the deficits associated with large class sizes in mind, it would only take a few minutes for any visitor in first year high school biology class with one teacher and over forty students to notice that student participation in the learning process varies widely. Some students prepare to learn and take part, while others remain disinterested and reluctant to take part throughout the class.

This scenario is common in all our schools and at all levels of the educational ladder in Ghana. Further, within these diverse groups of students, there are high academic achievers who are often left to their own devices as the teacher is stretched too thin to provide them with personalized instruction. In such a class, the traditional teacher ends up offering a universal lesson which targets the average student. The high achievers are bored and do not get the chance to maximize their potential, and the low achievers are lost and learn very little.

Can teachers tailor a strategy to teach the concept of cell division to make it easily understood by students? The theory of differentiated instruction is one of the sensational theories in education which changed the way a teacher teaches according to the needs of the learner. It also addresses the needs of students in a large class.

The theory behind personalized, or differentiated, instruction is that the instructor knows each student‘s level of ability and understanding and can customize instruction to meet differing learning needs (Tomlinson, 1998), thus increasing both engagement and retention of content. However, large class size combined with the widely diverse ability and levels of readiness, as well as diverse family/home dynamics all makes student engagement less likely to occur and differentiated instruction much more difficult to accomplish (Truscott, 2005).

The concept of differentiated instruction is rooted in Vygotsky‘s theory of the Zone of Proximal Development, which states that student learning is greatest when content or task is slightly more challenging than the student‘s comfort level. Vygotsky insists that such learning is supported by both teaching and peer interactions (Vygotsky, 1978). This further clarifies both differentiated instruction and student engagement, which defines the ideal learning environment. The converse of this often occurs in traditional instruction where there is front-of-room lecture by a teacher. Traditional instruction is typically only effective for the average student in the classroom while the higher achieving students are left unchallenged and unmotivated and the lower achieving students often either fail because they are without the proper prerequisite education or cannot progress at the same pace as the instructor (Konstantinou-Katzi, Tsolaki, Meletiou-Mayrotheris, & Koutselini, 2013). This type of instruction is ―teaching to the middle". Compounding the problem is the evidence showing that the interactions between teachers and students that lead to heightened teacher awareness of individual needs, is significantly reduced in large, highly heterogeneous classrooms (Truscott, 2005).

1.2 Statement of the Problem

The performance of Ghanaian students in the West African Senior Secondary Certificate Examination (WASSCE) in biology has been a worry to many stakeholders in the educational enterprise for some years now. The Chief Examiner‛s report in biology for the year 2020 stated that about 50 percent of the candidates performed poorly as they did not understand the cell division and genetics topic in the syllabus; let alone talk about drawing the stages in cell division. This problem can be associated with students of Delcam SHS, where the research was conducted

This poor performance has created the perception among most SHS students that biology and science in general is difficult and view the study of science as the exclusive preserve of their academically well-endowed colleagues. This seems to explain why many students shy away from studying science at the SHS level in Ghana. Could this be problem be coming the instructional teachers adopt in teaching biology. The research found that that his student performed poorly in cell division when a one size fits all approach (traditional method of teaching) was used in teaching the concepts of cell division.

Cell division is an abstract topic in biology and teachers have a lot of challenges teaching this concept. The way it is taught makes it difficult for students to have understanding. The one-size-fits-all approach of instruction for teaching biology is a big problem across the country. Any classroom with more than one student presents a range of learning needs, teachers struggle to provide all students‛ access; what works for some students will not work for others (Berliner & Biddle, 1995). If students are expected to navigate successfully through high stakes tests, then it seems only fair that their teachers have at least foundational skills in differentiation. Often, teachers are already besieged by the challenge of maintaining the status quo in such a varied, evolving classroom. Add to this the concept of differentiation, or appropriate, targeted instruction for each learner, and many teachers feel too overwhelmed to even attempt such a massive re-conceptualization of their classroom structure and teaching styles.

1.3 Purpose of the Study

The study aimed at improving the performance of Delcam Senior High School form three science students in cell division through differentiated instruction.

1.4 Objectives of the Study

The objectives of the study were to:

1. determine Delcam Senior High School students‘ alternative concepts on cell division.
2. Verify the use of differentiated instruction to improve the performance of Delcam Senior High School students‘ performance of basic concepts in cell division.
3. determine the effect of Differentiated Instruction on students‘ performance of cell division by gender.

1.5 Research questions

The research questions of the study were:

1. What are the alternate concepts of cell division among students of Delcam Senior High School?

2. To what extent will the use of Differentiated Instruction improve the performance of students of Delcam Senior High School on the concepts of cell division?
3. What is the effect of differentiated instruction on student‘s gender in their performance of cell division?

1.6 Research Hypothesis

Null Hypotheses

The following null hypotheses (Ho) were, tested in this study:

Ho 1: Gender has no effect on students‘ alternate view of the concepts in cell division

Ho 2: Differentiated instruction will not improve SHS students‘ performance of cell division

H_O 3: The use of differentiated instruction has no effect on gender in improving students‘ performance in cell division.

1.7 Significance of the Study

The study has produced a document that reports on the effect of the incorporation of differentiated instruction in the teaching and learning processes on the performance of SHS students in cell division at Delcam SHS.

It is hoped that the study will transform the teaching of biology from the traditional instructional approach of lecture, discussion, demonstration and illustration to a situation where differentiated instruction would be incorporated in the teaching and learning processes in Delcam SHS.

Finally, the study will be a reference material for other researchers who would wish to conduct research studies into the implementation of differentiated instruction in the teaching and learning of biology in Dlelcam SHS.

1.8 Delimitation of the study

The study aimed at investigating the influence of differentiated instruction on the teaching of cell division. The study was delimited to the third-year science students from Delcam Senior High School, in the Adentan Municipality on some selected topics in cell division as a result of constraints in accessing third year students of other SHSs.

1.9 Limitation of the study

This study like all other research works was not without limitations. One major limitation of this work was that this study was carried out on only students in Delcam Senior High School in Adentan. Therefore, generalizing the findings of this study must be done with caution.

1.10 Organization of the Study

The study is organised into five chapters. Chapter one discusses the background to the study, research objectives, research questions, significance of the study, delimitation and limitations of the study. The chapter ends with the organization of the study.

The chapter two presents the literature review. It reviewed and discussed literature that is relevant to the study. The chapter includes literature on cell division, differences among students and differentiated instruction

The chapter three outlines the methodology of the study. It describes the research design, population of the study, sample and sampling procedure, instruments used in data collection, validity and reliability, data collection and analysis procedures. The chapter four discusses the analysis of data and the findings of the study. The chapter five presents the summary of the study, main findings, conclusions, recommendations and suggestions for further studies.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter reviews relevant literature on theoretical underpinnings of this research. It further reviews the contributions by scholars in the area of cell division, differences among students and differentiated instruction. The chapter was arranged under the following themes to align with the objectives and research questions of the study. These are as follows: theoretical framework, conceptual framework, cell division, students‘ misconceptions in cell division, challenges in teaching cell divisions, differentiated Instruction, implementing differentiated instruction, benefits of differentiated instruction, characteristics of teachers who differentiate instruction, challenges in differentiating instruction.

2.1 Theoretical Framework

Theoretical framework is a theory to explain, predict, challenge and sometimes extend existing knowledge within the limit of critical bounding assumptions. It forms the basis to hold and support a research study. One educational theory that supports differentiated instruction is the constructivist learning theory. Constructivism is an ―approach to education in which learners actively create, interpret, and reorganize knowledge in individual ways" (Shah, 2019). Knowledge is explored and created by the learner through exploration and discussion. A teacher‘s role under the constructivist theory is one of a facilitator; they are to ―spur students‘ enthusiasm, motivation, and independence so that they are actively involved in the learning process" (Ndia, Solihate, & Syahrial, 2020, p. 7). Teachers help students ―construct knowledge rather than reproduce a series of facts" (Shah, 2019, p. 5). The student is in the center of education and learning. Lev Vygotsky‘s theory of zone of proximal development was the other theory that was used in the theoretical framework of the study. According to Vygotsky (1978), the zone of proximal development is the difference in what a student can accomplish independently and what they can accomplish with the help of others. Vygotsky believed that students have the potential to learn, but that potential cannot be reached unless they are assisted by someone who uses strategies to meet their learning needs. Teachers can help students reach their zone of proximal development by providing activities that help foster a connection to new information (Subban, 2006). Vygotsky believed that a teacher‘s job was to create an environment that helps students reach their zone of proximal development. Teachers can help students make these connections through differentiated instruction by providing encouragement through activities that interest the students or that the students feel they can be successful completing.

Using different instructional methods provides for each student and allows students to construct knowledge on their own with a teacher as a guide. It is very important in the teaching of cell division since the concepts of cell division are abstract and confusing as a result of having several similar terms which makes it confusing (Chin, 2012).

Students‘ science classroom come with diverse cultural background, learning styles, interests, abilities and multiple intelligence. The diversity of the students in the classroom will result in a significant challenge for teachers when it comes to meeting the needs of all the students. Some may find the lesson too easy while some find it too hard, some may find the topic interesting while some find it boring. It is the goal of differentiation to reach to each student and approach the lesson in a way that fits their learning styles, interests, abilities or multiple intelligence**.** Cell division is abstract and difficult to comprehend by students.

Differentiated instruction philosophy of teaching is based on well-established theories. One of such is socio-cultural learning theory based on the work of Vygotsky (1978). Socio-cultural learning theory holds that social interaction plays fundamental role in the development of cognition. Another aspect of Vygostky‘s theory is the zone of proximal development which is area of exploration for which the student is cognitively prepared to and for which development is attained with the help of social interactions. The sociocultural learning theory and zone of optimal development are the theoretical basis in differentiated instruction by readiness level.

Constructivist learning theory is another basis of differentiated instruction. It is a learner-centred theory that suggests that learners construct knowledge and meaning from their own experiences. A constructivist classroom provides opportunities for students to experience multiple perspectives and emphasizes authentic assessment. The constructivist learning theory provides the basis for differentiating instruction by students‘ readiness and interests. Learning styles are ways in which learners prefer to learn. There four types of learning styles namely, visual, aural, read/write and kinaesthetic. These learning styles and modalities are being considered in differentiated instruction. In order to maximise learning for everyone the lessons should be adapted to accommodate these differences because learners with different learning styles might benefit from different ways of presenting the materials. Differentiated instruction therefore encompasses majority of students requiring teachers to meet their needs by providing different opportunities to learn the same material.

Students have difficulties in learning cell division which are manifested in their inability to perform well on questions on cell division in their national senior high school terminal examinations. For instance, the chief Examiner‘s report on biology for the 2018 final year examinations stated that about 50 percent of the candidates performed poorly on questions on cell division because of their poor understanding of concepts of the cell cycle in the biology syllabus.

Majority of the students and teachers evaluated cell division as difficult to learn (Oztas, Ozay, & Oztas, 2003). This stems from the fact that the concepts of cell division are abstract and students are unable to bring their experiences to bear during instruction. However, processes of cell division processes are key to understanding growth, development, reproduction and genetics (Chinchi, Yue, & Torres, 2004). Yet biology teachers fail to address these known facts about students' difficulties with cell division as they continue to use unproductive traditional methods which, according to them, enable them to cover the topics in the overloaded biology syllabus. Again, they complain of the large biology class sizes in which they are unable to use learner-centred instructional method despite the diverse needs of the students. The abstract nature of concepts cell division and the diverse needs of biology classes could be addressed and resolved through the use of differentiated instruction. Differentiated instruction was used to address the inadequacies of using traditional instructional methods to teach the concepts of cell division.

2.2 Conceptual Framework

The conceptual framework that guided the study is presented in Fig. 1. The framework is guided by literature, researcher's experience and the research questions. The main idea of the study is differentiated instruction and its impact on biology students' understanding of concepts of cell division. The conceptual framework connected students' background factors that influenced differentiation of the content and the process relevant for the lessons taught. The bold block arrow connects these factors to the content on cell division and the learning environment. This segment is connected by another bold block arrow to differentiated structures or differentiated instructional strategies. The three variables are connected by single arrows to the products of differentiated instruction, that is, students' understanding of concepts of cell divisions.

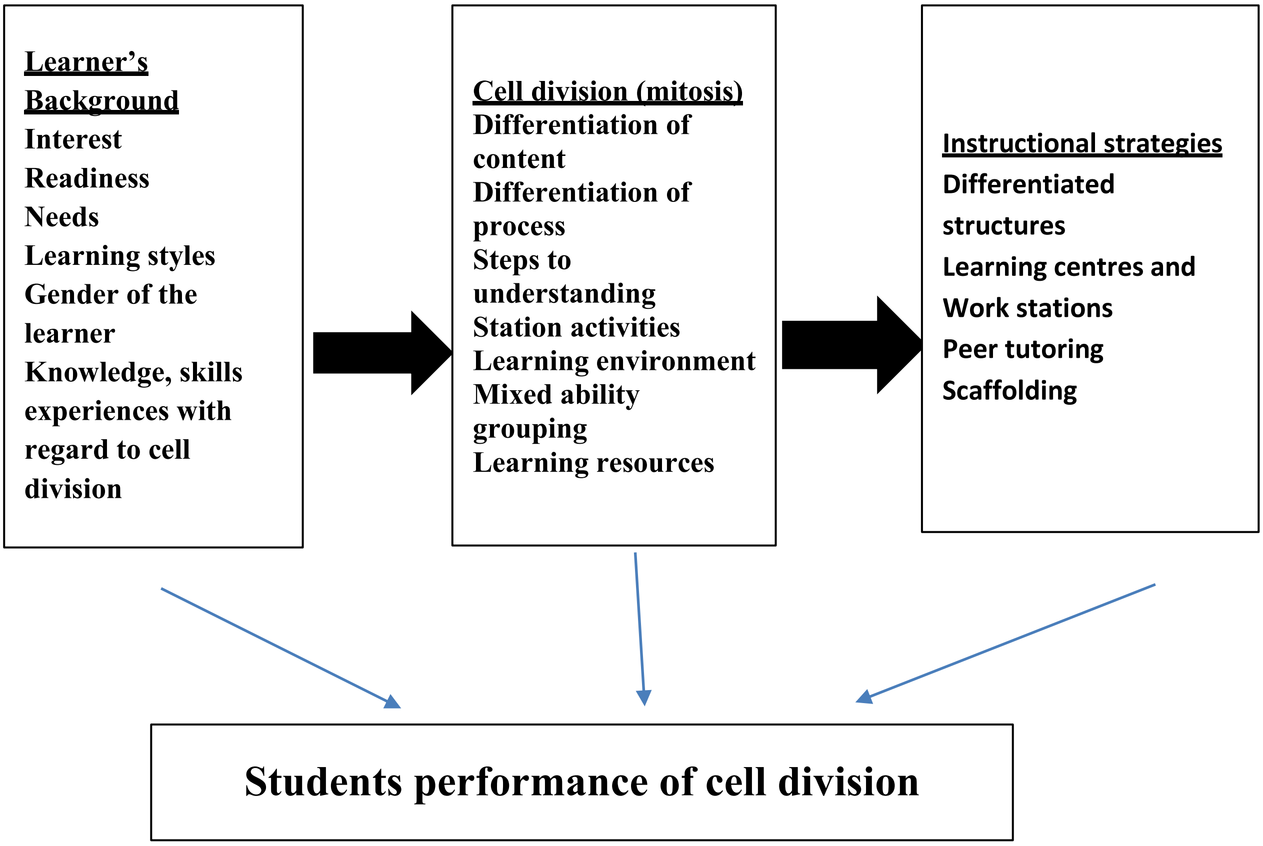


Fig. 1: Conceptual Framework of the Study

Source: author's own construct, 2022

Before differentiated instruction is initiated the teacher will have to assess the students background to identify their needs, interest, readiness, and characteristics such as learning styles, their knowledge, skills and experiences relevant to the content of lessons. One of such background factors is the gender of the learner. Males and females are fundamentally different. These variances have a biological basis and affect all aspects of life, including learning. Vision is one area where females and males are different. Due to the difference in distribution of rods and cones in the eye, male eyes are generally more sensitive to motion whereas female eyes are more sensitive to colour differentiation (Sax, 2005). Females are also more sensitive to sound than males (Sax, 2005). Vision and hearing are not the only places where males and females differ. Male and female brains vary in their myelination, structure, function, and chemistry (Menzler, Belke, Wehrmann, Krakow, Lengler, Jansen, Hamer, Oertel, Rosenow, & Knake, 2010; Cosgrove, Mazure, & Staley, 2007). Menzler et. al. (2010), found that adult male and female brains differ in their microstructure and suggest that “the origin of the observed sex differences of brain structure as well as their possible behavioural correlates and warrant future studies” (p.2559).

The influence of these background factors of the students on the level of differentiation of the content of the lessons on concepts of cell division and process in terms of the strategies is shown by the double arrow. The factors also influenced the differentiation of learner-centred environment. In this study differentiated classroom environment was characterised by mixed ability groups for peer-tutoring, peer and teacher scaffolding and opportunities for social interactions. Learning resources relevant for teaching concepts of cell division were provided. The content of the topics on the concepts of cell divisions was differentiated into stages as shown in the figure. These were used to organise into six study or work stations.

The differentiated instructional strategies used by the students at the six learning stations were word sort, stages in mitosis, root tip division, mitosis in music, grab a bag and video mitosis. Also, opportunities were provided for the students to engage in peer-tutoring, peer-scaffolding and teacher-scaffolding. The variables cumulatively influenced the students‘ understanding of the concepts of cell division.

The drawing from the literature (Houtveen & Van de Grift, 2001), the researcher identified three behaviours characteristic of teachers who differentiate instruction. They vary delivery of instruction within the classroom environment, use multiple resources and materials, and put students in flexible groupings within a learner-centred classroom environment.

Research has shown that teachers may group students in a number of configurations. The practice of grouping students by ability within classroom environments in biology has shown to increase student achievement in inclusive settings for both high performing and low performing students (Tieso, 2003; Houtveen & Van de Grift, 2001). Literature on the positive effects of homogenous and heterogeneous grouping to improve mathematics instruction (Gamoran & Hannigan, 2000) suggests adjusting the range of ability within classroom groupings to garner the highest benefits for students. The Researcher generated three categories of students namely, high achievers, average achievers and low achievers. Mixed ability groups were then formed to facilitate social interactions and peer scaffolding during instruction.

Several strategies for varying the delivery of instruction within a mixed ability classroom include responding to learners‘ needs by category of readiness, interest, learning profile or a combination of three of these categories (Tomlinson & McTighe, 2006). Differentiated instructional strategies that have been found to be effective when responding to a learner‘s need by readiness include: scaffolding, tiering, or compacting instruction. The concepts of scaffolding, tiering and compacting an assignment are closely related to the work of Vgotsky‘s Zone of Proximal

Development (‗ZPD') in which assignments are divided into small tasks that are constructed upon one another and focused on student readiness.

Gardner (1985) worked on multiple intelligences and addressed differentiated instructional strategies that best supported students' interests and learning profiles and included: interest centres, independent studies, intelligence preference tasks, and varying modes of teacher presentation to address multiple intelligences (Tomlinson & McTighe, 2006). The process component of differentiated instruction in this study was presented as different stations to meet the learning needs and learning styles of the individual students and provide opportunities for peer tutoring of scaffolding (word sort, stages in mitosis, root tip division, mitosis in music, grab a bag and video mitosis). The stations also represented differentiated content which corresponded to the different stages of cell division (or mitosis).

In the context of curriculum differentiation behaviours, a myriad of resources and materials need to be used by the teacher to address the unique needs of students by interest, readiness, and learning profile. Tomlinson and McTighe (2006) In this study, the resources used included videos, music, models word sort, mitosis in music, stages in mitosis at the various stations. The use of multiple resources and materials provides access for each type learner, challenging students to make meaning of their experiences and construct their own knowledge (Vygotsky, 1978).

2.3 Cell Division

Cell division can be described quite simply, as cell reproductive activities that transfer genetic information from parents to offspring, which can then be expressed in the offspring. But the process is actually very complex

2.3.1 Students' alternate concepting about cell division

A large number of prior studies reported that primary and secondary school students have many conceptional problems concerning cell biology and genetics such as mitosis and meiosis (Flores, Tovar, & Gallegos, 2003; Lewis & Wood-Robinson, 2000; Marabach-Ad & Stavy, 2000). Biologically literate students should be able to use and apply basic biological concepts when considering biological problems or issues. Cell division constitutes the basis for genetics, reproduction, growth, development, and molecular biology subjects in the biology curriculum. As a matter of fact, majority of the students or teachers evaluated topics such as gene, DNA, chromosome, and cell division as difficult to learn topics (Oztas, Ozay, & Oztas, 2003). Prior studies have shown that students experience difficulties in learning concepts related to the cell division process (Saka, Cerrah, Akdeniz, & Ayas, 2006). Research on students' conceptual understandings often indicates that, even after being taught, students use misconceptions different from the scientific concepts (Lewis, Leach, & Wood-Robinson, 2000). Reasons for these misconceptions include students' inability to differentiate between doubling (replication), pairing (synapsis), and separating (disjunction), as well as determining whether or not these processes occur in mitosis, meiosis, or both. Further misconceptions result from lack of understanding of basic terms confusing chromatids with chromosomes, or replicated chromosomes with unreplicated chromosomes, etc. (Saka et al, 2006). This is a concern for instructors because cell division processes are fundamental to the understanding of growth, development, reproduction, and genetics (Chinchi, Yue, & Torres, 2004).

Studies conducted on problem-solving related to genetics revealed that students have some misconceptions regarding the stages of meiosis (Chinchi, et al., 2004). Accurate organizing of many concepts in cell biology is dependent on the degree of understanding cell division (Flores, et al., 2003). As a matter of fact, a study related to genetics mentioned that students possess misconceptions and inadequate knowledge about the behaviour of chromosomes and transference of genetic material during cell division. It further suggested (indicated) that such misconceptions lead to conceptual problems in genetics (Kibuka-Sebitosi, 2007).

Lewis, et. al. (2000) examined levels of understanding with regards to mitosis, meiosis, and fertilization. The study concluded that students possessed inadequate knowledge and numerous misconceptions related to the physical relationships between the genetic material and the chromosomes, and the relationships between the behaviour of the chromosomes and continuity of the genetic information. Lewis, et. al. (2000) further emphasized the fact that the students mainly experienced difficulties in explaining the relationships between the cell, nucleus, chromosome, and gene concepts, and the similarities and differences between mitosis and meiosis. Clark and Mathis (2000) indicated that students experience difficulties particularly for discriminating chromatids, chromosomes, and the homologous parts of the chromosomes during the cell division process. Conclusions of this study were that these difficulties related to the structure and behaviour of the chromosome can easily be identified and removed by means of models. Altiboz (2004) studied the level of understanding and misconceptions of 9th grade students related to mitosis and meiosis. Conclusions of his study have shown that students experience difficulties in understanding fundamental concepts, such as DNA, chromosome, chromatid, homologous chromosomes, haploid and diploid cells, and the relationships between such concepts, and possess some misconceptions. Also, Saka, et. al. (2006) have shown that science student teachers have misconceptions, particularly regarding the concepts of gene and chromosome, in accordance with their findings obtained from written responses and drawings. Chin (2012) studied the concepts of students regarding cell division and growth. Conclusions of their study were that students generally focus on the increase occurring with number of the cells, as a result of cell division and disregard the growth occurring in the cells.

Riemeier and Gropengießer (2008) analysed the difficulties in learning as experienced by the 9th grade students regarding cell division, and their conceptual understandings within teaching experiments. They showed that well planned teaching activities for the cell biology might enhance the conceptual development process and might contribute to the conceptual learning by the students.

It is obvious from the literature that misconceptions related to cell division processes lead to a series of problems for biology teaching. When attending their biology classes, students bring along their perceptions, prejudices, and previous experiences which are in conflict with the scientific facts. This situation causes various problems to arise during their biology classes. Keeping knowledge or conceptual frames of the students in line with the scientific facts can only be possible with effective conceptual teaching.

2.3.2 Challenges in teaching cell division

Teachers have many challenges in teaching cell division. These challenges affect learning cell division. These challenges include attitudes of students, teachers‘ instructional approach and teachers‘ difficulties of cell division.

2.3.2.1 Attitude of students toward science (biology)

Students‘ poor attitude and interest towards school science is an issue identified across the world (Adu-Gyamfi, 2013 & Fensham, 2008). In some instances, students‘

lack of interest in science is associated with the use of science to select a small fraction of elite students at the early ages to become science specialists and in Malaysia, students' lack of interest in science is associated with scarcity of well-paid jobs for science professionals (Fensham, 2008). In Ghana the study of Adu-Gyamfi (2013) added that students' lack of interest in science is anchored on the time consuming and less practical nature of learning school science as well as the learning of science which is basically knowledge transfer from science teachers and textbooks to student. Science teachers' decisions about instructional practices such as procedures for assessment, grouping of students, and the types of rewards and punishments are crucial to influence students' interest and attitude in pursuing any science related subject or course in the future (Aderman, Sinatra & Gray, 2012). It is therefore recommended that teachers should inculcate in students the interest in and adequate knowledge of the contribution of school science to the development and technological advancement of the society they live in (Fensham, 2008).

2.3.2.2 Teachers' Instructional approaches among students

Students have several wrong concepts in cell division. These wrong concepts do not enhance the leaning process in cell division. From Hewson (1992, p. 76), ―accepting that students hold different conceptions that might need to change is one thing: concluding that it is the teacher's responsibility to engage in teaching practices that might facilitate conceptual change to occur is a separate matter." It is therefore the responsibility of teachers to identify students' conceptions and to instruct them in ways that will facilitate conceptual change. Consequently, Hewson asserted that teachers should not compel students to surrender their alternative conceptions but adopt appropriate instructional strategies that will offer students' alternative conceptions the opportunity to equally compete with teachers' or scientific conceptions for acceptance (Hewson, 1992). This can be achieved when science teachers encourage students to challenge any information presented to them and to discuss the information with respect to its personal merits (Dass & Yager, 2009).

The interpretation of student responses as driven by alternative conceptions suggests that learning may involve changing a person's conceptions in addition to adding new knowledge to what is already there. This view was developed into a model of learning as conceptual change (or CCM) by Posner, Strike, Hewson, and Gertzog (1982) and expanded by Hewson (1981, 1982). From this point of view, learning involves an interaction between new and existing conceptions with the outcome being dependent on the nature of the interaction. There are two major components to the CCM. The first of these components is the conditions that need to be met (or no longer met) in order for a person to experience conceptual change (Hewson 1982). The extent to which the conception meets these three conditions is termed the status of a person's conception. The more conditions that a conception meets, the higher its status (Unlu, 2014).

The second component is the person's conceptual ecology that provides the context in which the conceptual change occurs, that influences the change, and gives it meaning. The conceptual ecology consists of many different kinds of knowledge, the most important of which may be epistemological commitments (e.g. consistency or generalizability), metaphysical beliefs about the world (e.g. the nature of time), and analogies and metaphors that might serve to structure new information.

In order for conceptual change to take place, four conditions of the conceptual change model must be encountered. The following steps define these conditions (Posner et al., 1982):

1. Previous conceptions dissatisfaction.
2. Understandable new conception.
3. Reasonable new conception.
4. Fruitful investigation suggesting new conception

Science educators have used conceptual change as the theoretical framework for explaining a multitude of studies showing how individuals fail to develop conceptual understandings about numerous scientific phenomena (Carey, 2000). Further, the model has been used to propose instructional intervention that have proven promising in helping students change their preconceptions or naive theories about scientific phenomena (Unlu 2014). A lot of studies conducted on teaching strategies nowadays have tried to consider investigations related to students' conceptions of realistic incidents. Conceptual change method of teaching has emerged from these studies (Hewson, 1991).

Conceptual change teaching including features such as classroom climate, role of teacher and role of students are proved to be successful for students educated in elementary, middle and high schools, and in colleges for introducing concepts related with various fields like physics, chemistry, biology and earth science (Unlu, 2014).

Before starting their education at school, children possess wide number of concepts related to their real-life environment. Having such background information can be both useful and also problematic for receiving new information in terms of interaction. Because of this, conceptual change has an important role in restructuring prior concepts (Read, 2004).

In a constructivist classroom teachers' role as an instructor, changes from ―sage on the stage" to a ―guide on the side"(Tallman & Tastad, 1998)). Students have an intention of building alternate comprehension and cognitive models. Taber (2001) believes that students' alternate knowledge is mainly derived from the way they are taught. Failure to introduce new concepts lead to development of alternate concepts by students (Taber & Coll, 2002). For the success of conceptual change-based instruction learning, the environment must be collaborative and so is differentiated instruction. Students should feel safe enough to discuss their opinions and have opportunity to consider other point of views (Bruning, Schraw, & Ronning, 1999). This ―safety factor" really matters in conceptual change teaching. In a conducted study, Dreyfus, Jungwirth and Eliovitch, (1990) revealed that self-confidence loss in students causes achievement fall.

Applying conceptual change-based instruction successfully requires experience for teacher and students. Conceptual change-based instruction requires more time for preparation of instruction when compared to traditional direct teaching. Traditional instruction familiarized students may have difficulties in adapting discussion-based instruction method (Unlu, 2014). In this case the teacher must play more active role for adaptation of the students to the interactive instruction and provide the required encouraging environment for encouraging students to argue out their own ideas (Read, 2004).

The aim of conceptual change instruction is to promote adoption of more fruitful concepts by removing prior alternate concepts of students. There are many conceptual change theories which aim to replace or restructure alternate concepts with that of scientific ones to facilitate learning. The major difference between the conceptual change theories is the way they explain the change.

2.3.2.3 Difficulties teachers face in science (biology)

Abimbola (1998) has noted that physiology content areas are mostly abstract and microscopic and involve many fine processes that require proper explanation to enable students understand them. To Abimbola (1998), these are some of the reasons why teachers and students usually find physiology content areas such as photosynthesis, meiosis, cellular respiration, etc., difficult to deal with.

Some teachers also find some biology concepts difficult to teach. The study by Finley, *et. al.* (1982) examined both content importance and difficulty as perceived by some health science, physics, chemistry and biology teachers. They found that most of the important but difficult concepts for the science teachers were photosynthesis, cellular respiration and Mendelian genetics. Chromosome theory of heredity and hormonal control of human reproduction are also difficult for teachers to teach (Finley *et al*., 1982). Teachers who find some biology concepts difficult to teach may teach these concepts poorly. This may explain why students have a difficulty understanding some biology concepts.

Tekkaya, Özkan and Sungur (2001) attributed the possible sources of students‘ difficulties in learning some biology concepts to among others, the high school biology curriculum and the teaching-learning strategies employed by teachers. The Researcher however, believes the traditional teaching-learning strategies employed by biology teachers are mainly to blame for students‘ difficulty and hence their poor performance in biology at all levels of science education.

Further in Africa, the problem of teachers teaching at the JHS level in Sub-Saharan African is the inability of teachers to use student-centered instructional strategies instead of teacher-centered ones (Pryor & Ampiah, 2003) and in San Francisco Bay

Area, teachers in K-5 schools taught science using basically lecture methods based on textbooks (Thomberg, 2009).

Handelsman, et. al. (2004) reported that some teachers are intimidated by the challenge of learning new instructional strategies and therefore resist any change in their respective instructions. Wieman (2008) in his presentation revealed that the issue with science education is for teachers to develop a mindset that their instruction should be deployed in a similar way with all the rigour and standard as scientists conduct scientific research. Consequently, science teachers are expected to create an environment conducive for students' active questioning and identification of issues and answers by employing appropriate instructional strategies (Dass & Yager, 2009)

2.4 Differences among students in a mixed ability class

Every student differs in his approach towards studies, even inside a single classroom, the thought process, the perception towards the content being delivered, the type of content being delivered, emotional stability, the sequence of instruction being delivered each and every thing related to the instruction. Not each student learns from the same resource, the same process and same sequence, each of us is different in nature; time and again it has been proved that one size doesn't fit all, neither clothes, nor shoes and so does the differences apply to instruction as well. The contents in the textbook and the learning objectives are standardized for single class students, but it depends on the teacher to modify the presentation of content, the sequence in which they are delivered, the type of assessments for each learner or a group of learners.

Though all students learn, they still differ in their background knowledge, learning styles, learning abilities, motivation level and interests, pace of learning, and even proficiency of language. In the end, they are humans that have important differences and variances. But this does not mean that they do not share same similarity between them in terms of size, personality, hobbies, or even likeness.

Mixed ability or "heterogeneous" classes consist of students of different levels of skillfulness or proficiency. Such terms are deceptive as homogenous classes can't occur and there aren't two students who are similar (Ur, 1991).

So, in classes of mixed ability, students might differ in many ways. They might react to teaching techniques and instructions taught differently. Also, they have varied or different strengths and weaknesses. So, such factors are included only in mixed ability classes. Thus, there are no classrooms that have two students similar in everything. In addition, mixed ability classes are found in every school where students come from diverse backgrounds and have different background knowledge or skills which confirms what is mentioned above that students are not similar.

All children are born with potentials and we cannot be sure of the learning limits of any child (Fisher, 2001). So, for peers to accomplish their full potential, teachers should enable them to work according to their efforts by guiding them to the right track. So, learning obstacles might be eliminated by guiding and helping them to develop their abilities through their learning styles.

When it comes to the learning style, it is described by (MacKeracher, 2004) as ―the characteristic of cognitive, affective, social, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". Brown (2000) explains learning styles as the way in which people comprehend and process information in learning situations. He mainly identifies six main learning styles; visual learning, auditory learning, kinesthetic learning, tactile learning, group learning, and individual learning. The characteristic of different learner types is listed below:

1. Visual learners: Visual learners learn best in images. They are careful about teachers‘ body language, and are able to understand the situations, or conditions. They prefer sitting in front of the class.
2. Auditory learners: Auditory learners prefer processing information through listening and interpreting via pitch, emphasis, and speed. These learners favour reading aloud in the classroom.
3. Kinaesthetic learners: These individuals discover information through active ―hands-on" approach. They gain knowledge from interaction with the physical world. They have difficulty in focusing on the situation.
4. Tactile learners: These types of learners learn best by using their hands. They prefer touching things to learn about them. They often underline what they read, take notes during listening, and keep their hands busy in other ways.
5. Individual learners: When people like their privacy and are independent, and introspective, they are probably individual learners. Learners with individual preference often can focus on the issues well, be aware of their own thinking, and analyze in a different way what they think and feel.
6. Group learners: These individuals are good at communicating well with people, both verbally and non-verbally. They prefer mentoring and counseling others.

2.5 Differentiated Instruction (DI) in mixed ability classrooms

Differentiation can be accurately described as classroom practice with a balanced emphasis on individual students and course content (Tomlinson, 2014). Differentiated instruction is a principle-guided method to approach teaching and learning, and it is implemented in the context of a classroom system that contains interdependent elements: learning environment, curriculum, assessment, and instruction.

A review of literature reveals the absence of a clear definition of DI throughout history. Over the years there has been an evolution of the definition of differentiation set forth by various researchers (Oliver, 2016). However the fundamental principle – which is the belief that differentiation should promote higher level of thinking skills, creativity, and allowance for differences in process, product, and content domains continued throughout time (Linn-Cohen & Hertzog, 2007). These components accentuate (Tomlinson, 2014) definition of differentiation which describes differentiated instruction as curricular elements the teacher has modified in response to learner needs.

According to Tomlinson (2014), who is considered to be an expert in the field (Topley, 2010), DI is most frequently defined as an approach that ensures every single student‘s learning is aligned with the student‘s readiness level, interests, and preferred mode of learning. It is when the commonalities are acknowledged and built upon while student differences are embraced. It can also be called as responsive instruction since it advocates active planning for student differences. Tomlinson (2010), argue that although the above definition is widely accepted by practitioners, the scientific literature does not report any theoretically based conceptualisation.

Differentiation is making sure that the right students get the right learning tasks at the right time. Once you have a sense of what each student holds as ‗given‘ or ‗known‘ and what he or she needs in order to learn, differentiation is no longer an option. It is an obvious response" (Tomlinson, 2014 pp. 86–87).

In summary, differentiated instruction is ~~a~~ collection of best practices strategically employed to maximize students' learning at every turn, including giving them the tools to handle anything that is undifferentiated" (Wormeli, 2005, p. 28).

The current model for differentiated instruction is composed of a theoretical framework, four guiding principles, and seven essential beliefs. The theoretical framework that supports differentiated instruction is rooted in constructivism and based largely on research on student achievement (McTighe & Brown, 2005). Supporting the framework are four guiding principles that relate to differentiating classroom practices: (a) a focus on essential ideas and skills in each content area, (b) responsiveness to individual student differences, (c) integration of assessment and instruction, and (d) an ongoing adjustment of content, process, and products to meet individual students' levels of prior knowledge, critical thinking, and expression styles (Tieso, 2003; Tomlinson, 1999). Lending further credence to the model are seven basic beliefs (Tomlinson, 2000b): (a) same-age students differ markedly in their life circumstances, past experiences, and readiness to learn; (b) such differences have a significant impact on the content and pace of instruction; (c) student learning is heightened when they receive support from the teacher that challenges them to work slightly above what they can do independently; (d) student learning is enhanced when what they are learning in school is connected to their real-life experiences; (e) student learning is strengthened by authentic learning opportunities; (f) student learning is boosted when they feel they are respected and valued within the context of the school and community; and (g) the overarching goal of schooling is to recognize and promote the abilities of each student

Implementing DI

DI in a mixed-ability classroom refers to instruction that allows the teacher to meet the needs of all learners by providing multiple options for students to be able to learn and grasp various concepts and to be able to express what they have learned (Patterson, Conolly, & Ritters, 2009). There are many ways to differentiate instruction in the classroom to fit the needs of the students while allowing the teacher to maintain a comfort level of control. The important thing about implementing DI is that it happens in some form in the classroom (Bafile, 2009). For teachers to differentiate effectively, they must first recognize the different aspects of the learning needs of the students in the classroom (Herrelko, 2013; Latz & Adams, 2011).

Teachers should provide various ways for students to be able to grasp content that does not dilute below the expectation of the standards set or change it before a lesson, during a lesson, or after a lesson (Bowgren & Sever, 2010). DI does not follow a specific set of guidelines or rules, so teachers can transform it to fit their needs and the needs of their students (Scigliano & Hipsky, 2010). Though DI allows for flexibility, it can also lead to some teachers having difficulty in implementation. Because there is not a specific guideline to follow that some teachers might appreciate, giving teachers the right knowledge about DI could help to ensure they implement it more effectively. Teachers must have knowledge about DI to make sure all activities are designed for students to meet the essential learning targets (Dixon et al., 2014). Teachers need to establish these specific learning targets first to ensure that all activities will meet the standard and provides opportunities for all students in the classroom to be successful (Dobbertin, 2012). Learning targets are standards-based statements of what students are expected to learn (Dobbertin, 2012). Teachers then use these learning targets to design specific activities that will help students meet those learning targets. These learning targets often are used in conjunction with assessments, so students understand what targets they have mastered (Dobbertin, 2012). DI is tailored to student needs by providing different entry points, learning tasks, and outcomes (Watts-Taffe et al., 2013).

DI is an approach that does not label or segregate students; it should work to serve all students in a heterogeneous classroom (Wu, 2013). Small group instruction allows the teacher to work more closely with a smaller number of students to help them achieve more (Lipson & Wixson, 2012). Students who are more advanced or have a higher interest in a particular subject can complete an independent study project while the teacher works with a smaller group of students. Once the teacher gets the independent study group working, he or she could be able to focus more on the learning needs of the other students and give them more time and attention.

One approach to implementing DI is by using flexible or tiered grouping where different factors are taken into consideration for placing students based on characteristics such as gender, ethnicity, academic skill, interests, and personality (Herrelko, 2013; Patterson et al., 2009). These groups should be based on data for what the students‘ needs are and should often be reevaluated to ensure that these flexible groups are meeting each students‘ needs (Rakow, 2012). These collaborative groups could offer more flexibility to provide various strategies with the support of peer tutoring (Hoffman, 2002). These groups can also help motivate students through peer relations of wanting to be leaders among classmates (Wood & Jones, 1998). Assigning roles in the groups can help monitor and control negative classroom behavior (Wu, 2013). Students can help monitor that every person is completing their required tasks and contributing to the group (Patterson et al., 2009). By implementing grouping, a teacher can more easily assess what students understand and what they do not because they will be in smaller groups (Hodges & McTigue, 2014; Tieso, 2003). Teachers can group within their classroom, or teachers of the same subject area can utilize each other and split students up in different classrooms based on skill level. Ability groups can be formed by different activities based on assessments (Herrelko, 2013; Rubenstein, Gilson, Bruce-Davis, & Gubbins, 2015). Herrelko (2013) found that students who were placed in ability groups based on assessments could achieve more academically. The results from Herrelko's (2013) study revealed that students' scores in Tier 0 increased 30 points, students in Tier 1 increased by 64 points, and Tier 2 students increased by 114 points. Tiered lessons can also be constructed to provide DI by offering different degrees of difficulty of assignments to meet students' needs and challenge them to move up to higher levels of learning (Latz & Adams, 2011). Another example would be to give students a work packet with different degrees of difficulty, and depending on the students' skill levels determines how difficult the problems or tasks are for a particular student. Tiered tasks are a valuable tool as students are doing different activities or tasks that are focused on the same standard, but it allows for self-paced opportunities to practice skills and fluency (Kobelin, 2009). Sometimes implementing DI can require more work on the teacher's part at the beginning, but teachers in the same subject area can collaborate to share this workload. Teachers might have to give a little more effort when first implementing DI as it does take some training and planning (Bulgren et al., 2013). A common planning time of teachers in the same subject area can be beneficial to give teachers the time they need to collaborate. In the end, DI can make their job easier as students can be more successful as they will find more self-motivation (Bulgren et al., 2013; Hodges & McTigue, 2014; Morgan, 2014). Once students are more selfmotivated, there could be fewer discipline issues in the classroom (Dukes & Lamar-Dukes, 2009; Van der Ploeg, 2013).

Using DI can look different from one teacher to another as there is not just one way to use it. Teachers must recognize their comfort level and build from there (Bowgren & Sever, 2010). Beam (2009) suggests that DI can begin with “low-preparation activities like student choice tasks, homework options, use of reading buddies, varied journal prompts, different pacing options, goal setting, flexible grouping, and interest explorations” (p. 7). As teachers become more comfortable with DI, they can increase the level of its use in their classrooms (Bowgren & Sever, 2010). Beam (2009) recommends activities that can be instituted requiring “high-preparation are tiered activities and labs, independent studies, multiple texts, alternative assignments, multiple-intelligence options, varying graphic organizers, tiered learning centers, choice boards, graduated rubrics, personal agendas, or stations developed by readiness, interest, or learning profile” (p. 7).

Another way to use DI is by using student choice tasks, which provides the students with a variety of activity options and allows them to choose according to their interests (Dotger & Causton-Theoharis, 2010). Students having a choice can be a powerful tool in implementing DI as it gives students the power to learn based on their interests and strengths (Crim et al., 2013). Studies have shown that students will have more motivation and achieve more when they find interest in a topic (Morgan, 2014).

Using learning targets is another example of how to differentiate in the classroom based on student assessments (Blanchard, 2003). This method calls for students to progress at their pace and use assessment results to determine what they need to work on (Dobbertin, 2012). Students work on tasks based on what the assessments indicate they still need help with to master the standards. Students are given tasks to meet specific learning standards (Moss, Brookhart, & Long, 2011).

There are several different learning styles, so DI allows each student to be reached no matter how they learn best (Allcock & Hulme, 2010). A teacher who implements DI allows multiple ways for students to access content, process it, gain an understanding of the concepts and skills, and then create products that demonstrate that they are learning (De Jesus, 2012). Content and strategies should be flexible aspects of the classroom to meet the students where they are and to challenge them to achieve more (Roe, 2010). Flexibility is important with DI since it requires blending multiple features of instruction at the same time (VanTassel-Baska & Stambaugh, 2005). DI allows for meeting the needs of each student, so being flexible is important because these student needs may change (Roe, 2010).

According to Tomlinson (2004), teachers can differentiate their instruction via four methods: 1) content, 2) process, 3) product, and 4) learning environment. Activities based on various Blooms‘ Taxonomy levels fall within the content category. Process refers to how a student makes sense of the information and learns. Delivering material according to students‘ preferred learning style is process. Product is the medium through which the students show what they know and are capable of doing based on their investigation of a particular topic.

2.5.2 Benefits of differentiated instruction

Differentiating instruction has many benefits both to the learner and to the instructor. When used by instructors, this teaching strategy promotes engagement, facilitates motivation, and helps students make the connection with what is being taught in the classroom to the things they value outside of class. When such connections are made, students tend to improve in their retention of the information. In addition, differentiation can encourage students to discover new interests (Santangelo & Tomlinson, 2009).

Tulbure (2011) posited the following additional advantages: it places students as the focal point of the instructional process, it allows flexibility in learning tasks, it revaluates and respects the differences between individual student needs and preferred learning modalities, and it levels the field for student success. Further, differentiated instruction empowers instructors to be responsive rather than reactive to students‘ unique and individual personalities, backgrounds, and abilities (Anderson, 2007). Assessment based on students‘ preferred learning style is productive. Meeting the physical and psychological needs of students refers to the learning environment. Tomlinson‘s model suggests that teachers promote equity and excellence by differentiating high quality content, process, and product when instruction is centred on students‘ readiness levels, interests, and learning profiles (Santangelo & Tomlinson, 2009). This position is supported further by Dosch and Zidon (2014), who also added affect to the list for instructional differentiation. Furthermore, affect addresses students‘ emotions concerning school-related issues that are influential to their learning. Other researchers view that affect is embedded within the content, process, and product (Dosch & Zidon, 2014); therefore, many studies of differentiated instruction do not include affect with the other three diagnostic elements.

Implementing DI could raise the scores of students with disabilities, students at-risk for school failure, regular students, and students characterized as gifted and talented (Wu, 2013). Chicago Public Schools conducted a research study and integrated a flexible differentiated-instruction-based strategy and reported they saw an increased performance for students who had high and low math skills (Rubenstein, Gilson, Bruce-Davis & Gubbins, 2015). Research is being conducted that shows the results supporting the use of DI (Brighton, Moon, & Huang, 2015). Students in a program where reading was differentiated were more likely to achieve more when presented with opportunities for self-interest and self-selection of reading materials (Morgan, 2014). When teachers differentiate instruction, it showed students more on task and students in third grade increased their reading comprehension scores (Brighton et al., 2015). Over a seven, year period during this research study, the district reported improvement in all subject levels and all levels of proficiency. Results from this study showed that students in the lowest remedial band on state assessments reduced by 28% which left only 4% of this group classified as remedial (Beecher & Sweeny, 2008). Another research study that used a reading program showed that high-poverty students in an urban school resulted in significantly higher reading fluency scores compared to students who were not part of the program that used DI (Reis, McCoach, Little, & Kaniskan, 2011). Another research study showed that those students placed in a classroom that used DI increased their ITBS (Iowa Tests Basic Skills) scores by 23% (Callahan, Moon, Oh, Azano, & Hailey, 2015). The ITBS are national achievement tests that assess students‘ skills in Reading, Language, Mathematics, Social Studies and Science.

Schools that enacted a research study for teachers to implement DI reported that they saw an improvement in students‘ attitudes about school and more engagement in learning along with improved scores on district and state assessments (Beecher & Sweeny, 2008; Doubet, 2012; Konstantinou-Katzi et al., 2013). In another research study, more than 90% of the teachers reported that they saw a significant increase in students‘ desire and motivation to read more and became more actively involved after integrating DI into their reading program (Reis et al., 2011). DI can have a positive impact on student behavior in the classroom. Over a three-year period of another research study, one school noticed significant changes to students‘ behavior in classrooms where teachers focused on implementing DI. Teachers in the experimental group experienced significant changes at a 39% increase in more positive behavior of students compared to teachers in the control group (Van Tassel-Baska et al., 2008).

Pretests can be a tool that teachers use to organize a plan to implement DI. Another study looked at pretests and posttests scores of students and determined that those students exposed to DI could improve their individual progress with results showing that 67% of students increased their assessment score at least one grade (Konstantinou-Katzi et al., 2013). This study was used in a Calculus I class, and it lasted 13 weeks. The teacher used action research to plan lessons of the curriculum to meet the needs of the students. Assessments used throughout the study to gather evidence to document changes in the students‘ performance and attitudes. The students became active learners by taking part in joint discussions and collaboratively worked to complete assignments. DI was used throughout by the instructors outlining which knowledge must be attained by all students. They would then work with those students individually who struggled with this knowledge while other students progressed individually or in groups on learning activities in a hierarchic order. Technology was an important component of the DI used as applications developed to increase knowledge. These assessments included pretests, diagnostic questionnaires, in-class exams, and four assignments. A course completion survey was given as well along with in-class interviews of the students (Konstantinou-Katzi et al., 2013).

Results from another school favored an environment with DI for fifth-grade students (Brimijoin, 2005). The teacher in this study used a variety of assessments to collect data to determine the students‘ existing understanding of certain concepts. This teacher then used this data to design her lesson plans and continuously observed and evaluated the students‘ needs throughout the lessons. One technique that the teacher used to help gauge when the students needed additional help was through a ―windshield" question approach. She asked the students how many were clear as glass (meaning they understood), how many had bugs (meaning they did not completely understand), and how many were completely covered in mud (meaning they did not get it at all; Brimijoin, 2005). The teacher believed this approach allowed her to evaluate the lesson quickly and modified it on the spot for certain students. This teacher used a variety of DI techniques such as compacting, tiered lessons, Think DOTS (Think-Tac-Toe), graphic organizers, RAFTs for writing projects, anchor activities, and task cards (Brimijoin, 2005). The teacher saw positive results come from her use of DI.

When students started the school year, 47% had previously passed the statewide reading assessment, 53% had passed math, 34% had passed social studies, and 42% had passed science. At the end of the year, all subject areas showed an increase in student achievement with 74% of students passing reading, 58% passing math, 58% passing social studies and 74% passing science. This study also showed that some students improved their individual assessment scores by almost 30%. (Brimijoin, 2005, p. 257)

Promoting self-efficacy can be a result of implementing DI which can, in turn, lead to better assessment scores. DI was used to help improve reading scores at the middle school level. The reading levels of students increased by .88 grade levels and the NCE percentage rose by 6.6% (Stenson, 2006). This school focused their research on implementing a program that worked to promote self-efficacy among students for them to become active learners in their education. Graphic organizers and scaffolding were used to meet the students' needs and help them to feel success and not get frustrated (Stenson, 2006).

Implementing DI can be seen as a common-sense approach to planning (Stanford, Crowe, & Flice, 2010). Teachers who know their students and understand their learning needs will plan for DI as they create their lesson plans (High & Andrews, 2009; Tomlinson & Imbeau, 2012). Teachers who offer resources and activities that provide the needed pre-requisite skills and knowledge helps their students master the standards (Stanford et al., 2010). Students who feel understood, appreciated, and accepted tend to perform better academically and implementing DI allows students to feel these things (Tomlinson & Germundson, 2007).

DI enhances Cooperative Learning in Biology

Cooperative learning has been defined by Johnson and Johnson (1978) as an approach that engages students in working together noncompetitively toward a common goal. Cooper and Mueck (1990) also described cooperative learning as a structured, systematic instructional strategy in which small groups work together toward a common goal. The goals of cooperative learning are to enhance students' learning and to develop students' social skills like decision-making, conflict management and communication (Bonwell & Eison, 1991). The cooperative learning methods used in contemporary education have evolved over the last 30 years (Handelsman, Houser & Kriegel, 2002) and proponents of cooperative learning have developed classroom strategies that emphasize small groups of students working together in a structured process to solve academic tasks (Newberry, 1999). Cooperative learning tends to be more carefully structured and delineated than most other forms of small-group learning (Newberry, 1999). According to Borich (2004), in cooperative learning interaction among students is intense and prolonged and students gradually take responsibility for each other‘s learning. Cooperative learning is thus, the instructional use of small groups so that students work together to maximize their own and each other's learning.

The five critical elements make cooperative learning successful are positive interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing (Johnson & Johnson, 1999). The first of the five critical elements is positive interdependence. Positive interdependence is the process of linking students together so that they cannot succeed unless their teammates do (Johnson & Johnson, 1999). Positive interdependence is thus the act of working together to benefit one another. To ensure positive interdependence teachers must develop bonding and group trust, use group roles and structure content areas (Gibbs, 2001).

Individual accountability is the second critical element of cooperative learning. Individual accountability ensures individual and group assessments (Johnson & Johnson, 1999). Parveen, Mahmood, Mahmood and Arif (2011) have noted that individual accountability exists when the performance of each individual member is assessed, the results are given back to the individual and the group to compare against a standard of performance and the member is held responsible by group-mates for contributing his or her fair share to the group‘s success. Johnson and Johnson (1999) therefore, suggest that teachers give individual tests, randomly select students work and have each student explain what he or she learned to facilitate individual accountability during cooperative learning. In individual accountability each student within a group must thus be held accountable for mastery of the instruction presented to the group.

The third critical element of cooperative learning according to Johnson and Johnson (1999) is face-to-face promotive interaction. Face-to-face promotive interaction is individuals supporting each other in a cohesive group in which they promote each other's success by sharing resources, helping, assisting, supporting, applauding each other's efforts to achieve and encouraging one another. Also, in face-to-face promotive interaction students teach and encourage one another during the exercise to ensure that any team member randomly chosen will be prepared to answer for the group.

There are important cognitive activities and interpersonal dynamics that can only occur when students promote each other's learning (Johnson & Johnson, 1999). This includes orally explaining how to solve problems, teaching one's knowledge to others, checking for understanding, discussing concepts being learned and connecting present with past learning (Johnson & Johnson, 1999). Lampe, Rooze and Tallent-Runnels (1998) have stated that peer interaction is central to the success of cooperative learning as it relates to cognitive understanding and facilitated comprehension. During cooperative learning therefore, the feedback, reinforcement and support come from student peers in the group. This implies that science teachers dividing their students into groups of four or five, working together in physical closeness promoted by a common task, will encourage collaboration, support and feedback from the closest and most immediate source - one‘s peers (Ajaja & Eravwoke, 2010). According to Ajaja and Eravwoke (2010), science teachers should therefore, model their instructions to enforce student-student interaction. In a cooperative learning classroom therefore, the teacher must specify both the academic and social skill objectives, explain the tasks and goal structures, assign roles within the groups to facilitate learning.

The fourth critical element of cooperative learning according to Johnson and Johnson (1999) is social skills. To promote effective cooperative learning, Johnson and Johnson (1999) suggested that students must be taught social skills, such as leadership, decision making, trust building, communication, and conflict management, just as purposefully and precisely as academic skills. Vermette, Harper and DiMillo (2004) have found that conflicts do arise between students in cooperative learning groups however, they need to be resolved in a healthy manner for effective cooperative learning. Students cannot be placed together in a group situation and expected to cooperate they must therefore, be taught the social skills needed for collaboration, and they must be motivated to use them (Slavin, 1995 and Johnson & Johnson, 1985).

The fifth and final critical element of cooperative learning according to Johnson and Johnson (1999) is group-processing. According to Parveen *et al*. (2011), group processing may be defined as reflecting on a group session to describe what member‘s actions were helpful or unhelpful and take decisions about what actions to continue or change. Continuous improvement of the processes of learning results from the careful analysis of how members are working together and determining how group effectiveness can be enhanced (Johnson, Johnson & Holubec, 1993). To Johnson and

Johnson (1999), group members discuss how well they are achieving goals and maintaining effective working relationships while discovering how well each member performs and adjusts to change.

Dentler (1994) has noted that cooperative-learning approaches empower students, bolstering their self-esteem and confidence. Nelson (1996) speaks convincingly of the need to alter philosophies and practices and advocates a switch to alternative, non-lecture-based pedagogies, such as structured group work. Dentler concludes:

> *When we ask our urban community college students to find answers on their own and share them, non-competitively with their classmates, we empower them in a way that wasn't even necessary for my generation of college students. When our students work with their peers on research projects, we are literally inviting them to participate in the system. For many, this is the first time the system has welcomed them at the table.* (p. 11)

Millis and Cottell (1998) have noted the close affinity and links between cooperative learning and technology by asserting that cooperative learning and technology (such as computer simulations) are natural partners. This is because the use of technology involves human dimensions of caring, community and commitment (Yusuf & Afolabi, 2010). Accordingly, using technology in ways that promote sequenced learning within groups can lead to more in-depth processing of course content and hence, more retention of information (Newberry, 1999). Barron and Orwig (1997) have also opined that technology can be used to enhance and encourage cooperative learning in our schools through small groups using a single computer, network-based instructional programmes or collaborative projects on the internet.

2.5.4 Challenges in DI

Even though, the use of differentiated instruction has been supported to be an effective strategy for diverse learners (Joseph, Thomas, Simonette & Ramsoook, 2013) there are a number of factors that lead to differentiation not being applied effectively (Logan, 2011). Following some of these challenges reported from the available literature, Siam and Al-Natour (2016) conducted a mixed method study to identify DI practices and challenges teachers face when teaching students with learning disabilities. As reported by the authors, the main challenges found from the study include: (1) weak administrative support, (2) low parental support, (3) lack of time, and (4) shortages in learning resources. The study also revealed that the daily workload of teachers including documentation, paperwork and administrative burdens while lacking proper understanding and knowledge about DI strategies standing in the way of DI implementation which ultimately affects the education of students with learning disabilities.

In another study, after examining the impact of using DI approach to teaching undergraduate students at a tertiary institution, (Joseph et. al., 2013) found out time as one of the biggest challenges for teachers. The authors reported that, teachers need to spend long hours for planning, organising and scheduling individuals and groups in a large class setting when the strategy was implemented. It was found challenging to cater for individual needs as well as students' preferences to work alone rather than in groups or with the whole class.

The above results were in accord with the findings of (Roiha, 2014) who investigated differentiation in content and language integrated learning, and concluded that (1) time, (2) materials, and (3) physical classroom environment as the greatest challenges.

In another study, VanTassel-Baska and Stambaugh (2005) discovered ten potential barriers which are related to knowledge, skills, attitudes, resources, time, and support in which all found to be obstructing teachers' effort of DI implementation.

In summary the chapter started with theoretical and conceptual framework of the study. The two theories that underpin the study were constructivism and the zone of proximal development. These theories formed the theoretical framework of the study. These theories were also used to develop the conceptual frame work of the study. The chapter reviewed relevant literature on cell division, differences among students in mixed ability classrooms and differentiated instruction in cell division.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter describes the procedures adopted in conducting the study. Research methodology is essentially a systematic and focused procedure of gathering data for the purpose of extracting information that will in turn answer or solve the research question (Leedy, 1989). This chapter provides details related to the methodology of the study. It presents the research design, research area, population, sample size, sampling technique and research instrument. The validity, reliability of the main instruments, data collection procedures and data analysis are also presented

3.1 Research Area

The research area was the Delcam Senior High School in the Adentan Municipality in the Greater Accra Region of Ghana. The school was established in 2000. Delcam Senior High School started in Ashaley Botwe. The school is a private Senior High School.

The school offers General Science, Agricultural Science, Business, Home Economics and Visual Arts. It has a population of about 400 students (of which 38% females and 62% males). The school has chemistry, physics and biology laboratories. The performance of the school in the 2021 West Africa Secondary School Certificate Examination was encouraging. The school scored 70.45%, 65.89% and 80.67% in chemistry, physics and biology respectively.

3.2 Research Design

The research design is used to structure the research and to show how all of the major parts of the research project, including the sample, measures, and methods of assignment, work together to address the central research questions in the study.

It is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure (Kothari, 2004). Research approach is a scheme, outline or plan that is used to generate answers to research problems (Kombo & Delno, 2006).

The study employed the quasi-experimental research design. This is because quasi-experiments are exceptionally useful in instances, such as, evaluating the impact of public policy changes, educational interventions or large scale health interventions, where it is not feasible or desirable to conduct an experiment or randomized control trial (Shadish, Cook and Campbell, 2002). Quasi-experimental research design involves selecting groups, upon which a variable is tested, without any random pre-selection processes (Shuttleworth, 2008). Shadish *et al* (2002) have identified several types of quasi-experimental designs. According to them, these quasi-experimental research designs include, but are not limited to: the one-group posttest only design; the one-group pretest posttest design; the removed-treatment design; the case-control design; the non-equivalent control groups design; the interrupted time-series design and the regression discontinuity design.

According to Gribbons and Herman (1997) however, the frequently used types of quasi-experimental research designs include the following: posttest only nonequivalent control group design, time series designs and pretest-posttest nonequivalent control group design. Time series designs refer to the pre-testing and post-testing of one group of subjects at different intervals, the purpose of which might be to determine long term effect of treatment. In time series designs therefore, several assessments (or measurements) are obtained from the treatment group as well as from the control group, which occurs prior to and after the application of the treatment (Gribbons & Herman, 1997). Therefore, according to Gribbons and Herman (1997), in a time series design, many observations are made over time; both without intervention and with intervention (Gliner & Morgan, 2000). The multiple observations according to Zelenka (2010), are used to establish a baseline that shows an ideally stable level of the outcome of interest over time. Again according to Zelenka (2010), multiple observations are made during intervention, ideally showing a change due to intervention, the treatment may be withdrawn, again in an attempt to isolate the relationship of treatment to observed outcome. This may be used with or without a control group (Zelenka, 2010). In pretest-posttest nonequivalent control group design, both a control group and an experimental group is compared however, the groups are chosen and assigned out of convenience rather than through randomization (Heffner, 2004). To Leedy (1997), this design is one of the strongest and most widely used quasi-experimental designs, which differs from experimental designs because test and control groups are not equivalent. Posttest only non-equivalent control group design involves administering an outcome measure to two groups or to a programme or treatment group and a comparison (Gribbons & Herman, 1997).

The study employed the pretest-posttest design. The pretest-posttest design is much like a within-subjects experiment in which each participant is tested first under the control condition and then under the treatment condition. It is unlike a within-subjects experiment, however, in that the order of conditions is not counterbalanced because it is typically not possible for a participant to be tested in the treatment condition first and then in an –untreated” control condition (Posternakm & Miller, 2001). Quasi-experimental research approach was used for this study because the study used intact classes which did not permit random selection and assignment of participants (Cohen, Manion & Morrison, 2008).

The prefix *quasi* means –resembling.” Thus, quasi-experimental research is research that resembles experimental research but is not true experimental research. Although the independent variable is manipulated, participants are not randomly assigned to conditions or orders of conditions (Cook & Campbell, 1979).

3.3 Population

Kusi (2012) defined population as a group of individuals or people with the same characteristics and in who the research interest is. He further asserts that a population is a group of individuals that the research generalizes his or her findings to. The target population comprised all the four hundred (400) students of Delcam Senior High School. The accessible population was third year science students numbering forty (40)

3.4 Sampling Procedure

A census of 40 students comprising 20 males and 20 females was used for the study. Census in research is when all members of the target group are sampled. It is a study of every unit, everyone or everything in a population. It is known as complete enumeration because it is a count from part of the population. Census sampling was adapted because it deals with selection of people of a particular set of attributes that have an effect on the problem or issue of interest and ensures comprehensive representativeness (Stringer, 1996). It implies that, a particular sampling unit to be selected by the researcher depends on the subjective judgement of the researcher. Notwithstanding the subjectivity of this sampling procedure, the advantage of its ability cannot be overlooked. Census was used because every member of the target group was used.

3.5 Research Instrument

The data collecting instruments were two test instruments of comparable standard, which were used to collect quantitative data from all participants. ―Students' Knowledge of Mitosis Test" – SKMT (Appendix A) and ―Students' Achievement in Mitosis Test" – SAMT (Appendix B), which were both developed by the Researcher. The SKMT and SAMT were used as the pretest and posttest instruments respectively. The SKMT was used to assess the participants' knowledge and difficulty with the concept of ‗mitosis' in order to have a baseline about all participants before the implementation of the interventions as well as know the alternate concepts of the students. The SAMT was however, designed to measure participants' achievement after the implementation of the interventions.

The instrument used in this work was a closed ended question, open ended test questions and drawings on mitosis. The test had only one section which covered the terms, stages and drawings in mitosis. Both tests had a total mark of 20.

3.5.2 Validity of research instruments

To ensure that participants' scores from the SKMT and SAMT make sense, are meaningful and enable good conclusions to be drawn from the sample studied to the research population (Creswell, 2008), both test instruments were presented to one senior biology lecturer in the Science Education Department of the University of Education, Winneba and two SHS elective biology teachers with considerable teaching experience in the Adentan Municipality for their comments and suggestions in order to correct the errors that were associated with items on the SKMT and SAMT.

3.5.3 Reliability of the Research Instruments

Reliability refers to the extent to which a measuring instrument yields the same results on repeated application (Durrheim, 1999). It means the degree of dependability of measuring instruments (Hackman, 2002)

In order to ensure that the research instruments produced scores that are stable and consistent and their test items are devoid of any ambiguities (Creswell, 2008) as much as possible, the SKMT and SAMT were pilot-tested using 29 SHS elective biology students in Golden Gate SHS in the Adentan Municipality in the Greater Accra Region of Ghana. Data from the pilot test were statistically analysed to determine the reliability of the test instruments using the Spearman-Brown prophecy formula since all items on both SKMT and SAMT were dichotomously scored. The analysis yielded reliability coefficients of .59 and .62 for the SKMT and SAMT respectively. According to Ary, Lucy and Asghar (2002), if the measurement results are to be used for making a decision about a group or for research purposes, or if an erroneous initial decision can be easily corrected, then scores with modest reliability coefficients in the range of .50 to .60 may be acceptable. The above reliability coefficients for the SKMT and SAMT therefore, signify that both test instruments are considerably reliable.

3.6 Intervention Stage

The intervention was to achieve three objectives. Namely:

1. Explain the term cell division.
2. Outline the phases of cell division.
3. Describe the process of mitosis and its importance

The pre-test was administered to the sample on the first day of the intervention. The result of the test was used to categorise the students as high achievers, average achievers and low achievers (Table 1). The same topic had been taught by the researcher in previous months since the participants were his students.

Table 1: Mean Scores of SKMT for categorization of students

Category of students	Range	Number of students
Low achievers	0-7	33
Average achievers	8-11	6
High achievers	12-20	1

Six mixed ability groups were formed from the categories. Six activity stations were set-up. The stations are described below. The components of the station are provided in appendixes C-G. The intervention took three days within the week.

Day one was for the first and second station. Day two was for the third and fourth and day three was for the fifth and sixth station. And the activities for the stations are descried in the paragraphs below.

Day one

The first station was the word sort station. In this station, each decided how to sort out 14 terms in mitosis. The students were permitted to sort the terms in more than two categories. There were collaboration students in the group to make sure each member was able to explain why you sorted the terms in the manner that you did. The station was to address the learning needs of tactile learners.

In the second station students examined prepared slides of an onion root tip to identify the cells that are dividing. There were sets of questions that students answered and handed in for assessment. That was the end of the first day of intervention. This station was to address the learning need of tactile learners.

Day two

The third station was the first point of call in the second day of intervention. At this station, there were cell models each showing a different stage of mitosis. Each member will have one cell model in theirs hands before the music starts. One person was selected as the DJ to start and stop the music. As the music is stopped, students determine stage of the model in their hand. This was to address the needs of the auditory learners

In the fourth station which happens to be the last for the second day, group members completed the Fryer model worksheet. The worksheet had columns on all the stages of mitosis. It was discussed with group members and submitted.

Day three

The fifth station was dubbed grab a bag. Group members sat in a circle. Student were drawing words from a bag. One person formed a sentence with the word or term. Every group member gets a pick and the work sheet is submitted. This station was to address the needs of Kinaesthetic learners. These individuals discover information through active ―hands-on" approach.

The last station was a video on mitosis. Group members sat by the screen and watched a video mitosis. Students completed the worksheet provided. This station was to address the need of visual learners.

All the six groups took part in the activities of each station. All the students in all the groups took part in activities under all the stations.

3.7 Data Collection Procedure

The data collection started with the presentation of an introductory letter from the Head of Department of Science Education, University of Education, Winneba (UEW) to the Headmaster of Delcam Senior High School to conduct the study within the first week of March 2022. The research instruments were namely the pre-test and the post-test.

The pre-test was first administered to all the students before the intervention. The pre-test was administered to all students, not in groups. The pre-test was marked by the researcher and the results presented to the students the following day. The data collected was used to grouping the students. The data will help to find out the alternate concepts of Delcam SHS Students in mitosis. It was to answer research question one of the study. Three full days were used for data collection. One day for the ore-test and another full day for the post-test.

The post test was administered to all the students and not in groups after the intervention. It was marked and given to the students. The data from the post test was with the pre-test to answer the second research question and second objective

3.8 Data Analysis

The data from the tests were analysed using Statistical Package for Social Scientists (SPSS) version 20. Data analysis was based on the pre-test and post-test. The responses from the collected were analysed considering one research question at a time and analysing the data relevant to that particular question. The results presented in two parts, thus, the descriptive statistics and inferential statistics. Descriptive statistics such as averages and percentages were generated from the data to enable the researcher present the findings. In addition, frequency tables, graphs and charts were also used for graphical presentation of the data. Under inferential statistics, a t-test analysis was also used to find out if there was a significant difference between means scores of the pre-test and post-test. The t-test is an inferential statistic used to determine if there is a significant difference between the means of two groups which may be related in certain features. The t-test was used to find out if there was a significant difference between the post-test and pre-test. The t-test was used because the two samples of male and female were of same number and sat in the same class. The t-test was to the three null hypotheses.

3.9 Ethical issues

The researcher needed to protect the identity of the students and the institution, develop a trust with them and promote the integrity of the researcher. The researcher withheld the identity of Students to ensure proactive participation of the entire Students and the confidentiality of their information.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter focuses on presentation of results, analysis and discussions. Data analysis, is based on the pre-test and post-test. The results are presented in two parts, thus, the descriptive analysis where frequency tables, percentages and graphs were used and inferential analysis. The research involved a sample of students from the Delcam Senior High School in the Adentan Municipality of the Greater Accra Region of Ghana. In all, 40 students in the form three science class were involved in the study.

The chapter is divided into five sections including the following; background information of students, alternate concepts among SHS students in Cell division, Differentiated Instruction and its effect in improving Student‘s performance in Cell Division and the effect of gender on DI. The final part deals with the summary of the chapter.

4.1 Analysis and presentation of data on Research Questions

4.1.1 Research Question one

RQ 1: What are the alternate concepts of cell division among students of Delcam Senior High School?

This research question sought to find out the alternate concept about cell division of students because students have many alternate concepts before coming to school. Some of these preconceptions may be inconsistent with scientific knowledge and are called alternate concepts in cell division. These concepts hinder learning since students construct knowledge by the help of already existing conceptions. It is therefore necessary to find the alternate concept and correct them.

The alternate concepts of the students were identified through a pre-test (SKMT) that was answered by all forty students. The pre-test consisted of ten questions on mitosis. The test consisted of multiple choice, open ended and fill in questions. Each question carried two marks giving a total mark of twenty.

Below are alternate concepts elicited from students of Delcam Senior High School. The sample of questions and alternate concepts were collected from the pre-test. The questions are question two (2), three (3) and four (4). Many students had wrong (alternate) concepts on these questions.

Question 3: Do you think plant and animal cells divide in the same way?

Student 1: They divide in the same way

Student 5: They divide in the same way since, both undergo mitosis

Student 9: They divide in the same way

Many students provided incorrect answers to the question. Most of the student did know exactly how plant and animal cells divide. Basically, they follow the same means, but there is some difference between them.

Question 2. What is the chromosome number of an organism?

All Students had this question wrong. They all stated that the chromosome number is 46 for all organisms. This is false since organisms do not have the same number of chromosomes. Humans have 46 chromosomes, chicken has 78, cat has 38 chromosomes, corn has 20 chromosomes etc.

Question 7. Briefly distinguish between genes and chromosomes

Student 3: Genes are roundish whiles chromosomes are cylindrical

Student 10: Chromosomes are organs that carry the genetic materials. Examples are RNA and DNA. Chromosomes are not organs

Student 12: Genes are cells which can be inherited from parents while the chromosomes are cells which make up a particular part of the body

Result of this research was similar with Shaw (2008), who stated that most of the students were not able to describe the gene, its structure, and its function. Actually, gene is structurally a segment of DNA that expresses a particular nature while DNA is the genetic material that is composed of a phosphate, deoxyribose sugar and the nitrogenous bases forming a polynucleotide

The pre-test was answered by students prior to the intervention stage. The modal mark was 4 out of 20 which represented 20%. Nineteen Students representing 47.5% of the sample got this mark. The highest mark was 12 out 40. Only one Student (2.5% of the sample size) scored 12 in the test. The lowest mark was 2 out of 40. (Table 2). The performance in the pre-test was very low.

In all, only two students representing 5% of the sample size scored 10 marks and above in the test, they were above average (Table 2). This suggests that 38 Students representing 95% of the students scored below average in the test. This further suggests that Students have a lot of alternate (incorrect) concepts in cell division. The study agrees with Chin (2012) that students have alternate concepts in mitosis. The males performed slightly better than the females (see appendix H)

Testing of Hypothesis with Respect to Research Question One

To determine whether the difference in performance between the male and females in the pre-test were statistically significant, research question 1 was formulated into a null hypothesis and tested.

It was hypothesised that:

Ho 1: Gender has no effect on alternate concepts in cell division

Even though the males scored slightly higher than the females (Fig 2), the mean for the male scores was 5.2 and the mean for the female scores was 4.5, there was no significant difference between the means [t=1.48; p>0.05]. This means the gender has no effect on the alternate concepts of students in cell division. This agrees with other studies carried out by Altiboz (2004) and Riemeier and Gropengießer (2008).

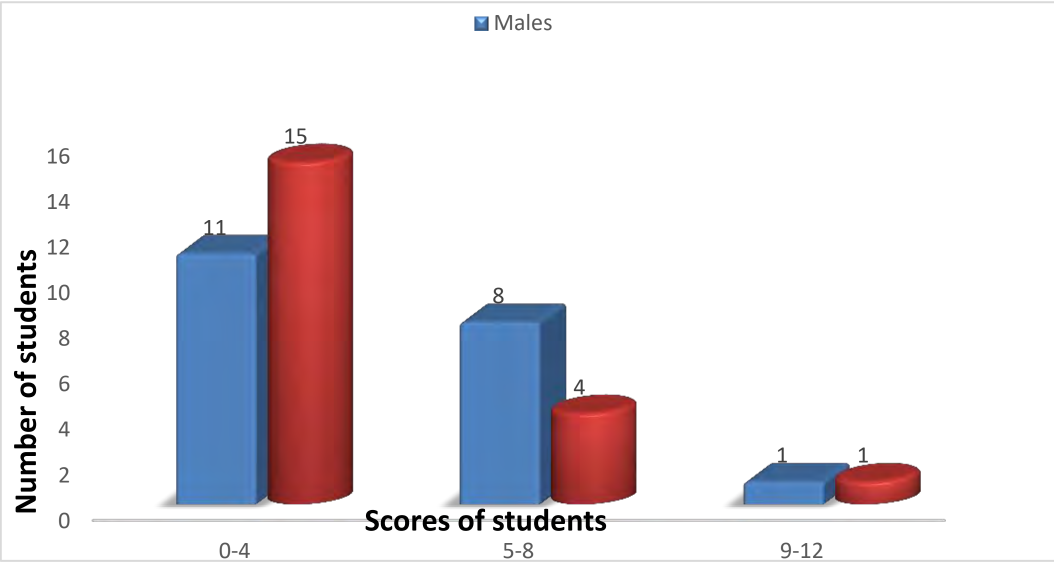


Figure 2: Graphical representation on Scores of males and females in pre-test

Table 2: A statistical table showing effect of Gender on pre test scores

	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Female scores for pre-test - Male scores for pre-test- females	2.8844	2.46376	.91188	.52055	4.36833	1.481	19	.006

4.2.2 Research Question Two

RQ 2: To what extent will the use of differentiated instruction improve understanding of students of Delcam SHS students on the concepts of cell division**?**

The research question sought to assess the effect of the intervention on students' understanding to the concepts of cell division.

The data collected from the post-test was to find out the extent to which the intervention (DI) will improve SHS students understanding in cell division was from the post-test (SAMT). The post-test was answered by all forty students. The test was marked and scored (Table 3).

Comparing pre-test and post-test it is clear that the scores in post-test is higher than that of pre-test.

Table 3: Performance of pre and Post-test stages

Marks (%)	Pre-test		Post-test	
	Frequency	% Frequency	Frequency	% Frequency
0-35	33	82.5	1	2.5
36-40	0		3	7.5
41-45	5	12.5	4	10
46-50	0		2	5.0
51-50	1	2.5	2	5.0
55-60	0		3	7.5
61-65	1	2.5	3	7.5
66-70	0		8	20.0
71-75	0		4	10.0
76-80	0		4	10.0
81-85	0		3	7.5
86-90	0		1	2.5
91-95	0		2	5.0

The scores of students in the post-test were quite impressive. The modal mark was 70%. Eight (8) out of the forty Students got this mark. The least mark was 35% and only one student representing 2.5% of the sample size got that mark. Only eight Students representing 20% of the sample size scored below the average mark (thus 50%). This then suggests that 80% got above the average mark (see appendix table 7).

Comparing the scores of post-tests and pre-test it can be observed that the post-test is an improvement of the pre-test. The highest mark was 67% for the pre-test whiles the highest was 95% for the post-test. The lowest mark for the pre-test was 10% whiles the lowest mark for the post-test was 35%. The modal mark in the post-test was 20% whiles modal mark for post-test was 70%. It can also be observed that in the pre-test only 5% of the students scored the above average mark. This suggests that only 5% passed the pre- test. Unlike the pre-test, post-test had 80% of Students scoring above the average mark. (see appendix K).

Testing of Hypothesis with Respect to Research Question Two

Ho 2: Differentiated instruction will not improve SHS students' understanding of cell cycle.

Table 4: A descriptive Statistics table showing means of Tests scores

	N	Minimum	Maximum	Mean	Std. Deviation
scores for post- test	40	7.0	19.0	13.175	3.2335
Scores for pre-test	40	2.00	12.00	4.8500	2.30440

The difference between the mean scores of the post-test and pre-test was 8.3250. The standard deviation of the different scores is 4.42258. On the average, the post-test scores were 8.325 higher than pre-test scores (see Table 4). This means that there was a significant difference between the post-test and pre-test scores [$t=11.69$; $p>0.05$]. This meant that the null hypothesis was rejected. The findings support the assertion by

Tomlinson and Javius (2012) stated that DI improves understanding in Biology and is associated with helping students who are struggling

The mean score of the pre- test was 4.8500 whiles the mean of the post-test was 13.175. This means that generally, the intervention adopted, corrected the alternate concepts and improved the understanding of students.

When used by instructors, this teaching strategy promotes engagement, facilitates motivation, and helps students make the connection with what is being taught in the classroom to the things they value outside of class. When such connections are made, students tend to improve in their retention of the information (Santangelo & Tomlinson, 2009). The result from the post-test supports this assertion. The Differentiated Instruction greatly improved the understanding of the Students in Cell division.

4.2.3: Research Question three

RQ 3: What is the effect of differentiated instruction on students understanding by gender?

The intent of this research question was to find out if students‘ performance in cell division with differentiated instruction is gender-related. The performance of the females was slightly better than their male counterparts. There were more female in the higher ranges than females (Fig. 3). The higher ranges, namely; 17-20, 13-16 and 9-12 had 19 females and 17 males. The lower ranges namely 5-8 and 0-4 had 1 female and 3 males.

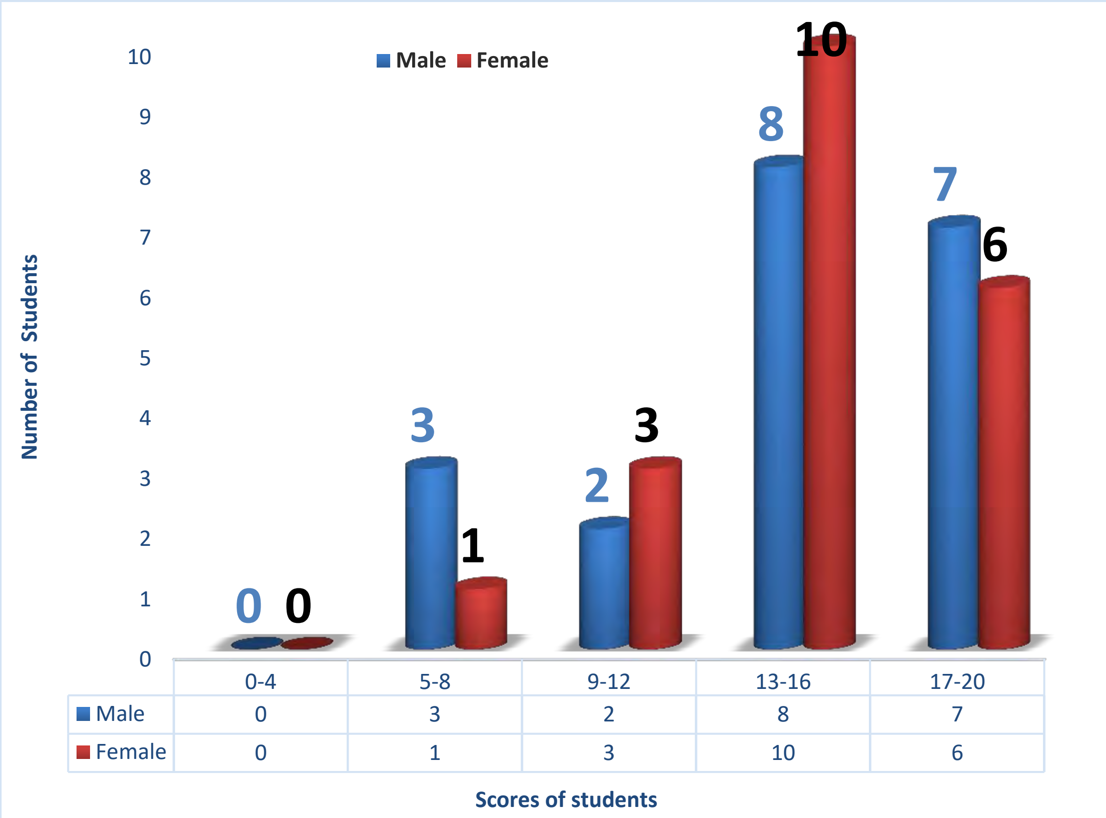


Figure 3: Graphical representation on Scores of males and females in Post-test

There was not much difference between the males and females. More males scored the highest mark range while than females more females scored the second highest range mark. The good thing was that no one scored zero to for marks (0-4). The average difference between the scores of males and females in the post-test and pre-test was 2.44. The standard deviation of the different scores was 3.87. On the average, the post-test scores were 2.44 higher than pre-test scores. The mean of the males (12.650) was less than the mean of the females (14.800). The mean difference was 2.4444 (Table 5). This then suggests that the females performed better than the males in the post-test.

Table 5: MS & SD of male and female tests scores

	Mean	N	Std. Deviation
Female scores for post-test	14.800	20	2.3974
Male scores for post-test	12.650	20	3.1668

Testing of Hypothesis with Respect to Research Question Three

In order to determine whether the difference in performance between the males and females were statistically significant, research question 3 was formulated into a null hypothesis and tested.

It was therefore hypothesised that:

Ho 3: Gender has no effect on differentiated instruction

There was no significant difference between the scores of males and females on the post-test [t=2.681; P> 0.05]. The null hypothesis was rejected. This means that gender has no effect differentiated instruction.

Table 6: A statistical table showing effect of Gender on post test scores

	Paired Differences					T	Df	Sig.
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Female scores for post-test - Male scores for post-test- females	2.444 44	3.8687 6	.91188	.52055	4.36833	2.681	19	.006

Aim of differentiated instruction is to promote adoption of more fruitful concepts by removing prior alternate concepts of students. The result from the post-test supports this assertion.

There is broad consensus among researchers in the education field that individuals should not be thought of as passive recipients of information during instruction, but rather that learners are active constructors of their own knowledge (Read, 2004). The differentiated instruction model involves each student and helps the student to better their performance.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the findings, conclusions deduced from the findings and recommendations proposed. The conclusions and recommendations drawn were focused on addressing the purpose of the study which was to determine if there was a significant improvement in the performance of students when Differentiated Instruction was used to teach the concept of Cell division.

5.1 Summary

The main objective of this study was to investigate if Differentiated Instruction (DI) will significantly improve the performance of students in cell division. To achieve this, the study employed the quasi-experimental study approach with the students of the Delcam Senior High School in the Adentan Municipality of the Greater Accra Region of Ghana as the case for investigation. In all, the census of forty students who happen to be the total number of form three science students was taken. A pre-test (SKMT) was answered by the students in order to obtain data for the first objective (which was to find alternate concept of the SHS students in Cell division. The data obtained revealed several alternate concepts in Cell division. The data from the pre-test was to answer the first research question of the study. The Differentiated Instruction was used.

The intervention that was employed in the implementation of differentiated instruction was the flexible grouping approach where the students were divided into six heterogeneous groups in the biology period and each group consisted of low achievers and average (and in some groups, high) achievers in order for the average (or high) achievers to support the low achievers during the differentiated activity. However, each group consisted of 6 or 7 students and they were grouped according to their abilities in a class consisting of 40 students. This cell division lesson was differentiated in terms of content and process.

After the teaching, a post-test (SAMT) was conducted by the researcher on the students and data obtained were to support the primary data in answering the second objective. Data from the post test was used to answer research question two. The post -test and pre-test were compared statistically to answer the second hypothesis.

Both the post-test and the pre-test were grouped according to the gender of the students. The males performed slightly higher than the females but there was no significant difference between the scores of the male and females in the pre-test.

The scores of the post and pre-test were compared statistically. The results of the post- test were higher than the pre-test. The difference between the two tests was statistically significant. Thus, Differentiated Instruction significantly improved the performance of students in Cell division.

The post test was categorised according to the gender of the students to check if the significant improvement was affected by gender. It was revealed that females did better than their male counterparts when the means of their scores were statistically compared. It was also observed that the difference was not statistically significant.

5.2 Conclusions

1. It was observed that Delcam SHS students had many alternate concepts in Cell division.
2. It was clear from the results that differentiated instruction improved the understanding of students in a large class.
3. It was also realized that gender had no significant effect on Differentiated Instruction
4. Achievement of males and females in both the post-test and pre-test were not significantly different. The students‗ achievement scores did not seem to be affected by the student‗s gender. This means that gender played no significant change students ‗performance in Cell division when differentiated instruction was employed as a method of teaching.

5.3 Recommendations

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

1. Innovative and more effective learner-centered instructional strategies, such as differentiated instructional packages, should be used by biology teachers to promote meaningful learning of difficult biology concepts like mitosis. Appropriate differentiated instruction packages should therefore, be developed or adopted for use in the Ghanaian school systems.
2. Since the findings of the study showed that students exposed to the differentiated instructional in cooperative learning settings performed better, learning settings, students should be encouraged to develop social interaction in the use differentiated instructional. This implies that biology teachers should model their instructions to enforce student – student interaction. This will further enhance students‗ understanding of difficult biology concepts like mitosis.

3. School authorities should organise regular workshops and in-service training sessions for biology teachers on the effective use of differentiated instructional packages to enhance the effective learning especially in cooperative learning settings in the classroom.

5.4 Limitations of the Study

The Researcher understands that all environments are inherently unique and does not claim that the findings of the study will necessarily be found in other environments was the study to be replicated somewhere else. The following can be considered as limitations to the study. The study was designed to focus on learning of cell division (mitosis) by SHS students. Thus, the findings may not be generalisable to cover the entire SHS elective biology syllabus.

Also, the study was intended to include all SHSs in the Adentan Municipality Area but was conducted in only one SHSs in the Adentan Municipality Accra. The findings must not be generalized to cover all the SHSs in the Accra Metropolitan Area.

5.6 Suggestions for Further Studies

In light of the findings of the study and their educational implications, the following suggestions are made for further research with respect to the use of differentiated instructional packages on biology at the SHS level:

- It is suggested that the study be replicated using differentiated instructional packages on other difficult biology concepts, such as, cellular respiration, genetics, chromosome theory of heredity and hormonal control of human reproduction, water transport in plants, protein synthesis, Mendelian genetics, meiosis, etc. This would also provide a basis for greater generalisation of the conclusions drawn from the findings of the study.

- Additionally, it is suggested that the study be replicated using larger samples to provide a basis for more generalisation of the conclusions drawn from the findings of the study about the effectiveness of differentiated instructional packages in the teaching and learning of mitosis.
- Also, it is recommended that a similar study should be conducted with larger samples using qualitative data from both teachers and students to find their attitudes towards the use of differentiated instructional packages on the teaching and learning processes and also the cause of the alternate concepts students carry.
- Finally, similar empirical studies should be carried out on the use of differentiated instruction on other science subjects and at different levels of science education to provide sound basis for the integration of differentiated instructional packages in science education in Ghanaian schools.

REFERENCES

Abimbola, I. O. (1998). Teachers' Perceptions of Important and Difficult Biology Contents. *Journal of Functional Education*, 1 (1), 10-21

Achilles, C., Krieger, J., & Sharp, M. (2003). School improvement should rely on reliable, scientific evicence. Why did "no child left behind" leave class behind? Anerican Association of School Administrators. New Orleans, LA: ERIC Document Reproduction Service No ED475011.

Addonizio, M., & Phelps, J. (2000). Class size ad student performance: A framework for policy analysis. Journal of education Finance, 26(2), 136-156.

Ahmmed, M., Sharma, U., & Deppeler, J. (2012). Variables affecting teachers' attitudes towards inclusive education in Bangladesh. Journal of Research in Special Educational Needs, 12(2), 132-140.

Ajaja, O. P. & Eravwoke, O. U. (2010). Effects of Cooperative Learning Strategy on Junior Secondary School Students Achievement in Integrated Science. University of Benin, Benin City, Nigeria. *Electronic Journal of Science Education*, 14 (1), 1-18. Retrieved March 29, 2010, from http://ejse.southwestern.edu

Allan, J., Clarke, K., & Jopling, M. (2009). Effective teaching in higher education: Perceptions of first year undergraduate students. *International Journal of Teaching and Learning in Higher Education*, 21(3), 362-372.

Allcock, S., & Hulme, J. (2010). Learning styles in the classroom: Educational benefit for planning exercise? Psychology Teaching Review, 16(2), 67-79.

Ary, D., Lucy, C. J. & Asghar, R. (2002). Introduction to Educational Research. USA: Wadsworth Group Press.

Altiboz, N. (2004). *9th Grade students' understanding levels and misconceptions about mitosis and meiosis.* J. Gazi Edu Faculty, 24(3): 147-157.

Amua-Sakyi, E. (2010). Teaching in universities in Ghana: The tensions and dilemmas. Ghana Journal of Education Teaching, 9, 141-149.

Ananga, E., & Tamanja, E. (2017). Managing the effects of large class sizes on qulity education in Ghana. Accra.

Baeten, M., Dochy, F., Struyven, K., Parmentier, E., & Vanderbruggen, A. (2016). Student-centred learning environments: an investigation into student teachers'instructional preferences and approaches to learning. Learning environments research, 19(1), 43-62. https://doi.org/10.1007/s10984-015-9190-5

Bafile, C. (2009). Different strokes for little folks: Carol Ann Tomlinson on differentiated instruction. Education World. Online. Retrieved from http://www.educationworld. com/a_issues/chat/chat107.shtml

Barron, A. E. & Orwig, G. W. (1997). New technologies for education: a beginner‘s guide, (3rd Ed). Englewood, CO: Libraries Unlimited, Inc.

Beam, A. (2009). Standards-based differentiation: Identifying the concept of multiple intelligence for use with students with disabilities. TEACHING Exceptional Children Plus, 5(4).

Beecher, M., & Sweeny, S. (2008). Closing the achievement gap with curriculum enrichment and differentiation: One School‘s Story. Journal of Advanced Academics, 19(3), 502-530.

Benbow, J., Mizrachi, A., Said-Moshiro, L., & Oliver, D. (2007). Large Class Sizes in the Developing World:What do we Know and What can we do? Educational Quality Improvement Programme (EQUIP 1) and USAID.

Berliner, D., & Biddle, B. (2002). Small class size and its effects. Educational Leadership, 59, 12-23.

Blatchford, P. B. (2011). Examining the efect of class size on classroom engagement and teacher-pupil interaction: Differences in relation topupil prior attainment and primary vs. secondary schools. Learning and Istruction, 21(6), 71-73.

Borich, G. D. (2004). Effective teaching method. (5th edn.), New Jersey: Pearson Merrill Prentice Hall.

Bonwell, C. C. & Eison, J. A. (1991). Active learning: Creating excitement in the classroom. ASHE-ERIC Higher Education Report No. 1. Washington, D.C.: The George Washington University, School of Education and Human Development

Bosworth, R. (2014). Class size, class composition and distributio achievement. Educatoion Econmics, 22:2, 141-165.

Bowgren, L., & Sever, K. (2010). Three steps lead to differentiation. Journal of Staff Development, 31(2), 44-47.

Brighton, C., Moon, T., & Huang, F. (2015). Advanced readers in reading first classrooms: Who was really ―left behind"? Considerations for the field of gifted education. Journal for the Education of the Gifted, 38(3), 257-293.

Brimijoin, K. (2005). Differentiating and high-stakes testing: An oxymoron? Theory Into Practice, 44(3), 254-261.

Brown, E. A. (2016). General principles and methods of teaching. Cape-Coast: Centre for Distance Education, UCC.

Brown, H. D. (2000). Principles of language teaching and learning, (4th ed.). White Plains, NY: Longman.

Bruning, R. H., Schraw, G. J., & Ronning, R. R. (1999). Cognitive Psychology and instruction. Upper Saddle River, New Jersey: Prentice-Hall.

Bulgren, J., Graner, P., & Deshler, D. (2013). Literacy challenges and opportunities for students with learning disabilities in Social Studies and History. Learning

Disabilities Research & Practice, 28(1), 17-27. doi: 10.1111/ldrp.12003

Callahan, E. (2018). Teacher aides: An alternative to small classes? In J. D. Finn, How Small Classes Help Teachers Do Their Best (pp. 131-174). Philadelphia: University Centre for Research in Human Development.

Callahan, C., Moon, T., Oh, S., Azano, A., & Hailey, E. (2015). What works in gifted education: Documenting the effects of an integrated curricular/instructional model for gifted students. American Educational Research Journal, 52(1), 137-167.

Carey, S. (2000). Science Education as Conceptual Change. Journal of AppliedDevelpmental Psychology, (21)1:3-19.

Carmichael, P., Driver, R., Holding, B., Phillips, I., Twigger, D., & Watts, M. (1990). Research on students‘ conceptions in science. Leeds, UK: Children‘sLearning in Science Research Group, University of Leeds.

Chien, C. W. (2012). Differentiated instruction in an elementary school EFL classroom. TESOL Journal, 3(2), 280-291

Chinn, C. A., & Brewer, W. (1993). The role of anomalous dad knowledge acquisition: A theoritcal framework and implication for science education. Review of Educational Research, 63, 1-49.

Chinchi, J., Yue, J., & Torres, K. (2004). Student as ―human chromosomes" in role-playing mitosis and meiosis. The Am. Bio.Teach., 66(1): 35-39.

Clark, D., & Mathis, P. (2000). Modeling mitosis and meiosis, a problem-solving activity. The Am. Bio. Teach., 62(3): 204-206.

Clinkenbeard, P. (2012). Motivation and gifted students: Implications of theory and research. Psychology in the Schools, 49(7), 622-630.

Cohen, L., Manion, L. & Morrison, K. (2008). Research Methods in Education. New York: Routledge.

Cooper, J. & Mueck, R. (1990). Student involvement in learning: Cooperative learning and college instruction. Journal on Excellence in College Teaching, 1, 68-76

Crim, C., Kennedy, K., & Thornton, J. (2013). Differentiating for multipleintelligences: A study of students‘ understandings through the use of aesthetic representations. Issues in Teacher Education, 22(2), 69-91.

Cosgrove, K.P., Mazure, C.M., & Staley, J.K. (2007). Evolving knowledge of sex differences in brain structure, function, and chemistry. Biological Psychiatry, 62, 847-855.

Dass, P. M., & Yager, R. E. (2009). Professional development of science teachers: History of reform and contributions of the STS-Based Iowa Chautauqua

programme. Science Education Review, 8(3), 99-111. De Jesus, O. (2012). Differentiated instruction: Can differentiated instruction provide success for all learners? National Teacher Education Journal, 5(3), 5-11.

Dentler, D. (1994). Cooperative learning and American history. Cooperative Learning and College Teaching, 4 (3), 9-12.

Di Biase, R. (2019). Moving beyond the teacher-centred/learner-centred dichotomy: implementing a structured model of active learning in the Maldives. Compare: *A Journal of Comparative and International Education*, 49(4), 565-583. https://doi.org/10.1080/03057925.2018.1435261

Dixon, F., Yssel, N., McConnell, J., & Hardin, T. (2014). Differentiated instruction, professional development, and teacher efficacy. Journal for the Education Of the Gifted, 37(2), 111-127.

Dotger, S., & Causton-Theoharis, J. (2010). Differentiation through choice: Using a think-tac-toe for science content. Science Scope, 33(6), 18-23.

Doubet, K. (2012). Formative assessment jump-starts a middle grades differentiation initiative. Middle School Journal, 43(3), 32-38

Dreyfus, A., Jungwirth, E., & Eliovitch, R. (1990). Applying the ―cognitive conflict" strategy for conceptual change—some implications, difficulties, and problems. *Journal of Science Education*, 74(5), 555-569.

Dukes, C., & Lamar-Dukes, P. (2009). Inclusion by design: Engineering inclusive practices in secondary schools. TEACHING Exceptional Children, 41(3), 16-23.

Durrheim, K. (1999). *Qualitative measurement. In M. Terre Blanche & K. Durrheim (Eds). Research in practise* (applied methods for social sciences), 72-77.

Etsey, K. (2005). Causes of low academic performance of primary school pupils in the Shama Sub-Metro of Shama Ahanta East Metropolitan Assemby (SAEMA) in in Ghana. In Proceedings of the Regional Conference on Education in West Africa. Accra.

Evans, D., & Popova, A. (2016). What really works toimprove learning in developing countries? An analysis of divergent findings in systematic reviews . The World Bank Research Observer, 31(1), 242-270.

Firmender, J., Reis, S., & Sweeny, S. (2013). Reading comprehension and fluency levels ranges across diverse classrooms: The need for differentiated reading instruction and content. Gifted Child Quarterly, 57(1), 3-14.doi:10.1177/0016986212460084

Fisher, R. (2001). Teaching children to learn. Chelttenham: Nelson Thornes Ltd. Glossary of education reform.

Fleming, T., Toutant, T., & Raptis, H. (2002). A class size and its effects: A review flashback. Phi Delta Kappa Educational Foundation, 497-500.

Flores, F., Tovar, M., & Gallegos, L. (2003). Representation of the processes in high school students: An integrated view. Int. J. Sci. Edu. , 25(2): 269-286.

Forlin, C., & Chambers, D. (2011). Teacher preparation for inclusive education Increasing knowledge but raising concerns. Asia-Pacific Journal of Teacher Education, 39(1), 17-32.

Gardner, H. (1985). Frames of mind: The theory of multiple intelligences. New York: BasicBooks

Gamoran, A., & Hannigan, E. (2000). Algebra for everyone? Benefits of college-preparatory mathematics for students with diverse abilities in early secondary school. Educational Evaluation and Policy Analysis,, 22(3), 241-254.

Gibbs, J. (2001). Tribes TLC A New Way of Learning and Being Together. Windsor: Center Source Systems, LLC

Glass , G., & Smith, M. (1978). Meta-analysis of research on the relationship of class-size and achievement. The class size and instruction project., ERIC Document Reproduction Service No. ED168129

Grubb, M. (2011). Predictors of High school student success in online courses. A Doctoral Thesis Presented to the Faculty of the College of Education, University Houston

Guillemette, Y. (2005, September 6th September, 2006). School class size: smalle isn't better. Retrieved from C.D. Howe Institute Web site: : http//www. cdhowe.org/pdf/commentary_215.pd

Hackman, K. (2002). Mathematics and statistics learning and teaching package. Weija-Accra: Polylink Research and Publication.

Handelsman, J., Houser, B. & Kriegel, H. (2002). Biology Brought to Life: A Guide to Teaching Students to Think Like Scientists. McGraw-Hill. ISBN 0-07 282389-5.

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R.,

Gentile, J., Lauffer, S., Stewart, J., Tilghman, S. M., & Wood, W. B. (2004). Scientific teaching. Science, New Series, 304(5670), 521-52

Helbench, E. (2001). Class Size Reduction, Education Leadership. United Kingdom: Harcourt Brace College Publishers.

Heffner, C. L. (March 11, 2004). Quasi-Experimental Designs. In Research Methods, ch. 5. egel, H. (2002). Biology Brought to Life: A Guide to Teaching Students to Think Like Scientists. McGraw-Hill. ISBN 0-07-282389-5.

Herrelko, J. (2013). A four-tier differentiation model: Engage all students in the learning process. Teacher Education and Practice, 26(3), 415-430.

Hewson, P. W. (1992) Conceptual change in science teaching and teacher education. National Center for Educational Research, Documentation, and Assessment, Madrid, Spai

Hewson, P. W. (1981). A conceptual change approach to learning science. Euopean Journal of Science Education, 3(4), 383-396.

Hewson, P. W. (1982). A case study of conceptual change in special relativity: Th influence of prior knowledge in learning. European Journal of Science Education, 4(1), 61-78.

Hewson, P. W. (1991). Conceptual change instruction. Paper presented at annual meeting, National Association for Research in Science Teaching, Fontana, WI.

High, J., & Andrews, P. (2009). Turning points 2000: Lessons learned. Middle School Journal (J3), 41(2), 58-63.

Hodges, T. & McTigue, E. (2014). Renovating literacy centers for middle grades: Differentiating, reteaching, and motivating. Clearing House: A Journal of Educational Strategies, Issues and Ideas, 87(4), 155-160. doi: 10.1080/00098655.2014.886550

Hoffman, J. (2002). Flexible grouping strategies in the multiage classroom. Theor Into Practice, 41(1), 47-52. doi: 10.1207/s15430421tip4101_8

Houtveen, T., & Van de Grift, W. (2001). Inclusion and adaptive instruction in elementary education. Journal of Education for Students Placed At Risk, 6(4), 389-409.

Hoxby, C. (200). The Effects of Class Size on Student Achievement: New Evidence from Population Variation. The Quarterly Journal of Economics,, 115(4), 1239–1285.

Joseph, S., Thomas, M, Simonette, G, & Ramsoook, L. (2013). The impact od differentation instruction in teacher education setting: success and challenges. Int. J. High Educ, vol. 2, no. 3, pp. 28-4

Johnson, D. W. & Johnson, R. T. (1999). Making Cooperative Learning Work. Theory into Practice, 38 (2), 67.

Johnson, D. W. & Johnson, R. T. (1985). Classroom conflict: Controversy versus debate in learning groups. American Education Research Journal, 22: 237-256.

Johnson, D. W. & Johnson, R. (1978). Cooperative, competitive, and individualistic learning. Journal of Research and Development in Education, 12: 3-15.

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1993). Cooperation in the Classroom. (6th Ed.). Edina, MN: Interaction Book Company.

Jones, J., & Hebert, T. (2012). Engaging diverse gifted learners in U.S. History classrooms. Gifted Child Today, 35(4), 252-261. doi: 10.1177/1076217512455476

Johnson, J. (2002). Will parents and teachers get on the bandwagon to reduce school size? Phi Delta Kappan, 83, 353-356.

Kahveci, N., & Atalay, O. (2015). Use of integrated curriculum model (ICM) in social studies: Gifted and talented students‘ conceptions. Eurasian Journal of Educational Research, 59(1), 91-111. doi: 10.14689/ejer.2015.59.

Karaduman, G., & Cihan, H. (2018). The effect of multiple intelligence theory on students‘ academic success in the subject of geometric shapes in elementary school. International Journal of Higher Education, 7(2), 227—233.

Kibuka-Sebitosi, E. (2007). Understanding genetics and inheritance in ural schools . J. Bio. Edu., 41(2): 56-61.

King-Sears, M. (2008). Facts and fallacies: Differentiation and the general education curriculum for students with special education needs. Support for Learning, 23(2), 55-62. doi: 10.1111/j.1467=9604.2008.00371.x

Kobelin, M. (2009). Multi-age made me do it: A teacher tackles differentiation in math instruction. Schools: Studies in Education, 6(1), 10-22.

Kombo, K. L., & Delno, L. A. (2006). Proposal and thesis writing: An introduction. Sidney: Paulines.

Konstantinou-Katzi, P., Tsolaki, E., Meletiou-Mayrotheris, M., & Koutselini, M. (2013). Differentiation of teaching and learning mathematics: an action research. International Journal of Mathematics Education in Science and Technology, 44:3, 332-349.

Kothari, C. R. (2004). "Research methodology,methods and techniques" second edition. New Age International Publishers.

Krieger, C. (2003). Class Size Reduction Project. London: McMillan.

Lecturers), A. (. (2009, April 6-9). School and Class size matters. Retrieved from atl.org.uk: http://www.atl.org.uk

Latz, A., & Adams, C. (2011). Critical differentiation and the twice oppressed: Social class and giftedness. Journal for the Education of the Gifted, 34(5), 773-789.

Lampe, J. R., Rooze, G. E. & Tallent-Runnels, P. (1998). Effects of cooperative learning among Hispanic students in elementary social studies. In Macmillan, J. H. & Wergin, J. F. (Eds) Understanding and evaluating educational research: New Jersey: Prentice Hall, 77-87.

Leedy, D. (1989). Plannning and design (4th ed). NewYork: Macmillan Publishing Company.

Leedy, P. D. (1997). Practical research: Planning and design (6th Ed.). Upper Saddle River, New Jersey: Prentice-Hall, Inc.

Lewis, J., Leach, J., & Wood-Robinson, C. (2000). Chromosomes: The missing link - young people‘s understanding of mitosis, meiosis and fertilisation. J. Bio Edu., 34(4): 189-199.

Lipson, M., & Wixson, K. (2012). To what interventions are students responding? Reading Teacher, 66(2), 111-115. doi: 10.1002/trtr.0111

Linn-Cohen, R., & Hertzog, N. (2007). ―Unlocking the GATE to differentiation: A qualitative study of two self-contained gifted. J. Educ. Gift., vol. 31, no. 2, pp. 227–259, 2007.

Logan, B. (2011). Examining differentiated instruction: Teachers' respond..". Res. High Educ., J., vol.13.

MacKeracher, D. (2004). Making sense of adult learning, (2nd ed.). Canada: Toronto: University of Toronto Press Incorporated.

Manning, S., Stanford, B., & Reeves, S. (2010). Valuing the advanced learner: Differentiating up. Cleaning House: A Journal of Educational Strategies, Issues and Ideas, 83(4), 145-149. doi: 10.1080/00098651003774851

Marabach-Ad, G., & Stavy, R. (2000). Students cellular and molecular explanations of genetic phenomena. J. Bio. Edu., 34(4): 200-205.

McAdamis, S. (2000). A district-wide plan for acceleration and enrichment. Gifted Child Today, 23(3), 20-27. doi: 10.1177/107621750002300307

McGee, G. (2004). Closing the Achievement Gap: Lessons From Illinois' Golden Spike HighPoverty High-Performing Schools. Journal of Education for Students Placed at Risk, 9:2, 97-124.

McNamara, D. (2001). Classroom pedagogy and primary practice. London: New Yok.

Menzler, K., Belke, M., Wehrmann, E., Krakow, K., Lengler, U., Jansen, A., Hamer, H.M., Oertel, W.H., Rosenow, F., & Knake, S. (2010). Men and women are different: Diffusion tensor imaging reveals sexual dimorphism in the microstructure of the thalamus, corpus callosum and cingulum. NeuroImage, 54, 2557-2562.

Meynert, M. (2014). Inclusive education and perceptions of learning facilitators of children with special needs in a school in Sweden. International Journal of Special Education, 29(2), 35-52.

Milesi, C., & Garmoran, A. (2016). Effects of class size and instruction on kindergarten achievement. Educational Evaluation and Policy Analysis, 28(4), 287-313.

Millis, B. J. & Cottell, Jr., P. G. (1998). Cooperative learning for higher education faculty. Phoenix, AZ: American Council on Education, Oryx Press.

Morgan, H. (2014). Maximizing student success with differentiated learning. Clearing House: A Journal of Educational Strategies, Issues and Ideas, 87(1), 34-38.

Newberry, S. (1999). Cooperative learning or individualized instruction: Which is best for computer-based instruction of the adult learner? University of South Florida, Tampa.

Ndia, L., Solihate, E., & Syahrial, Z. (2020). Teachers' perspectives on the use of differentiated instructionin inclusive classrooms: Implication for teacher education. International Journal of Higher Education, 9(6), 136—150.

Obakor, M., & Oguejioffor, C. (2020). Impact of Classroom Size on Academic Performance of Secondary School Students in Enugu North Local Government Area of Enugu State, Nigeria. African Journal of Educational Management, Teaching and Entrepreneurship Studies, 1(1) 1-9.

Ogbondah, L. (2010). Adequate funding of public universities in Nigeria for sustainable development. Africa Journal of Historical Sciences in Education, 6(2), 318-329.

Olayinka, A.-R. B. (2016). Effects of Instructional Materials on Secondary Schools Students' Academic Achievement in Social Studies in Ekiti State, Nigeria. World Journal of Education, 6(1), 32-39. https://doi.org/10.3102/01623737188198309

Oliver, F. (2016). ―Teachers' perspectives on differentiated instruction in the foreign language classroom.".

Oztas, H., Ozay, E., & Oztas, F. (2003). Teaching cell division to secondary school students: An investigation of difficulties experienced by Turkish teachers. J. Bio. Edu, 38(1): 13-15.

Park, S., & Oliver, J. (2009). The translation of teachers' understanding of gifted students into instructional strategies for teaching science. Journal of Science Teacher Education, 20(4), 333-351. doi: 10.1007/s10972-009-9138-7

Patterson, J., Conolly, M., & Ritters, S. (2009). Restructuring the inclusion classroom to facilitate differentiated instruction. Middle School Journal, 41(1), 46-52. doi:10.1080/00940771.2009.11461703.

Parveen, Q., Mahmood, T., Mahmood, A. & Arif, M. (2011). Effect of Cooperative Learning on Academic Achievement of 8th Grade Students in the Subject of Social Studies. International Journal of Academic Research, 3 (1), 1-5.

Pedder, D. (2006). Are small classes better? Understanding relationship between small class size,class room process and pupils' learning . Oxford Review of Education, 32(2), 231-234.

Pfundt, H., & Duit, R. (1991). Students‘ alternative frameworks and science education. Germany: University of Kiel: IPN Reports in Brief.

Philpott, D., Furey, E., & Penney, S. (2010). Promoting leadership in the ongoing professional development of teachers: Responding to globalization and inclusion. Exceptionality Education International, 20(2), 38-54.

Powers, E. (2008). The use of independent study as a viable differentiation technique for gifted learners in the regular classroom. Gifted Child Today, 31(3), 57-65. doi:10.4219/gct-2008-786

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a ScientificCoception: Toward a Theory of Conceptual Change. Science Education, 66, 211-227.

Posternak, M. A., & Miller, I. (2001). Untreated short-term course of major depression: A meta-analysis of studies using outcomes from studies using wait-list control groups. Journal of Affective Disorders, 66, 139–146

Read, J. R. (2004). Children's misconceptions and conceptual change in secience educatoion. NSW, 1-21.

Reis, S., McCoach, D., Little, C., & Kaniskan, R. (2011). The effects of differentiated instruction and enrichment pedagogy on reading achievement in five elementary schools. American Educational Research Journal, 48(2), 462-501.

Riemeier, T., & Gropengießer, H. (2008). On the roots of difficulties in learning about cell division: Process-based analysis of students conceptual development in teaching experiments. Int. J. Sci. Edu., 30(7): 923-939.

Roiha, A. S. (2014). Teachers view in differentiation in content and landguage integrated learning: perception, practice and challenges. Lang. Educ, vol. 28, no. 1, pp. 1-18.

Rakow, S. (2012). Helping gifted learners soar. Educational Leadership, 69(5), 34-40. Rubenstein, L., Gilson, C., Bruce-Davis, M., & Gubbins, E. (2015). Teachers‘ reactions to pre-differentiated and enriched mathematics curricula. Journal for the Education of the Gifted, 38(2), 141-168.

Rubin, M. (2012). Social class differene in social integrationamong students in higher education: A meta-analysis and recomendation for future research. Journal of Diversity in Higher Education, 5, 22-38.

Saka, A., Cerrah, L., Akdeniz, A., & Ayas, A. (2006). A cross-age study of the understanding of three genetic concepts: How do they image the gene, DNA and chromosome? J. Sci. Edu. Technol., 15(2): 192-202.

Santangelo, T., & Tomlinson, C. (2009). ―The application of differentiated instruction in postsecondary environments: Benefits,challenges, and future directions,". Int. J. Teach. Learn. High. Educ., vol. 20, no. 3, pp. 307–323.

Sax, L. (2005). Why gender matters: what parents and teachers need to know abouttheemerging science of sex differences. New York, NY: Doubleday.

Schmitt, C., & Goebel, V. (2015). Experiences of high-ability high school students: A case study. Journal for the Education of the Gifted, 38(4), 428-446.

Scott, P., Asoko, H., & Driver, R. (1991). Teaching for conceptual chang: a review of strategies. Resaerch in Physics Learning, 15(11).

Shadish, W.R., Cook, T.D. & Campbell, D.T. (2002). Experimental and Quasi-Experimental Designs for Generalized Causal Inference. New York: Houghton Mifflin Company.

Shuttleworth, M. (2008). Quasi-Experimental Design. Retrieved April 11, 2011, from Experiment Resources: hppt://www.experiment-resources.com/quasi-experimental-design.html

Seedorf, S. (2014). Response to intervention: Teachers' needs for implementation in gifted and talented programs. Gifted Child Today, 37(4), 248-257. doi: 10.1177/1076217514544029

Shah, R. (2019). Effective constructivist teaching learning in the classroom. Shanlax International , 7(4), 1—13.

Sharp, D. (2003). Summary of an analysis of pupil-teacher ratio and class size: Differences that make a difference and its implications on staffing for class-size reduction. Symposium presented to the Conference Within a Convention, American Association of School Administrators (AASA). New Orleans, LA: ERIC Document Reproduction Service No. ED476106.

Smith, D., & Tyler, N. (2011). Effective inclusive education: Equipping education professionals with necessary skills and knowledge. Prospect: Quarterly Review of Comparative Education, 41(3), 323-339. doi: 10.1007/s11125-011-9207-5

Stanford, P., Crowe, M., & Flice, H. (2010). Differentiating with technology. Teaching Exceptional Children Plus, 6(4), 1-9.

Starkey, L. (2019). Three dimensions of student-centred education: a framework for policy and practice. Critical Studies in Education, 60(3), 375-390. https://doi.org/10.1080/15391523.2016.1175856

Siam, X, & Al-Natour. (2016). "Teachers differentiated instruction practices and implementationchallenges for learning disabilitiesin Jordan". Int. Educ. Stud., vol. 9, no. 12, p. 167 .

Slavin, R.E. (1995). Cooperative learning; Theory, research, and practice. Boston, MA: Allyn and Bacon

Stenson, B. (2006). Programs and methods to improve reading comprehension levels of reading resource special needs students at Austin Road Middle School. *International Journal of Special Education*, 21(2), 37-46.

Stodolsky, S., & Grossman, P. (2000). Changing students, changing teachers. Teachers College Record, 102(1), 125-172.

Stringer, E. T. (1996). Action RESEARCH. London: SAGE: Publication.

Taber, K. S. (2001). The mismatch between assumed prior knowledge and the learners_ conceptions: A typology of learning impediments. Educational Studies, 27(2), 159-171.

Taber, K. S., & Coll, R. K. (2002). Towards research based practice. Chemical Education, 213-234

Tallman, J., & Tastad, S. (1998). Library Power: a potent agent to change in media. School Libraries Woorldwide, 4 (1),33-49.

Thorndike, L. (1996). Measurement and Evaluation in Psychology and Education. Columbus, OH: Prentice Hall.

Tieso, C. (2003). Ability grouping is not just tracking. Roeper Review, 26(1), 29-36.

Tomlinson, A. (2014). The differentiated classroom: Responding to the needs of all learners. Ascd.

Tomlinson, C. &. (1998). Teach me, teach my brain: A call for differentiated classrooms. . Educational Leadership, 52-55.

Tomlinson, C., & McTighe, M. (2006). Integrating differentiated instruction and understanding by design. Alexandria: Association for Supervision and Curriculum Development.

Tomlinson, C. (1999). The differentiated classroom: Responding to the needs of all learners. Alexandria, VA: Association for Supervision and Curriculu Development.

Tomlinson, C. (2005). Grading and differentiation: Paradox or good practice? Theory into practice, 44(3), 262-269. doi: 10.1207/s15430421tip4403_11

Tomlinson, C., Brighton, C., Hertberg, H., Callahan, C., Moon, T., Brimijoin, K., & Reynolds, T. (2003). Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. Journal for The Education Of The Gifted, 27(2-3), 119-145.

Tomlinson, C., & Doubet, K. (2005). Reach them to teach them. Educational Leadership, 62(7), 8-13.

Tomlinson, C., & George, P. (2004). Teaching high ability learners in an authentic middle school. Middle School Journal, 35(5), 7-11. doi: 10.1080/00940771.2004.11461444

Tomlinson, C., & Germundson, A. (2007). Teaching as jazz. Educational Leadership, 64(8), 27-31.

Tomlinson, C., & Imbeau, M. (2010). Leading and managing a differentiated classroom.Alexandria, VA: ASCD

Tomlinson, C., & Imbeau, M. (2012). Common Sticking Points: About Differentiation School Administrator, 69(5), 19-22.

Tomlinson, C., & Javius, E. (2012). Teach up for excellence. Educational Leadership, 69(5), 28-33.

Tomlinson, C., & Strickland, C. (2005). Differentiation in practice: A resource guide for differentiating curriculum, grades 9-12. Alexandria, VA: Association for Supervision and Curriculum Development.

Topley, B. (2010). Professional Development Implementation: Perceptions of Elementary and Middle-School Teachers and Administrators. ERIC.

Truscott, D. M. (2005). Differinf Circumstances, Shared Challenges. Finding Common Ground Between Urban and Rural School., 87(2), 123-130.

Tulbure, C. (2011). Differentiating instruction upon learning styles in higher education: A controversial issues. Bulletin of the Transilvania University of Braşov, 53(1).79-84.

Unlu, Y. (2014). Conceptual Change Texts orionted instruction in teaching solution concepts. Thesis submitted to the Graduate School of Natural and Applied Science of Middle East Technical University, pg. 30.

Ur, P. (1991). A course in language teaching. Cambridge. Cambridge: Cambridge University Press.

Van der Ploeg, P. (2013) The Dalton plan: Recycling in the guise of innovation. Paedagogica Historica: International Journal of the History of Education, 49(3), 314-329. doi: 10.1080/00309230.2012.725840

VanTassel-Baska, J. (2015). Common core state standards for students with gifts and talents. TEACHING Exceptional Children, 47(4), 191-198.

VanTassel-Baska, J., & Stambaugh, T. (2005). ―Challenges and possibilities for serving gifted learners in the regular classroom," . Theory Pract., vol. 44, no. 3, pp. 211–217.

Vermette, P., Harper, L., & DiMillo, S. (2004). Cooperative & collaborative learning...with 4-8 year olds: how does research support teachers' practice? *Journal of Instructional Psychology*, 31, 2,130.

Vosniadou, S. (1994). Capturing and Modeling for conceptual Change. Learning and Instruction, 4, 45-69.

Vygotsky, L. (1978). Mind and Society: The Development of Higher Mental Processes. Cambridge, MA.: Harvard: University Press.

WAEC (2020). WAEC Chief Examiners' Report. WAEC Press Ltd.

WAEC (2006). WAEC Chief Examiners' Report. WAEC Press Ltd.

Watts-Taffe, S., Laster, B., Broach, L., Marinak, B., McDonald Connor, C., & Walker- Dalhouse, D. (2012). Differentiated instruction: Making informed teacher decisions. Reading Teacher, 66(4), 303-314. doi: 10.1002/trtr.01126

Wieman, C. (2008). *Science education in the 21st century using the tools of science to teach science*. A summary of paper presented at the Forum's 2007 Aspen Symposium, British Columbia

Wojciechowski, A., & Palmer, A. (2005). Individual students characteristics: Can any be predictors of success in online classes. Portland, USA.

Wood, K., & Jones, J. (1998). Tips for teaching: Flexible grouping and groupretelling include struggling learners in classroom communities. Preventing School Failure, 43(1), 37-38.

Wu, E. (2013). The path leading to differentiation: An interview with Carol Tomlinson. *Journal of Advanced Academics*, 24(2), 125-133.

Yusuf, M. O. & Afolabi, A. O. (2010). Effects of Computer Assisted Instruction (CAI) on Secondary School Students' Performance in Biology. TOJET: The Turkish Online Journal of Educational Technology: 9 (1), 1-8.

Yelkpieri, D. (2009). The state of the university infrastructure and academic user facilities and their effects on teaching and learning in public universities in Ghana . The Social's Educator,, 4(1), 111-128.

Zahorik, J., Molnar, A., & Halbach, A. (2003). Teaching reduced-size classes: Lessons for teachers. In J. Finn & M. Wang (Eds.), Taking small classes one step further (pp. ix-xvi). Greenwich, CT: Information Age.

Zelenka, A. (August 8, 2010). Research and evaluation methods. In Experimental and quasi-experimental research designs. Retrieved from http://annezelenka.com/phd-topics/research-methods/

APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE EDUCATION

MASTER OF PHILOSOPHY IN SCIENCE EDUCATION

STUDENT KNOWLEDGE ON MITOSIS TEST (SKMT)

PRE-TEST

RESEARCH TOPIC:

USING DIFFERENTIATED INSTRUCTION TO IMPROVE SHS STUDENTS' UNDERSTANDING OF CELL DIVISION

Dear Student,

This study seeks to investigate if differentiated instruction will improve the understanding of students of the Delcam Senior High School in the Adentan Municipality of the Greater Accra Region of Ghana in cell division. The outcome of this study will help to improve the teaching and learning of cell division in Senior High Schools. Please note that this research is entirely for academic purposes and any information given would be very appreciated and treated with utmost confidentiality.

Name____________________ **Gender**_______________ **Date**________

Read these passages from the text and answer the questions that follow.

Questions

1. Would the human gender cell new (egg and sperm cell) contain the **same** or **different** genetic information of their parents (male or female)?..………………………………......

……………………………………………………………………………………………

2. What is the chromosome number of an organism?

a. 23 b. 46 c. 96 d. different for all organisms

3. Do you think plant and animal cells divide in the same way?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

4. In which phase does a cell spend most of its life? ……..

5. According to your knowledge if a cell divides via mitosis, how many new cells are produced?...

…………………………………………………………………………………………

…………………………………………………………………………………………

6. Genderual reproduction always involves two parents. True/False……………………………………………………………………………

…………………………………………………………………………………………

7. Briefly distinguish between chromosomes genes………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

8. In humans, females have ________ gender?..........................

(a) XY (b)XX (c)XO (d) YY

9. What is the genetic information of an organism before and after mitosis

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………1

0. Give one difference between the cell division in eukaryotes and prokaryotes

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE EDUCATION

MASTER OF PHILOSOPHY IN SCIENCE EDUCATION

STUDENTS ASSESSMENT ON MITOSIS TEST (SAMT)

POST-TEST

RESEARCH TOPIC:

USING DIFFERENTIATED INSTRUCTION TO IMPROVE SHS STUDENTS' UNDERSTANDING OF CELL DIVISION

Dear Student,

This study seeks to investigate if differentiated instruction will improve the understanding of students of the Delcam Senior High School in the Adentan Municipality of the Greater Accra Region of Ghana in cell division. The outcome of this study will help to improve the teaching and learning of cell division in Senior High Schools. Please note that this research is entirely for academic purposes and any information given would be very appreciated and treated with utmost confidentiality.

Name___________________ Date______________ Gender________

Please attempt all questions

1. Cell division is the same in prokaryotic and eukaryotic cells. True/False

2. Which cells undergo cell division?

(a) Prokaryotic cells only (b) eukaryotic cells only

(c) Cancer cells only (d) both prokaryotic and eukaryotic cells

3. Cancer is a disease that occurs when the ____________ is no longer regulated.

4. In which of the stages of mitosis does the centromeres divide?

(a) Prophase (b) Metaphase (c) Anaphase (d) Telophase

5. In bacterial cell division, the cell divides into two nearly equal halves. This process is referred to as:

(a) binary fission (b) mitosis (c) fusion (d) cytokinesis

6. Write whatever you know about cell division

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………..

7. How does cell division differ between animal and plant cells?

(a) Plant cells do not have centrioles

(b) Animal cells form a cell plate

© Animal cells do not have centrioles.

(d) Plant cells are always haploid

8 . Draw all the stages in Mitosis

APPENDIX C

MARKING GUIDE FOR PRETEST (SKMT) ITEMS

1. No, they half of the total number of the total genetic information of their parents **2 marks**
2. D. different for all organisms **2marks**
3. Similar but has a slight difference. The plant cell forms cell plate between the two daughter cells in mitosis whereas cell membrane forms a cleavage furrow in between two daughter cells. **2 marks**
4. Interphase **2 marks**
5. Two new cells **2 marks**
6. True **2 marks**

Genes	**Chromosomes**
Gene is located on the chromosome.	Chromosomes are the packed structure of a DNA with proteins.
Genes are not visible under the microscope.	Chromosomes are visible under the microscope
A single gene is a locus on a chromosome.	A single chromosome comprises of many genes.

7.

2marks for one correct answer

8. XX **2 marks**
9. It is doubled after mitosis **2 marks**

Prokaryotic cell division	Eukaryotic cell division
a. A relatively simple process	a. A complex process
b. Process is responsible for the production of new cells through binary fission	b. Process is responsible for the production of new cells through mitosis and meiosis
c. Occurs through binary fission	c. Occurs through mitosis and meiosis
d. DNA replication occurs inside the cytoplasm	d. DNA replication occurs inside the nucleus

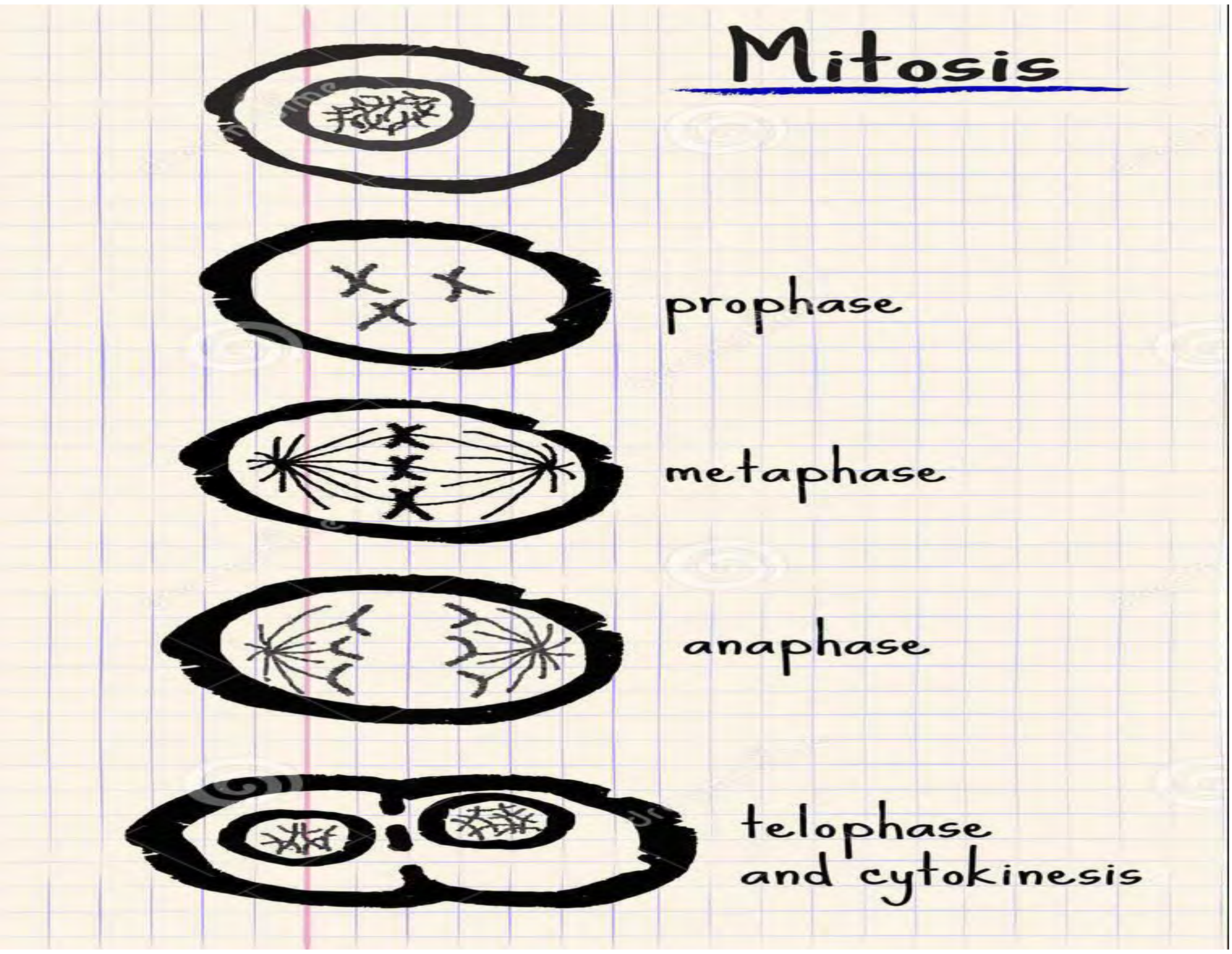
10.

2 marks for one correct answer

APPENDIX D

MARKING GUIDE FOR POSTTEST (SAMT) ITEMS

1.	True	2 marks
2.	D. Both prokaryotic and eukaryotic	2 marks
3.	Cell cycle	2 marks
4.	C. Anaphase	2 marks
5.	B. Mitosis	2 marks
6.	Any correct concept in mitosis	2 marks
7.	Animal cells form a cell plate	2 marks
8.	The stages of mitosis	6 marks
	Total	**20 marks**



APPENDIX E

STATION 1: WORD SORT

Instruction

1. As a GROUP sort out the following terms. HINT: Students are permitted to sort the terms in more than two categories. You are allowed to use you cell division notes.

2. Sorted terms must be copied on the paper provided

GROWTH

DUPLICATING CHROMOSOMES

PREPARATION

MEMBRANE DISAPPEARS

SPINDLE FIBRES

CENTRIOLES

EQUATOR

ALIGNMENT

PULLED APART

CENTROMERE SPLITS

OPPOSITE POLES

NUCLEAR MEMBRANE FORMS

CLEAVAGE FURROW

CELL PLATE

DAUGHTER CELL

APPENDIX F

STATION 2: STAGES IN MITOSIS

Introduction:

Examine prepared slides of an onion root tip to identify cells that are dividing. Since these slides are prepared, the cells were essentially frozen in time and students did not have the opportunity to watch a single cell divide from prophase to telophase. The onion root tip is an area of rapidly dividing cells. This means that there is a lot of growth in this area and rapidly dividing cells are usually smaller than cells in an area where no cell division occurs.

Procedure:

1. look at the four microscopes that are set up. Each microscope (numbered 1-4) has a pointer showing a different stage of mitosis.

2. In the observation section, you are to draw and title each of the phases available.

3. Label the chromosomes if they are visible.

4. State one or two reasons that helped you identify which stage of mitosis the onion cell is in.

HAND THIS IN FOR ASSESSMENT. DO NOT TOUCH OR ALTER THE MICROSCOPE SETTINGS!!!!

APPENDIX G

STATION 3: HOT POTATO

1. There ARE cells each showing a different stage of mitosis. Each group member should have 1 cell model in their hands before the music starts.

2. Select one group member as the DJ to start and stop the music.

3. DJ: must randomly start and stop the music.

4. When the music starts group members are to pass their cell models clockwise.

5. When the music stops, each member must identify which stage of mitosis their cell model is in and share the information with the rest of the group. Explain how you know which stage your cell model is in.

6. The process was continued for at least 5 rounds of hot potato

APPENDIX H

STATION 5: GRAB BAG

In the bag there are many terms that relate to mitosis.

1. Students are to sit in a circle.

2. One person draws a word or term out of the bag.

3. You must think of a sentence that has the word or term in it that relates somehow to Mitosis.

4. Group members discusses the sentence that was chosen.

5. Once everyone agrees that the sentence makes sense in relation to the term one group member recorded the sentence on the sheet of paper provided.

WORDS FOR THE GRAB BAG

CYTOKINESIS INTERPHASE CLEAVAGE FURROW

PROPHASE METAPHASE NUCLEARMEMBRANE

ANAPHASE TELOPHASE 23 PAIRS OF CHROMOSOMES

MOTHER CELL DAUGHTER CELLS SOMATIC CELL

CELL DIVISION SPINDLE FIBRES CYTOPLASM

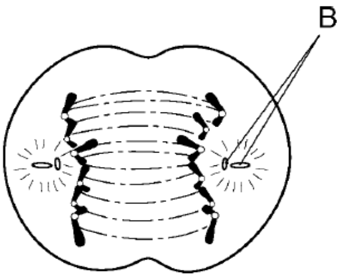
CENTRIOLES 46 CHROMOSOMES

APPENDIX I

STATION 6

1.

The cell in the diagram below illustrates a stage of mitotic cell division.



Letter *B* indicates the

A. paired chromosomes

B. centrioles

C. cell plate

D. endoplasmic reticulum

2.

Which two processes are involved in mitotic cell division?

A. nuclear duplication and cytoplasmic division

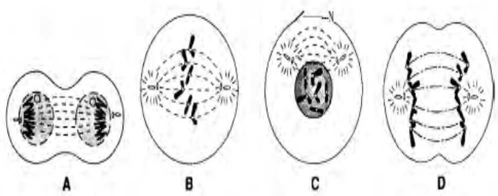
B. nuclear duplication and cytoplasmic duplication

C. spermatogenesis and cytoplasmic duplication

D. oogenesis and cytoplasmic division

3

The diagrams shown represent stages of a cellular process. Which is the correct sequence of these stages?



A. A → B → C → D

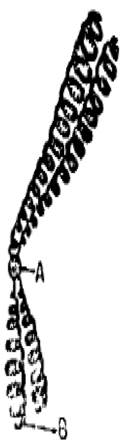
B. B → D → C → A

C. C → B → D → A

D. D → B → A → C

4

The diagram shown represents a microscopic structure observed during the process of cell division. Letter *B* indicates a



A. centrosome

B. spindle fiber

C. chromatid

D. cell plate

APPENDIX J

Table 6: Raw scores of Students

S/N	Gender	Pre-test	Post-test
1.	Male	4	19
2.	Male	4	9
3.	Male	2	9
4.	Male	6	19
5.	Male	4	12
6.	Female	12	12
7.	Male	10	11
8.	Female	8	8
9.	Male	4	11
10.	Male	4	14
11.	Male	8	9
12.	Male	4	13
13.	Male	6	13
14.	Female	2	17
15.	Male	8	8
16.	Male	8	14
17.	Male	4	18
18.	Male	2	8
19.	Female	4	12
20.	Female	2	17
21.	Female	4	13
22.	Female	8	14
23.	Male	6	9
24.	Male	6	16
25.	Male	4	16
26.	Male	4	10
27.	Male	6	7
28.	Female	2	14
29.	Female	4	14
30.	Female	4	15
31.	Female	4	15
32.	Female	6	14
33.	Female	4	10
34.	Female	2	14
35.	Female	4	16
36.	Female	2	14
37.	Female	4	17
38.	Female	4	16
39.	Female	6	15
40.	Female	4	15

APENDIX K

STATISTICAL TABLES

Table 7: A table showing descriptive statistics

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
scores for post- test	40	7.0	19.0	13.175	3.2335
Scores for pre-test	40	2.00	12.00	4.8500	2.30440

Table 8: Statistical table showing significant different between Tests

	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	Interval of the Difference				
				Lower	Upper			
scores for post- test - Scores for pre-test	8.3250	4.42248	.69926	6.91062	9.73938	11.906	39	.006

Table 9: A table comparing the performance in pre-test and post-test

	Pre-test	**Post-test**
Highest mark	60%	95%
Lowest mark	10%	35%
Modal mark	20%	70%
Percentage of those who scored average and above	5%	80%

Table 10: Paired Samples for male and female scores

	Mean	N	Std. Deviation	Std. Error Mean
Female scores for post-test	14.800	20	2.3974	.54316
Male scores for post-test	12.650	20	3.1668	.74645

Table 11: A statistical table showing effect of Gender on post test scores

	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Female scores for post-test - Male scores for post-test- females	2.44444	3.86876	.91188	.52055	4.36833	2.681	19	.006

Table 12: A descriptive Statistics table showing means of Tests for average achiever

	N	Minimum	Maximum	Mean	Std. Deviation
scores for post- test	33	8.0	14.0	10.70	3.2335
Scores for pre-test	33	8.00	10.00	8.33	2.30440

Table 13: A descriptive Statistics table showing means of Tests for high achievers

	N	Minimum	Maximum	Mean	Std. Deviation
scores for post- test	1	12.0	12.00	12.00	3.2335
Scores for pre-test	1	12.00	12.00	12.00	2.30440