THE EFFECTS OF AN INSTRUCTIONAL STRATEGY ON GRADE 11 LEARNERS' UNDERSTANDING OF GENETICS

SIMASIKU CHARLES SISEHO

A mini-thesis submitted in partial fulfilment of the requirements of the degree of

MASTER OF EDUCATION

(SCIENCE EDUCATION)

2004

School of Science and Mathematics Education

Faculty of Education

UNIVERSITY OF THE WESTERN CAPE

SUPERVISOR: PROF. MESHACH BOLAJI OGUNNIYI

Keywords

Constructivism

Conceptual change

Conceptions

Epistemology

Gene

Genetics

Instructional strategy

Prior knowledge

Scaffolding

Socio-cultural constructivism

Dedication

I present this work in memory of my late father SISEHO DANIEL SINVULA who wished to see this event, however, did not have the chance.

Certification

I hereby certify that Mr Simasiku Siseho in the School of Science and Mathematics Education, Faculty of Education, University of the Western Cape carried out this work.

Mr SIMASIKU CHARLES SISEHO

27.05.2005

DATE

PROFESSOR: MESHACH BOLAJI OGUNNIYI

30.05.2005

DATE

ACKNOWLEDGEMENTS

First and foremost I would like to thank Professor Meshach Bolaji Ogunniyi, for being an exemplary supervisor, facilitator, mentor and editor throughout every page of this study. Despite his busy schedule, he always provided me with advice and insightful questions that guided me as I explored the complex nature of research and thesis writing. Professor Ogunniyi has guided me from a neophyte researcher through the Master's programme with patience, persistence, encouragement and wisdom. He has given me enough freedom to pursue my interests while at the same time directing me to remain within the boundaries of rigorous research that will contribute to the knowledge base in science education. Professor Ogunniyi has encouraged a collaborative research environment from which I have greatly benefited. I would also like to thank Paul Wilton, Gilbert Dolo, Faiz Marlie and Hedwig Kandjeo-Marenga for the many hours of enlivened discussion and debate. The environment at the School of Science and Mathematics Education for postgraduate students is most conducive for intellectual stimulation and supportive companionship. I would like to thank Professor Cyril Julie for encouraging this environment and for the camaraderie over the year.

I am also grateful to the teachers and learners who have participated in this research and the principals who allowed me to enter their schools for the purpose of data collection. I should also thank all the academic staff members of the writing centre and those of the school of science and mathematics education whose names are many to mention, for proof reading and editing the typographical errors and language while working on my project paper especially the interpretation of the quantitative data and other statistical figures. I want to present my deep appreciation to the National Research Fund (NRF) for its generous financial support of my research study through Professor Ogunniyi, despite my being a foreign student. It would have been very difficult to cope without this support. However, the content of this report is solely my responsibility and not that of the NRF.

I would like to thank my mother, Ms Regina Kachana Mubita, for instilling in me a love of teaching and, most importantly, a love for learning. Thanks are also due to my cousin, Mr George Mubita and his wife, Patience Mubita, for giving me the necessary moral support

and encouragement throughout my Master's programme. My thanks also go to my elder brother Mr Nicksen Siseho for unwavering support and taking care of the village business and assets. I must also thank my dearest friend Mr George Troupe Jr. and his parents for the support and for the many hours when they listened to me talk about my research and for the ability to 'distract' and refresh my mind. Thanks to my parents and parents in-laws, brothers and sisters and in-laws whose prayers made me strong in completing this study. Also, my gratitude goes to my fellow countrymen and 'homeboys' namely, Mr Israel Maswahu, Mr Bernard Neo and Mr Innocent Kamwi for their moral support and their assistance during the period of data collection.

Last, but not the least, I am indebted to my wife, Mrs Gloria Mutimbwa Siseho, 'Banyina Tabo' and my young offsprings, Kachana Siseho, Tabo Siseho and Mumbone Siseho for their moral support and understanding during the long months of absence from home in the pursuit of this Master's degree. Over and above all, I give praises to the almighty God for this privilege and providence of life.

DECLARATION

I declare that **The Effects of an Instructional Strategy on Grade 11 Learners' Understanding of Genetics** is my own work, that it has not been presented for any degree in any other institution and that all the sources I have used or quoted have been indicated and acknowledged by means of references.

SIMASIKU CHARLES SISEHO

Abstract

Research into learning genetics has largely focused on issues such as problem solving and the process of meiosis. The central concept of genetics, however, has received very little attention despite the fact that it is one of the concepts that learners find difficult (Ogunniyi, 1999; Bahar, Johnstone and Hansell, 1999; Collins and Stewart, 1989). In view of this, the specific purpose of this study was to investigate: (1) concepts of genetics that grade 11 learners hold before and after a period of instruction in genetics (2) the differences in the understanding of genetics held by learners exposed to an instructional model and those not so exposed; and (3) possible influences of gender, age, and language on grade 11 learners' understanding of genetics. The method adopted for this study was a multidimensional approach in which both qualitative and quantitative approaches were used to complement each other. The role of the researcher in this study was that of the participant-as-observer. An induction workshop was conducted for both the combined instructional teacher (i.e. experimental teacher) and the traditional instructional teacher (i.e. control teacher) to help them explore and reflect on their practice with the view to create in them an appreciation for multiple teaching strategies or traditional teaching strategies to teaching and learning respectively.

Two schools and two teachers were used in this study. The instruments used in the study were pilot tested in a school with similar characteristics to the two schools used in the main study. The instruments used to generate data for the study include: Classroom Interactions Observation Schedule, Structured Interviews with teachers and learners, Genetics Achievement Test (GAT), a Cloze Test and Learner Worksheet. All the instruments were subjected to the rigour of triangulation to attain a high level of validity, reliability as well as credibility. The findings of this study amongst other things suggest differences in the interactions of behaviours of the experimental teacher and the control teacher. The control teacher tends to out-talk the learners while the experimental learners tend to out-talk their teacher. Also, the learners in the treatment group (experimental group learners) performed significantly better than those in the control group. The study was premised on the socio-constructivist epistemology, which construes the learning as knowledge construction based on one's interaction with the learning environment (Von Glasersfeld 1993; Mintzes and Wandersee, 1998). The constructivist epistemology does not assume that the learner enters into the science classroom *tabula rasa*. Rather, it assumes that the learner holds ideas and views about various phenomena based on prior experience with the environment.

TABLE OF CONTENTS

CHAPTER ONE
Introduction

CHAPTER TWO
Literature Review

CHAPTER THREE
Methodology

CHAPTER FOUR
Data Presentation, Analysis, Interpretation

CHAPTER FIVE
Conclusion, Implications and Recommendation

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

Abbreviation	Words written in full
C	Control (group/learners/teacher)
CTBS	Comprehensive Test of Basic Skills
E	Experimental (group/learners/teacher)
GAT	Genetics Achievement Test
GCIOS	Genetics Classroom Interaction Observation Schedule
IILTI	Individual Implicit Learning Theory Interview
LIP	Learner Interview Protocol
MER	Multiple External Representations
TIP	Teacher Interview Protocol

CHAPTER ONE

Introduction

1.1 Background

As a high school learner I found the study of genetics very fascinating and enjoyable. I thrived on doing investigations where I had to find out who in my family could roll their tongues, who had a "widow's peak", or who had attached earlobes and so on. It was interesting finding out things about my family and myself. My study of genetics has helped me to understand myself better and to gain insight into my shared inheritance. As a learner I was good at solving genetics problems because they were consistent and predictable. At the university, however, genetics became a little more difficult and confusing. It was reduced to estimating the locus of genes from the rate of crosses with other genes on the chromosome. Problems that were once rewarding to get right had become removed from the inheritance of characteristics in my family in which I had originally been interested. Nevertheless, we had several opportunities to examine various types of genetic combinations in a number of organisms. These practical activities, though rather arduous, have helped to sustain my interest in the subject.

As a teacher, I loved teaching genetics. One of the vivid memories was when my wife, a nurse, visited me during one of my afternoon classes. I was teaching a grade 10 Biology class then. The learners were laughing and chatting in anxious anticipation of the investigation we were about to conduct to find out the learners' blood groups. Of course, this was in the days when such investigations were still allowed. My wife came into my class to find out what all the excitement was about and I invited her to stay. She eagerly accepted.

During the pre-laboratory session, I demonstrated the use of sterile blood lancets and showed the learners how to prick a finger to get a few drops of blood to which they could add clotting agents to determine their blood group. Even though I had done this experiment many times before and knew it did not really hurt, I still felt my heartbeat quickening, as I was about to prick my own finger. The learner squirmed and groaned and my wife mocked them for their lack of stoicism. To my horror, one of the bold members of the class suggested that my wife should be the first to demonstrate

composure while inflicting a prick wound in her finger for the purpose of scientific endeavour. I did not expect that and I racked my brain to think of an excuse that would allow my wife to leave the class with her pride still intact. To my surprise, she swabbed her finger, picked up a blood lancet, removed the wrapper and without hesitation or sign of inhibition pricked herself and drew blood that would be enough for the entire class to do their experiments. My wife's blood was O positive. The learners worked out their blood groups and had become familiar with the A, B, AB and O alleles. I found such practical exercise on human blood groups was a good way of introducing ideas like multiple alleles to my learners. Such an exercise could serve as an effective way for studying more complicated concepts in genetics.

1.2 Motivation for the study

Ever since the Dutch colonists landed in 1652, "Blacks" and "Whites" have lived apart in South Africa. Long before the historic 1948 white elections, which gave the Nationalist Party power, there was a system of segregation and unequal education in South Africa. While white schooling was free, compulsory and expanding, black education was sorely neglected. The blacks schools were under-funded and lacked essential facilities, qualified teachers and infrastructures for the swelling urban population. Prior to 1948 there was not much mixing between White and Black learners in schools (Amukugo, 1993). The Bantu Education Act of 1953 was designed to create an entirely separate educational system for African learners. According to Hendrick Verwoed, the Minister responsible for education at the time, the purpose of 'Bantu' Education was to adapt and prepare Africans for the subordinate role, which they could expect to play in a white community. According to a report in an Afrikaans newspaper 'Die Burger' (as cited by Cross, 1992), Verwoed had the following to say on equality:

> *"When I have control of 'Native' education, I will reform it so that the 'Natives' will be taught from childhood to realize that equality with Europeans is not for them" (Cross, 1992:23).*

Bantu Education Act No. 47 of 1953 was intended to separate black South Africans from the main, comparatively very well resourced education system for whites. Blacks were not allowed to attend school after 14 years except with the express permission of a high-class white person, usually to make a good slave. The schoolwork they were given was of a strikingly different syllabus to the whites and they had far lower expectations

(Amukugo, 1993). An example of how blacks were restricted was that they would be allowed to hammer a nail but would not be allowed to use the claw of the hammer to extract a nail, which was considered to be more refined work for more intelligent whites. In the apartheid system, amenities were all separated: beaches, hospitals, toilets, schools, and almost everything (Kallaway, 1984). Blacks were allowed into white churches only to clean them but not to pray in them. Under no circumstances were the black people allowed to make use of the white amenities. Even if a black child was run over by a truck, and the closest black hospital was an hour's drive away while the white hospital was just around the corner, the child would not be admitted.

Verwoed (then Minister of Native affairs, who later became Prime Minister) was tasked with the compilation of a curriculum that suited the "nature and requirements of the black people". African learners were to be educated in a way that was appropriate to their culture. No consultation occurred on this matter (Amukugo, 1993). All the definitions of culture, appropriate education content and levels, all the decisions about purpose and outcomes of the system were controlled by the apartheid government. Its stated aim was to prevent Africans receiving an education that would lead them to aspire for positions they would not be allowed to hold in society. Instead, Africans were to receive an education designed to provide them with skills to serve their own people in the Bantustans 'homelands' or to work in manual labour jobs under white control (Cross, 1992).

Over the years, the races got even more segregated, having isolated territories. The whites felt they were far superior to the black people in every way. They took slaves from black communities, and just dominated the race entirely. This disgraceful treatment was not without opposition from within the white race itself. These few people fought (unsuccessfully) for black rights. Eventually, this led to interracial relationships (Amukugo, 1993). Children born of these relationships were known as "coloureds" and were regarded with shame as little better than blacks themselves. They were perplexed in a fix because they were never truly accepted into the black or white communities. In a similar predicament were the Indian peoples, brought over by the British from their colonies. These were treated with only a tiny bit more respect, and their plight in the 1950s went mostly unrecognized. This study is delimited in the Western Cape province

predominantly inhabited by the whites, coloured and Indian communities because of the legacy of the past.

Though Bantu Education was designed to deprive and isolate blacks from 'subversive' ideas, indignation of being given such 'gutter' education became a major focus for resistance, most notably in the 1976 Soweto uprising. In the wake of this effective and clear protest, some reform attempts were made, but it was a case too little, too late (Cross, 1992). This cornerstone of apartheid ideology wrecked havoc on the education of black people in South Africa, and disadvantaged millions for decades. Its devastating personal, political and economic effects continue to be felt and wrestled with today. The black people were made to suffer in this regime for a total of 46 years before Apartheid ended.

Since this study was carried out in the Western Cape Province in South Africa, I thought the opinions of experienced high school biology teachers in Cape Town schools and Atlantis about biology topics found most difficult to teach and learn in biology would provide a better understanding to this study. All the teachers interviewed without exception indicated that genetics was one of the most difficult topics to teach or learn. Further, I explored the new biology syllabus to determine how much space of time was given to the study of genetics. From the scheme of work perused from four different schools in North Metropole, genetics lessons should not be fewer than 20 teaching periods. The grade 11 syllabuses in use in South African schools are common for all schools. It is quite explicit in what it requires learners to be taught and what skills need to be developed. Also, in an earlier study Ogunniyi (1999) explored the views of 95 randomly selected grade 7-9 learners on concepts of genes, mitosis and chromosomes respectively and found that only 17%, 4% and 15% respectively expressed familiarity with genes, mitosis and chromosomes.

My contention was that if learners did not understand the basic structure and especially the functioning of genes, it would be unlikely for them to understand genetics and related concepts and generalizations. Of central importance in this regard are questions such as: What conceptions of the gene do grade 11 learners hold? How capable are the learners in applying the understanding of the concept in solving genetics problems? Before discussing the issues implied by these questions, it is appropriate to provide a brief historical background to the study of genetics.

Genetics emerged as a new scientific discipline in the early 20th century revolutionizing people's thinking and understanding about heredity and reproduction. According to Kindfield (1992), classical genetics established the foundations upon which modern molecular biology has been built. She sees genetics "not as one of many branches of biology but more as the central organizing feature of biology that has relevance in all sub-disciplines and can be studied at all levels of organization" (p.39). Her contention is that an understanding of the theories and concepts of genetics is necessary for fundamental understanding of the discipline of biology as a whole and essential for some associated aspects of biology such the theory of evolution, adaptations, populations and ecology. However, research has shown that, even after instruction, learners often hold conceptions about genetics that differ significantly from the scientific valid viewpoint (Brown, 1990; Clough and Wood-Robinson, 1985; Hackling and Treagust, 1984; Hildebrand, 1985; Kindfield, 1994; Smith, 1991; Wood-Robinson, 1994).

One of the most significant findings of these studies is that learners often do not understand the process of meiosis or the concept of the gametes as haploid cells, which carry the genetic information to the offspring. The related notion that the sperm and the egg both contribute information relevant to the determination of the phenotype of each feature of the offspring is also not well understood by most learners. For example, Deadman and Kelly (1978) investigated what high school learners understood about evolution and heredity before they were taught these topics. They found that while the learners "had a firm idea of heredity as the transmission of characteristics from one generation to another, still their understanding was shallow" (p. 10).

Kargbo, Hobbs and Erickson (1980) found that "from age seven to 13, learners have a large number of novel ideas about the nature and the mechanism of inheritance" (p. 145). They further suggested that a considerable number of children "believe that environmentally induced characteristics, such as a missing finger, can be transmitted to offspring under certain circumstances" (p.137). Clough and Wood-Robinson (1985) came to similar conclusions that many learners of all ages believe that acquired characteristics are inherited, although the results suggest some improvement in understanding with age.

Hackling's and Treagust's (1984) work is similar to those carried out by Deadman and Kelly (1978), Karbo et al. (1980), and Clough and Wood-Robinson (1985) in that it scrutinizes learners' conceptions after a ten-week genetics course. They found that

inheritance of acquired characteristics was believed by only 13% of the 10-year-old learners after instruction and that 40% of the learners understood that such features were not inherited. Features of young people's understanding of inheritance described in the literature by Wood-Robinson (1994) include the widespread belief that plants do not reproduce sexually, that there is an unequal contribution by the parents to the features of the offspring and that the belief in the inheritance of the acquired characteristics is common. It is against this background that this study was construed.

1.3 Research problem

Research into young people's understanding of genetics has perhaps been more documented than any other aspect of the biological sciences. Despite this, however, Bahar, Johnstone, and Hansell (1999) have reinforced the difficulties that learners experience with concepts in genetics. Indeed, most of these studies (see, for example, reviews of the literature by Wood-Robinson, 1994; 1995) have focused on children's understanding of inheritance rather than genetics. The fact that learners themselves have admitted that they have difficulties with the concepts of genetics has been further confirmed by Bahar et al. (1999). They found that meiosis, gametes, alleles, and genes and genetic engineering, along with monohybrid and dihybrid crosses and linkages, were topics that learners found difficult.

Though the concept of genetics is reasonably well articulated in most biology textbooks, it is quite clear that the concept is not always taught in a coherent and successful way (Department of Education and Science, 1991). There are also difficulties when it comes to the translation of the curriculum into teaching. Areas such as growth, cell structure and functioning, cell division, gamete formation, sexual and asexual reproduction, inheritance, and genetics are often taught at different points in the school year or even in different years. It is therefore hard for learners to see the coherent thread that unites these areas. Whatever the case, it must be admitted that genetics is a biological concept which most learners find difficult. In view of this, it seems necessary to devise ways to present the concept in a clearer and concise manner for the learners.

One way to facilitate learners' understanding of genetics is to use relevant illustrations, models and analogies. Another way is to situate the tasks within the learners' life experiences. Whatever the drawbacks of these approaches, the ultimate goal should be to