INTEGRATION OF KNOWLEDGE OF SYSTEMATICS IN THE TEACHING OF POPULATION STUDIES AND BIODIVERSITY TO GRADE 11 LIFE SCIENCES LEARNERS

By

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DECLARATION

I, Eddie Michael Morrison, declare that this work is entirely my own and it is original. All the work of others and sources that I have used or quoted have been indicated and acknowledged by means of references. The material contained in this report has not been previously submitted at this university or any other educational institution for degree purposes.

STUDENT'S SIGNATURE: ______________________________

DATE: _____________________

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ABSTRACT

The implementation of the National Curriculum Statement in 2006 saw the name of the subject known as Biology change to Life Sciences accompanied by changes in subject content. The curriculum committee excluded systematics as a separate unit from the new outcomes-based Life Sciences curriculum for grades 10 to 12 that was implemented in 2006. Educators had to include aspects of systematics in teaching these concepts without guidance from the curriculum. This posed the question whether mastery of population dynamics and biodiversity is dependent on content of systematics in the context of the new curriculum. The New Content Framework for Life Sciences implemented in 2009 reintroduced systematics as a single unit. This raised the question why systematics has been reintroduced in the Life Sciences curriculum. This study aims to determine the influence the exclusion of systematics as a separate unit from the Life Sciences curriculum, implemented in 2006, had on the teaching of population studies and biodiversity.

Data was gathered by evaluating and analysing the relevant curriculum statements, work schedules and content frameworks. Semi-structured interviews were conducted, first in 2008 when systematics was excluded from the curriculum and then in 2009 after the reintroduction. The first interviews dealt with the exclusion of systematics and the second interviews queried the reintroduction of systematics in the New Content Framework. Interviews were conducted with grade 11 Life Sciences educators at two secondary schools and two curriculum developers involved in compiling the Life Sciences curriculum. An expert in systematics and another in ecology were interviewed about the exclusion of systematics. The workbooks of some grade 11 learners were studied. Classroom observations were conducted when the relevant topics were being covered in class.

A number of reasons for the exclusion of systematics from the NCS were advanced. These included: there was no population dynamics expert in the curriculum development team, emphasis was placed on outcomes and not content, the academic background of the

members of the curriculum team and the difficulty of teaching systematics, perceived to be uninteresting. There was disagreement whether systematics is essential for understanding population dynamics but there is consensus that the study of systematics influences biodiversity and its exclusion left a regrettable void. However, systematics should be taught in a more interesting way. Prior knowledge is important for understanding of certain processes and concepts as well as for the application of practical skills like problem-solving and scientific inquiry. The curriculum does not provide detailed guidance on the content and practical activities to be covered and educators are encouraged to develop their own curriculum and activities. Experienced educators with strong academic backgrounds in animal and plant sciences referred to or used knowledge of systematics in some lessons. In 2009, systematics was reintroduced in the Life Sciences curriculum to ensure that learners understand biodiversity and evolution through natural selection. It provides learners a better foundation to understand similarities and differences in the structure and function of different organisms and body plans and ensures that they use higher-order thinking skills when doing problem-solving and scientific inquiry activities.

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LIST OF KEY WORDS

Systematics

Biodiversity

Population dynamics

Population studies

Substance

Syntax

National Curriculum Statement for Life Sciences

New Content Framework for Life Sciences

Curriculum change

Work schedule

Prior knowledge

LIST OF ABBREVIATIONS

GET – General Education and Training

FET – Further Education and Training

C2005 – Curriculum 2005

NATED 550 – *A Résumé of Instructional Programmes in Public Schools, Report 550*

NCS – National Curriculum Statement (implemented in 2006)

LO – Learning outcome

SAFCERT – South African Certification Council

Naptosa – National Professional Teachers Organisation of South Africa

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1.1 Introduction and background

1.1.1 Introduction

We are living in an ever-changing world, where the only constant is that things will change. Similarly, curricula need to adapt to the challenges that these changes pose in politics, economics, science, technology and in general. Changes are occurring worldwide in education and the focus of this research will be on curriculum change in science, specifically Life Sciences within the South African context. After the 1994 elections the main focus in education has been on the development and implementation of a new curriculum in our schools from grade R to grade 12. The Department of Education (2005a:5) puts it as follows:

> "With the opening up of the political and economic space in 1990 and the installation of a democratically elected government in 1994, the scene was set for a non-racial, non-sexist and democratic system of further education and training."

The content-based education system used in schools prior to 1994 was replaced by an outcomes-based education (OBE) system. The approach in this system is learner-centred and the focus is on learning outcomes which must be achieved. According to the National Curriculum Statement (Department of Education, 2005b:2), the development of this new curriculum for the school system was necessary due to global changes and the demands of the 21st century (learners need to be exposed to different levels of skills and knowledge) because South Africa has changed (new values and principles need to be reflected in the curriculum of the schools).

1.1.2 Background to the Life Sciences curriculum

While the national education department began to explore these new approaches to education, an interim curriculum (NATED 550 - *A Résumé of Instructional Programmes* *in Public Schools, Report 550*) (Department of Education, n.d.) was introduced. "The biology interim curriculum was the old core syllabus – highly structured and outdated and had not kept pace with new developments in the biological/life sciences, but in the new century a curriculum committee was appointed to develop a new 'outcomes-based' Life Sciences curriculum" (Doidge, Dempster, Crowe and Naidoo, 2008:1). This new curriculum is known as the National Curriculum Statement (NCS) Life Sciences curriculum (Department of Education, 2003) implemented in 2006.

Black and Atkin (1996:35) have commented that educational goals for sciences are changing and the result is a conception that draws attention to the actual and everyday connections between scientific knowledge on the one hand and human needs on the other. The three broad and interrelated changes Black and Atkin (1996:32) found among the 23 curricula they studied were:

- the importance of practical work for learners
- emphasis placed on connections, both between the sciences and between the sciences and other fields of study; and
- science pursued as a way of knowing how the world works or manifests itself

These directions of change are also envisaged within the South African NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 in the Further Education and Training (FET) phase.

1.1.3 The development of the NCS Life Sciences curriculum implemented in 2006

The National Curriculum Statement (Department of Education, 2005b:2) asserted that the first version of the new curriculum for the General Education band, known as Curriculum 2005 (C2005), was introduced into the Foundation Phase in 1997, however the concerns of educators and others led to a review of the curriculum in 1999. The review of C2005 provided the basis for the development of the Revised National Curriculum Statement for General Education and Training Grades R-9 (Department of Education, 2002) and the

National Curriculum Statement for Further Education and Training Grades 10-12, that includes the NCS Life Sciences curriculum (Department of Education, 2003).

With the implementation of the National Curriculum Statement, name changes as well as changes in the content of learning areas occurred. This research focuses on one name change and its concomitant content change, in the subject formerly known as Biology. The new grade 10 Life Sciences curriculum was implemented at the beginning of 2006 and the content of the new grade 11 and 12 curricula were made available in the form of the Curriculum Statement. Four strands (themes) were used in the FET phase, namely:

1) Tissues, Cells and Molecular studies;
2) Structure, Control and Processes in Basic Life Systems;
3) Environmental Studies; and
4) Diversity, Change and Continuity.

The same three learning outcomes were used in the new Life Sciences FET band as in the General Education and Training (GET) band for Natural Sciences. These outcomes are:

"**Learning outcome (LO) 1** – Scientific inquiry and problem-solving skills
The learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem-solving, critical thinking and other skills.
Learning outcome (LO) 2 – Construction and application of Life Sciences knowledge
The learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.
Learning outcome (LO) 3 – Life Sciences, Technology, Environment and Society
The learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in the Life Sciences, and the interrelationship of science, technology, indigenous knowledge, the environment and society" (Department of Education, 2003:12).

Doidge, Dempster, Crowe and Naidoo (2008:2) have indicated that these outcomes corresponded with current thinking in many countries on appropriate science education and that the new movement in science was for science teaching at school level to be relevant to all learners, not just to those intending to make a career of it. Learning outcome 2 formed the central framework to which learning outcomes 1 and 3 are linked, however "the content framework was described in broad terms, especially outcomes 1 and 3 to ensure that the notion of content doesn't count is followed" (Doidge, Dempster, Crowe and Naidoo, 2008:2).

A detailed table that outlines all the changes that occurred in the FET phase with the implementation of the grade 10 Life Sciences curriculum in 2006 will be presented and discussed later in Chapter 5. Importantly, the changes included more content related to learning outcome 3 within each strand, for example biotechnology, dialysis machines, cloning, transplants and genetically modified foods. Doidge, Dempster, Crowe and Naidoo (2008:3) commented on this aspect by stating that there was enthusiasm for a much reduced and more manageable curriculum that introduced modern biotechnologies and had a greater focus on the application of content.

This researcher's concerns regarding the changes in the NCS Life Sciences curriculum (Department of Education, 2003) are discussed in the next section. It must be noted that in 2009 a New Content Framework for Life Sciences (Department of Education, 2007a) was implemented for grade 10. This latest version of the Life Sciences curriculum reintroduced systematics into the FET curriculum (see Appendix A).

1.1.4 Concerns regarding the content of the NCS Life Sciences curriculum implemented in 2006

Three major concerns regarding the new Life Sciences curricula are addressed in this thesis. These are the exclusion of systematics as a separate unit from the Life Sciences curricula, the interpretation of the curricula by the educators and the shifting of the content between the grades in the FET phase.

Although the Life Sciences curriculum is based on the three learning outcomes and not on content, the content is described in broad terms. A major concern is that systematics was removed as a separate unit from the NCS Life Sciences curriculum (Department of Education, 2003) in the FET phase. The lack of systematics could severely influence the successful teaching of other parts of the curriculum. In the past the inclusion of systematics enabled effective teaching of other concepts. However, it is noteworthy that the nature of the curriculum provides freedom to the educators, Life Science facilitators, textbook publishers and other materials developers to interpret the nature and extent of the content to be covered (Doidge, Dempster, Crowe and Naidoo, 2008:3). Systematics has to do with the classification of organisms into groups according to their characteristics. Such classifications also reflect the different levels of development from primitive to more developed organisms and can be used to identify where these organisms fit in an ecosystem and the effects they have within an ecosystem.

The grade 10 curriculum includes content on the biodiversity of plants and animals and their conservation. The grade 10 work schedule, which gives a more detailed breakdown of the requirements for the four strands, includes the following topics: statement of the five-kingdom classification, explanation of the need for classification, mention of different systems of classification of life forms and use of examples, illustration of the general characteristics of each kingdom. The grade 11 curriculum includes a section on management of populations. The work schedule describes this as managing populations in terms of biodiversity of plants and animals and their conservation, significance and value of biodiversity to ecosystem function and human survival, threats to biodiversity and diseases. In grades 10 and 11, the aforementioned content is included in the Diversity, Change and Continuity strand. However, in grade 11 viruses, bacteria, protists and fungi are included in the Tissues, Cells and Molecular Studies strand. This part is a fragment of systematics, because it only describes these organisms (viruses, bacteria, protists and fungi) and not the plant and animal kingdoms. The grade 12 content in the Diversity, Change and Continuity strand focuses on evolution.

The grade 10 Life Sciences educator only needs to ensure that learners can name the five-kingdom classification – no details are required. Simply stating a five-kingdom classification does not give learners an idea of the dynamic nature of classification, for example there are domains which represent a higher taxonomic group than kingdoms. Woese, Kandler and Wheelis (1990:4576) have proposed that a formal system of organisms be established in which a new taxon, called a "domain", exists above the level of kingdom. Their proposal contends that:

> "Life on this planet would then be seen as comprising three domains, the Bacteria, the Archaea, and the Eucarya, each containing two or more kingdoms. The Eucarya, for example, contain Animalia, Plantae, Fungi, and a number of other yet to be defined" (Woese, Kandler and Wheelis, 1990:4576).

Changes in classification reflect the changing nature of science, which does not have a fixed knowledge base. The latter statement can be aligned to the grade 11 Life Science work schedule and curriculum in which one of the guidelines under learning outcome 3 is "History and the nature of science" (Department of Education, 2003:40; 2007b:37). Furthermore, the content of animal and plant systematics can be used to help learners understand the geographic distribution of certain animals and plants and their trophic-level positioning within the ecosystem. Examples of adaptations to climate, environment and other resources could also be useful in understanding biomes and ecosystems.

As the study of biodiversity forms part of the grades 10 and 11 Life Sciences curricula, learners will need to understand why there are different species, how they relate to each other and what their importance is. According to Woodland (2000:3), one of the main purposes of systematic botany is to attempt to understand the great diversity within the botanical world. For instance, some plants are pioneers, whereas others provide shade for other plants. This purpose of systematics is not limited to plants and is applicable to all groups of organisms. When looking at the different organisms within a certain area, each of the different types of organisms is fulfilling a certain function. Certain animals survive in certain biomes due to their characteristics and the environmental features within that area. Clearly, knowledge of animal and plant systematics will make this easier to grasp and more comprehensible for the learners. Moreover, the relationships between biodiversity and systematics will become clearer to learners. Learners will benefit more if educators use the prior knowledge of the learners as a point of departure on which to build new knowledge.

Apart from biodiversity, another concept related to systematics is population dynamics. Population dynamics, which forms part of the grade 11 curriculum, is referred to as population studies in the curriculum. Population dynamics refers to changes in population numbers and the reasons for the decline or increase in these numbers. This could be due to immigration, emigration, natality, mortality, predation, habitat destruction, competition or inability to adapt to changes, to name a few. Knowledge of systematics can be applied to determine whether and which of the aforementioned factors has caused a fluctuation in specific population numbers. Knowledge of the characteristics associated with certain groups of animals (systematics) will help learners to determine whether the fluctuation is due to the group's inability to adapt to changes or some other factor.

Knowledge of systematics can be used to explain the reasons for the extinction of some species due to habitat destruction. Hydrophytes (water plants) will not be able to survive in dry conditions for long periods, due to their characteristics (type of stems, roots and leaves). Similarly, learners will understand that habitat destruction causes some species to become extinct in a particular area thereby reducing the diversity in that area (biodiversity). Extinction of species will have an effect on other species (population dynamics) living there. Knowledge of population studies can be used to describe the effect of the extinction of one species on another in the particular area. Biodiversity, population dynamics and systematics are concepts which form part of Life Sciences and these concepts can be used to explain certain phenomena, like ecology, extinction, conservation, natural selection and taxonomy in the world around the learners.

However, the limited guidance provided by the curriculum means that learners' exposure to certain aspects of population dynamics is determined by the educator because different educators interpret the curriculum differently. This statement accords with the previously made comment, that the Life Sciences curriculum gives educators freedom to determine the nature and extent of content to be covered. For example, some educators might concentrate on concepts such as predation and competition, some on graphs (j- and s-curves) and others on the reasons behind phenomena such as immigration and emigration. Similarly, in the content relating to biodiversity, some educators might focus on the endangered species list, whereas others might feel that other conservation issues (management of species, diseases and adaptations for survival) are more important. The inclusion of or reference to systematics is also dependent on the educator. The resources educators use, including textbooks, might also influence their choice of the concepts they will emphasise.

It is important to note that educators teaching grade 10 Life Sciences learners received training during 2005 to prepare them for the implementation of the subject in 2006. According to Hewson, Kahle, Scantlebury and Davies (2001:1138), the expertise and commitment of the science educators are important factors in the reformation of science education. This comment is true for every school and also applies to the NCS Life Sciences curriculum (Department of Education, 2003) for grades 10 to 12. If educators are not fully prepared and do not believe that the changes are for the better, the curriculum cannot be implemented successfully. Educators have mixed feelings about the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 – especially the more experienced educators who are not convinced that the new approach to teaching is an improvement as they feel it lacks content. Despite their reservations, the educators must also take responsibility for developing activities to challenge their learners' knowledge as well as their practical skills.

Another argument worth mentioning, but which will not be investigated in this research, is the link between systematics and evolution. Regarding the evolution of species, systematics familiarises learners with the concept of species and how species developed from other species. Woodland (2000:2) states that systematics has been applied to various kinds of organisms and to the relationships between them. Evolution and population theories are located in the grade 12 curriculum but learners may have difficulty with these concepts due to the removal of systematics as a separate unit from the FET phase. Problems that may be encountered include the current patterns of biodiversity and how these groups are related – the so-called "tree of life." Learners need to understand that animals and plants evolved from the same ancestors. Knowledge of systematics is a prerequisite to understand descent and this knowledge will help learners to understand the modifications that lead to the development of different groups of animals and plants. This knowledge can also be applied to explain the different body plans from primitive to more developed organisms. Modification of basic body plans indicates common descent from a single ancestor. Therefore, it is necessary for learners to be exposed to knowledge about systematics during grade 10, and especially in grade 11, because evolution will probably make more sense to them when they reach grade 12.

Another concept which links to systematics is natural selection. Natural selection has to do with the survival of the fittest and this occurs when individuals have genetically based traits that increase their chances of survival (Miller, 2007:85). For example, such traits will enhance the survival chances of some individuals because they adapt better than other individuals of the population to changes in the environment and the factors affecting it. The characteristics of these individuals can be aligned with systematics because the individuals can be classified in certain animal or plant groups.

Thus, at the end of the FET phase the learners would not have been taught how to determine why certain organisms are classified in particular groups or what characteristics need to be considered when classifying certain organisms. This means that when learners enter a tertiary institution, these concepts that form an integral part of some BSc subjects, especially botany, microbiology and zoology, will be unfamiliar to the learners. With the previous curriculum this was certainly not the case because systematics formed a major part of the NATED 550 Biology curriculum (Department of Education, n.d.) in grade 11. In addition to this, the holistic picture of an ecosystem regarding population studies, biodiversity, evolution, natural selection and systematics will not be clear.

The last concern is the shift in the Life Sciences content between the different grades in the FET phase and the relevance of this to the learners' ability to conceptualise. The largest section of content was moved from grade 12 to grade 10. This researcher believes that these are some of the most difficult concepts (photosynthesis, respiration, gaseous exchange) in Life Sciences and that learners are now confronted with these complicated concepts at an even younger age. Stern and Roseman (2004:538) warn that although topics such as photosynthesis and cellular respiration have been taught for many years, research on student learning indicates that students have difficulties in conceptualising these ideas. This, may on the other hand, result in these concepts being explained and taught in even lesser detail for learners to understand them and on the other hand in the danger of exclusion of essential detail. To validate these suppositions the learning outcomes for grade 10 need to be investigated. Furthermore, the relevance of detailed content for certain age groups and the sequence in the development of content from one grade to the next grade should be studied.

This thesis will examine these concerns as stated at the beginning of this section (1.1.4).

1.1.5 The changed Life Sciences curriculum implemented in 2009

As mentioned in section 1.1.3, a New Content Framework for Life Sciences (Department of Education, 2007a) was introduced into schools in the FET phase in 2009. This curriculum reintroduced systematics as a single unit in the FET Life Sciences curriculum. The reason given by the Department of Education for introducing this New Content Framework was,

> "Because the content in the subject Life Sciences as listed in the National Curriculum Statement (NCS) Grades 10 – 12 (General) was underspecified, it was deemed necessary to revise the subject with a view to supporting the implementation of the NCS Grades 10 – 12 (General)" (Department of Education, 2007a:3).

A possible reason for the inclusion of systematics in this curriculum could be that the curriculum developers felt that this content is necessary as prior knowledge for learners to understand other concepts such as biodiversity. The New Content Framework for Life

Sciences (Department of Education, 2007a:5), contends that this knowledge framework focuses on ideas, skills, concepts and connections between them, rather than on listing the facts and procedures that need to be learned.

Therefore, this New Content Framework for Life Sciences (Department of Education, 2007a) will be studied to determine why systematics has been reintroduced into the curriculum and whether it makes any difference to the curriculum. This also links to the concern of the researcher in section 1.1.4 about the exclusion of systematics as a separate unit from the NCS Life Sciences curriculum that will be examined in the thesis. The changes made to the latest version of the Life Sciences curriculum are compared to the previous curricula (NATED 550 Biology curriculum and NCS Life Sciences curriculum) in a table in Chapter 5.

1.2 Research problem statement

The Department of Education (2005b:2) requires learners to be exposed to different and higher level skills and knowledge than those required by the previous South African curricula. Therefore, in 1995 the South African government began the process of developing a new curriculum for the school system. With the implementation of the National Curriculum Statement, name changes as well as changes in content of subjects occurred. The name of Biology has been changed to Life Sciences and the new Life Sciences curriculum underwent some significant changes for implementation in 2006.

Derived from Ausubel's (1968) work is that prior knowledge is an important component in the mastery of biological knowledge, process skills and problem-solving skills. In the past, systematics was important components of the Biology curriculum and was seen as prerequisite for mastering of the content of certain biological processes, for instance population dynamics and ecology.

If learners have prior knowledge of systematics, educators have a base on which to build and to which the new content of the population dynamics and biodiversity can be linked. This was easy to do in the previous NATED 550 Biology curriculum (Department of

Education, n.d.) for grades 10 to 12 because systematics was covered in detail in grade 11 – from micro-organisms to primitive plants and animals, to the more developed species. In systematics (refer to Chapter 2 for definition) learners are taught how different organisms are classified according to the classification system of Linnaeus. This means that learners not only know into which groups organisms are divided, but also the reason(s) for this classification. This ensured that learners were knowledgeable about the content of biological classification and they were also *au fait* with terms such as species, population and community. This will not be elaborated here, because it has been discussed in the previous section.

Knowledge of many of these processes and components (anatomy, classification, characteristics, ecological and economical use and reproductive ability) was, and still is important for the explanation of certain ecological and population interactions. Systematics was not included as a separate unit in the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 for grades 10 to 12. Consequently, it is hypothesised that this Life Sciences curriculum (Department of Education, 2003) does not provide the necessary structure for educators to effectively interpret and explain certain interactions and integrations of population dynamics and biodiversity. The onus is now on educators to selectively identify particular aspects of systematics and to include them in their teaching of population dynamics and biodiversity without explicit guidance from the curriculum document.

The question arises whether mastery of population dynamics and biodiversity is indeed dependent on systematics content of the curriculum. The changed Life Sciences curriculum implemented in 2009, has reintroduced systematics as a single unit under the Diversity, Change and Continuity strand. This begs the question why systematics has been reintroduced into the Life Sciences curriculum (Department of Education, 2007a)?

1.3 Purpose of the research

The purpose of this study is to determine the influence the exclusion of systematics as a separate unit from the Life Sciences curriculum implemented in 2006 has on the teaching of population studies and biodiversity.

1.3.1 The main research question

What influence do the changes in the curriculum that excluded systematics from the Life Sciences curriculum implemented in 2006 have on the way educators interpret the curriculum when teaching population studies and biodiversity?

1.3.2 Sub-questions

1. What are the main elements and components of population dynamics and biodiversity in the grade 11 Life Sciences curriculum in terms of substance and syntax?
2. How do educators interpret the curriculum in order to integrate content of systematics with population dynamics and biodiversity content knowledge (substance) when planning or designing problem-solving or scientific inquiry tasks?
3. How do educators integrate the science process skills and scientific inquiry (syntax) related to systematics when teaching population dynamics and biodiversity?
4. What are the links between content knowledge (substance) of systematics, population dynamics and biodiversity?
5. How do educators interpret the curriculum when selecting content knowledge (substance) of systematics when preparing to teach population dynamics and biodiversity?
6. Why has systematics been reintroduced into the Life Sciences curriculum and what differences has this reintroduction brought about?

1.3.3 Research assumptions

1. Most educators do not use knowledge of systematics when teaching population dynamics and biodiversity.
2. Scientific inquiry and problem-solving relating to science process skills (syntax) are limited or restricted in the teaching of population dynamics and biodiversity.
3. The grade 11 Life Sciences curriculum leaves room for interpretation by the educator and this influences the use of systematics when teaching population dynamics and biodiversity.
4. The background training of the educator influences the teaching of population dynamics and biodiversity, especially the inclusion or exclusion of systematics content.
5. There is not enough prior knowledge related to systematics, included in the teaching of population dynamics and biodiversity so that only the main concepts receive attention.
6. Educators do not prepare lessons in a manner that leads to effective teaching of population dynamics and biodiversity.
7. Systematics and prior knowledge have implications for learners in understanding population dynamics, biodiversity, problem-solving, scientific inquiry and possible future studies after school.
8. Educators follow the guidelines of the National Curriculum Statement, but do not use their own initiative.
9. Systematics has been reintroduced into the Life Sciences curriculum in 2009 because knowledge of systematics is a necessity for understanding biodiversity and population dynamics.

1.3.4 Key research objectives

1. Identify the main elements and components of population dynamics and biodiversity measured in terms of substance and syntax in the grade 11 Life Sciences curriculum implemented in 2006.

2. Determine whether and how educators integrate content of systematics with population dynamics and biodiversity content knowledge (substance) when planning or designing problem-solving or scientific inquiry tasks.
3. Distinguish ways in which educators integrate the science process skills (syntax) and scientific inquiry related to systematics when teaching the topics of population dynamics and biodiversity.
4. Discover the links between content knowledge (substance) of systematics, population dynamics and biodiversity during scientific inquiry and problem-solving in grade 11 Life Sciences.
5. Examine how educators select content knowledge (substance) of systematics when preparing to teach population dynamics and biodiversity.
6. Establish why systematics has been reintroduced into the Life Sciences curriculum.
7. Detect the changes caused by the reintroduction of systematics into the Life Sciences curriculum.

1.3.5 Significance of the proposed research

By conducting this research, the evidence produced will hopefully provide some clarity that the mastery of population dynamics and biodiversity is still dependent on knowledge of systematics within the context of the National Curriculum Statement for Life Sciences implemented in 2006. There is reference in this Life Sciences curriculum (Department of Education, 2003) to systematics but it is fragmented (in the content on micro-organisms, protists and fungi) and there is no evidence of systematic classification. It is anticipated that this research will show the need to include knowledge of systematics in the curriculum or even the necessity for inclusion of systematics as a separate unit in the curriculum. The call for systematics to be included in the Life Sciences curriculum was emphasised by the reintroduction of systematics into the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009. The research should provide guidelines for educators to follow when teaching population studies and biodiversity. The research results could also be valuable to curriculum design and even for improving teaching. The findings could aid educators and learners involved in the grade 11 Life Sciences curriculum, curriculum developers, policy makers as well as biological sciences lecturers at tertiary institutions.

It should be borne in mind that most courses in botany and zoology require mathematics and physical sciences at grade 12 level as prerequisites (examples are BSc degrees with specialisation in botany, microbiology and zoology and even a Degree in medicine) but not Life Sciences. However, it would be to a prospective student's advantage to take Life Sciences as a subject. Examples of tertiary institutions which have these requirements are the Universities of Pretoria and Stellenbosch. It seems, therefore, that the aforementioned fields of study do not require learners to master population dynamics and biodiversity at school level with a view to further studies.

1.4 The research design and methodology

There are many methods for doing qualitative research. In this investigation, the FET policy document (Department of Education, 2003) as well as the grade 11 Life Sciences curriculum and work schedule (Department of Education, 2003, 2007b) were analysed and evaluated using methods associated with qualitative research. The New Content Framework for the subject Life Sciences (Department of Education, 2007a) was also studied, because systematics was reintroduced into the curriculum implemented in 2009. Information was also gathered by conducting semi-structured interviews with educators, who teach Life Sciences to grade 11 learners at various secondary schools. Furthermore, a curriculum developer involved in compiling the new Life Sciences curriculum was interviewed and correspondence was conducted via email with another. An expert in the field of systematics as well as one in ecology was interviewed and relevant literature was reviewed. Two interviews were conducted with each of the educators and curriculum developers. The workbooks of ten learners per school, equal numbers of girls and boys following the grade 11 Life Sciences curriculum were also studied. Portfolio files were not studied because no portfolio work was done for the Diversity, Change and Continuity strand. Classroom observations were made at times when the relevant lessons were being taught. The sampling procedures, strategies chosen and data collection methods are discussed in detail in Chapter 4.

1.5 Research constraints

The research constraints comprise two categories, namely limitations that weakened the study and delimitations which explain why the study placed emphasis on a particular group or area only. According to Watkins (2006:54), research constraints are any inhibiting factors which would in any way restrict the researcher's ability to conduct the research in a normal way.

1.5.1 Limitations

The limitations which will be discussed are the non-probability sample and the size of the sample.

1.5.1.1 Non-probability sample

A non-probability procedure, namely convenience sampling, was used which means personal bias and subjectivity determined which elements were included in the sample. In this case the most accessible schools in the same geographical area were visited where the data were collected.

1.5.1.2 Size of the sample

Due to the limited number of people interviewed, only generalised conclusions will be made from the research findings. The research is thus narrow in scope as opposed to a wider or holistic overview one would wish for.

1.5.2 Delimitations

The delimitations which will be presented in this section are the participants who were involved in the study, the classroom observations, the workbooks and portfolio files of the learners and the ethical considerations.

1.5.2.1 Participants involved

Participants in the study are restricted to a sample of grade 11 Life Sciences educators, curriculum developers involved in the development of the NCS Life Sciences curriculum

(Department of Education, 2003) and several experts in the field of systematics and ecology.

1.5.2.2 Observations

Observations were conducted at times when either population dynamics or biodiversity lessons were being taught to grade 11 Life Sciences learners. This means that the researcher only observed lessons which are part of the Diversity, Change and Continuity strand.

1.5.2.3 Learners' workbooks and portfolio files

Only the content relating to population dynamics, biodiversity and systematics (if included) in the workbooks and portfolio files of the learners was studied. Because there was no evidence of such content in the portfolio files of the learners, the portfolio files were excluded from the study.

1.5.2.4 Ethical considerations

The findings are reported in a complete and honest fashion without misrepresenting what the researcher did and without intentionally misleading others as to the nature of the findings. Data to support a particular conclusion have not been fabricated, no matter how seemingly "noble" that conclusion may be.

1.6 Overview of the thesis structure

The thesis consists of six chapters, structured so that flow is ensured from one chapter to the next. Similar concepts and content have been grouped together in separate chapters to ensure that the reader grasps the reasons for the research as well as the themes pursued and processes followed to reach the final conclusions. The chapters are grouped in four parts.

Part 1: Scope

This is represented by Chapter 1 which includes the introduction and background to the research as well as the problem statement, research question, sub-questions and objectives of the investigation. It also documents the research process, including design and methodology, followed and the possible shortcomings of the research.

Part 2: Substance, syntax, scientific inquiry and problem-solving

This consists of the literature review in which the following content is included:

- Chapter 2 – the substance and syntax of grade 11 population dynamics and biodiversity as well as arguments for and against the inclusion of systematics.
- Chapter 3 – scientific inquiry and problem-solving as modes of inquiry in population dynamics and biodiversity as well as the importance of content knowledge and prior learning.

The literature review puts the research problem into context because the assumptions, opinions and findings of authors in the academic field are taken as support or critique of the researcher's views.

Part 3: Methodology and results

This part of the thesis (Chapters 4 and 5) contains the methods and approaches followed to collect the necessary data which marshalls evidence to give answers to the research question and sub-questions.

Part 4: Culmination

In the final part (Chapter 6) the findings are discussed, conclusions are drawn, recommendations made and suggestions for further research are offered.

1.7 Summary

Because the current Department of Education requires learners to be exposed to different and higher-level skills and knowledge than curricula that were in use during apartheid years, name changes as well as changes in content of subjects were made to curricula. The main concern here is the removal of systematics as a separate unit in the NCS Life Sciences curricula (Department of Education, 2003) in the FET phase. However, systematics has been reintroduced as a single unit into the New Content Framework for

Life Sciences (Department of Education, 2007a) from 2009. The purpose of this study is to determine the influence of the exclusion of systematics as a separate unit from the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 on the teaching of population studies and biodiversity.

To obtain a better understanding of the concepts and topics involved in this research it was important to consider the opinions of other authors about these concepts and topics. The literature review gave the researcher a better and informed background for his concerns and line of thought.

The next chapter gives a clear indication of the main elements of population dynamics and biodiversity. The link between knowledge of systematics, population dynamics and biodiversity during problem-solving and scientific inquiry is also discussed and the importance of content knowledge and prior learning is given attention.

Chapter 2

The substance and syntax of grade 11 population dynamics and biodiversity

2.1 Introduction

The NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 in the FET phase included more content focused on achieving learning outcome 3 (see section 1.1.3) (for example biotechnology, dialysis machines, cloning, transplants and genetically modified foods). However, the point is not just that learning outcome 3 is defined in a specific way, but that the focus has shifted from a content based to an outcomes based approach. This was the major shift. Changes were also made in the content of the different grades, changes that may or may not make any sense. The main concern here is the removal of systematics as a separate unit in the NCS Life Sciences curriculum (Department of Education, 2003). This could lead to a lack of understanding of other sections in the curriculum.

The researcher's standpoint is that unless learners have some knowledge of systematics, population dynamics and biodiversity cannot be fully understood by learners, leading them to be unable to do proper problem-solving and scientific inquiry concerning population dynamics and biodiversity.

2.2 Meaning of substance and syntax

The grade 11 NCS Life Sciences curriculum (Department of Education, 2003) has theoretical and practical parts. The theoretical part comprises of the content, whereas the practical part involves skills (experimental skills like observations and recording information as well as data-handling skills like identifying, selecting, interpreting of data and making conclusions). This was also the case in the previous NATED 550 Biology curriculum (Department of Education, n.d.). Fraser, Howie and Plomp (2003:ix) distinguish between the substance and syntax of subject knowledge. The theoretical part can be referred to as the substance of the subject – all the facts and concepts. The practical part can be referred to as the syntax of the subject, including microscopy work, dissections, observations, experiments, problem-solving and fieldwork. Schwab (in

Pinar, 2003:101) defines syntax as the kind of methodology which is legitimate within a certain field of research and the identification of basic concepts that guide the research and give rise to generalisations.

2.3 The content of the National Curriculum Statement for Life Sciences implemented in 2006

The grade 11 NCS Life Sciences curriculum (Department of Education, 2003) is divided into four strands, namely:

1) Tissues, Cells and Molecular Studies
2) Structure, Control and Processes in Basic Life Systems
3) Environmental Studies; and
4) Diversity, Change and Continuity.

The emphasis in this study is on the Diversity, Change and Continuity strand. In the grade 11 NCS Life Sciences curriculum (Department of Education, 2003) two key concepts featured in the Diversity, Continuity and Change strand, namely population studies (dynamics) and biodiversity. My belief is that the successful teaching of these concepts requires prior knowledge of systematics. When using systematics as a basis for explaining these concepts, learners will gain an understanding of where and how these two concepts fit into the bigger picture of Life Sciences. Learners will also find it easier to do problem-solving and/or scientific inquiry because they will be familiar with the characteristics of different groups of plants and animals. Overall learners will be able to understand and address the learning material better and more effortlessly, because they will have the necessary background and prior knowledge.

There is also the likelihood that learners will experience difficulties with the interpretation of content related to population dynamics and biodiversity because teachers interpret the curriculum differently. This will be affected by the background of the educators regarding their training and also the time allocated to the teaching and learning of these concepts. Educators with an academic background which includes systematics might possibly incorporate the knowledge of systematics into the population dynamics and biodiversity learning material, whereas the probability that educators without such a background in systematics will do so is slight. This contention will be assessed in this study. Table 2.1 details some content of the population dynamics unit.

Table 2.1: The population dynamics unit in the Diversity, Change and Continuity strand of the grade 11 NCS Life Sciences curriculum.

The grade 11 Life Sciences Curriculum includes the following:

- "characteristics of populations
- population growth
- population fluctuation
- limiting factors
- managing populations."

The following scientific inquiry and problem-solving skills are also included but it must be noted that this refers to the whole FET phase (grades 10-12):

- "Planning, conducting and investigating plants and animals – a comparison.
- Analysis of given data and findings to evaluate growth and behavioural issues within a population.
- Measurement of population growth using different techniques.
- Collection and analysis of data on specific community diseases that could impact on the population vigour dynamic.
- Analysis and evaluation of any specific human behaviour that could influence population growth.
- Collection and analysis of data on evolutionary trends in a population (e.g. human beings)."

(Department of Education, 2003:39)

Population dynamics and biodiversity form an integral part of some BSc degrees, especially botany, microbiology and zoology. Systematics is also included in some modules at tertiary level but it is now excluded as a separate unit at FET level. The modules presented at the Universities of Pretoria and Stellenbosch serve as examples as detailed in Table 2.2. The prospect exists that learners will enter tertiary institutions without really understanding or being able to interpret the meaning and impact of these two Life Sciences concepts. Under the previous NATED 550 Biology curriculum (Department of Education, n.d) this was not the case because systematics formed a major part of the Biology curriculum in grade 11, ensuring that learners grasped the concepts of population dynamics and biodiversity better.

Table 2.2: Modules which include systematics at two South African universities.

Level	Module	Content
University of Pretoria		
First year (Zoology)	Animal Diversity	Animal classification, phylogeny, organisation and terminology. Evolution of the various animal phyla, morphological characteristics and life cycles of parasitic and non-parasitic animals.
Second year (Zoology)	Invertebrate Biology	Origin and extent of modern invertebrate diversity.
	African Vertebrates	Introduction to general vertebrate diversity, African vertebrate diversity, vertebrate relationships, vertebrate characteristics, classification.
Third year (Zoology)	Population Ecology	Population characteristics.
	Mammalogy	Mammalian origins and their characteristics: Social behaviour, parental care and mating systems.
	Insect Diversity	The extent and significance of insect diversity. The basic principles of taxonomy and the classification of taxa within the Insecta. Insect orders and economically and ecologically important southern African insect families. Identification of insect orders and families using distinguishing characteristics. General biological and behavioural characteristics of each group. Grouping of insects into similar lifestyles and habitats.
First year (Botany/Plant Science)	Plant Biology	Introduction to plant systematics and plant diversity.
	Introductory Plant Biology	Principles of plant taxonomy, diagnostic properties of selected plant families.

Continued overleaf

Table 2.2 continued

Level	Module	Content
University of Pretoria		
Third year (Botany/Plant Science)	Plant Diversity	Basic principles and methods of plant classification. General structural and biological characteristics of evolutionary and ecologically important plant groups. Botanical nomenclature.
	Practical Plant Identification	Plant identification in practice; identification methods, keys, herbaria and botanical gardens. Diagnostic characters for the field identification of trees, wild flowers and grasses. Family recognition of southern African plants. Available literature for plant identification. Methods to conduct floristic surveys. Nature and significance of voucher specimens.
Third year (Animal and Wildlife Sciences)	Animal Breeding	Karyotyping of farm animals; breed and species differences and the influence on classification of breeds.
	Animal Ecology	Animal-ecological factors which influence regional classification.
University of Stellenbosch		
First year (Botany and Zoology)	Biodiversity and Ecology	Classification and diversity of organisms.
	Biosystematics	Vertebrate systematics.
Second year (Botany and Zoology)	Evolution and Systematics	Phylogenetic systematics
	Animal Diversity	Classification characteristics of major animal groups from Protozoa to Metazoa, Phylogenetic relationships among major animal groups incorporating both traditional morpho-logically based hypothesis as well as recent molecular hypothesis.
	Plant Diversity	The main evolutionary lineages within the Plant Kingdom. Phylogenetic relationships between both the living and main fossil plant groups. The morphological diversity within the Plant Kingdom (with specific emphasis on the Angiosperms).

Continued overleaf

Table 2.2 continued

Level	Module	Content
University of Stellenbosch		
Second year (Botany)	Plant Diversity	The origin and phylogenetic relationships of angiosperms as determined by different classification systems. Angiosperm diversification and classification using morphological, anatomical, biogeographical, hemotaxonomical, palynological and molecular characters. Angiosperm naming based on the International Code of Botanical Nomenclature. Morphological diversity of Angiosperms from the most primitive to the most derived families in a practical series, with specific focus on Fynbos families.
Second year (Micro-biology)	Introductory Microbiology Microbial Diversity	Microbial taxonomy. Prokaryotes, kingdoms of life and modern classification.
Second year (Conservation Ecology and Entomology)	Nematology	An introduction to nematology, which includes morphology, anatomy, classification, biology, identification, control of plant parasitic nematodes and the control of insects with entomopathogenic nematodes.
Fourth year (Conservation Ecology and Entomology)	Insect Diversity	Introduction to the Arthropoda and its classes. Nomenclature of insects. Diversity and classification of the Hexapoda (Protura, Collembola, Diplura and Insecta) with emphasis on ecologically and economically important groups.
First year (Biochemistry, Botany and Zoology, Genetics and Microbiology)	Biodiversity and Ecology	Classification of organisms; diversity of micro-organisms, plants and animals.
First year (Agronomy, Horticultural Science, and Viticulture and Oenology)	Introduction to Applied Plant Science (Agriculture)	Classification systems and classification of agricultural crops.

(University of Pretoria, 2009 and University of Stellenbosch, 2009)

The shifting of the content between different grades in the NCS Life Sciences curriculum (Department of Education, 2003) is another concern. Content was moved between the different grades in the FET phase and the rationale behind these shifts is questionable. A substantial amount of content was moved from grade 12 to grade 10. Some of the concepts that learners have traditionally found difficult to understand (photosynthesis, respiration and gaseous exchange) (Stern & Roseman, 2003:538) in Life Sciences were moved to grade 10 and now the learners are confronted with these concepts at an even younger age. This may result in these concepts being explained and taught in less detail to ensure that learners understand the learning material. However, a possible reason for the aforementioned statement might be that less detail is required in the curriculum. The grade 10 work schedule tersely states: "Study of biochemical mechanisms not required" (Department of Education, 2007b:24). To corroborate this comment the learning outcomes for grade 10 need to be investigated together with the age and prior knowledge of learners. This also applies to population dynamics and biodiversity. These two concepts are included in the grade 11 NCS Life Sciences curriculum (Department of Education, 2003) without any links to systematics. Learners are confronted with these concepts and they may not have the necessary prior knowledge to build on them. Due to this and because the curriculum and work schedule do not provide educators with detailed guidance, it is possible that these two concepts will be taught with less detail to ensure the learners understand the content.

2.4 Definition of systematics

Although already defined in Chapter 1, systematics has been variously defined over the years. A selection of examples suffice to illustrate the variants, viz. "systematics is the study of the kinds and diversity of organisms and the evolutionary relationships among them" (Miller & Harley, 1999:227) and "taxonomy and classification are part of systematics, which is the study of the diversity of organisms at all levels of organisation" (Mader, 2004:346).

According to Jones and Luchsinger (1986:1) systematics is the science of identifying, naming and classifying and is the broad field concerned with the study of diversity while Curzon (1985:65) expounds it as follows:

> "Organisms may be grouped and classified on the basis of class, order, genus, species, etcetera. Lower classes are subordinated to higher, until, finally, the summum genus, or most inclusive category with which the science is concerned, is reached."

Despite their apparent differences, these definitions express similar views. There are authors who maintain that taxonomy and systematics are synonymous, to wit Stace (1989:5) states that taxonomy is the study and description of the variation of organisms, the investigation of the causes and consequences of this variation, and the manipulation of the data obtained to produce a system of classification.

2.5 Definition of population dynamics

The NCS Life Sciences curriculum (Department of Education, 2003) and work schedule (Department of Education, 2007b) use the term population studies which is interchangeable with the term population dynamics as they have similar meanings. In order to understand population dynamics, it is necessary to define population. Mader (2004:836) sees a population as all the organisms within an area belonging to the same species and Miller and Harley (1999:164) add that these same species share a unique set of genes. Chapman and Reiss (1995:26) point out that it is a group of organisms that lives together in one geographical area at the same time.

Population dynamics has to do with the fluctuations in numbers occurring in populations and the reasons for these variations, for example mortality (death rate) or natality (birth rate) or even competition, predation and environmental factors. Grobler (n.d.:112) defines population dynamics as the study of the changes or fluctuations in the number of organisms in a population over a certain time and the causes of or factors associated with the fluctuations. Mader (1998:384) points out that ecologists are interested in the factors that affect the growth and regulation of population size. Isaac, Chetty, Naidoo, Manganye, Mdhluli, Mpondwana and White (2006:299) explain that population dynamics refers to studying the following aspects of changing populations:

- "change in the numbers of organisms that form a population;
- environmental and internal factors that influence these changes;
- the rate at which the size of the population increases or decreases; and
- processes that regulate the population, for example processes that keep the size of the population stable or constant."

The number of individuals in populations must be studied, as well as the relationships between different populations or organisms and the inherent or environmental factors influencing population size.

2.5.1 Population dynamics as part of the grade 11 NCS Life Sciences work schedule

A work schedule (Department of Education, 2007b) was developed by an independent committee and not by the curriculum development team. The work schedule is included in the Learning Programme Guidelines for Life Sciences. The work schedule provides information on the time that should be allocated to each strand as well as the topics under each strand. Furthermore, it specifies the content and skills in Life Sciences under the three learning outcomes. The work schedule is set out in Table 2.3.

Table 2.3: Work schedule for the population dynamics unit in the Diversity, Change and Continuity strand of the grade 11 NCS Life Sciences.

The grade 11 work schedule for Life Sciences includes the following:

I. "Characteristics of populations and population growth, fluctuations, limiting factors.
II. Define population by referring to cells, unicellular and multicellular organisms.
III. Define species with reference to shared characteristics and reproductive ability.
IV. Outline characteristics of populations in terms of habitat, size, density and distribution.
V. Provide details on environmental changes – earthquakes, volcanos, earth slides, tornados, droughts, flood and extreme temperatures that affect biomes, ecosystems and habitats (Density-independent factors).
VI. Brief outline of factors influencing population growth – births, migration, resources, death and human developments (Density-dependent factors).
VII. Fluctuations of populations as influenced by limited resources: population size and growth, cells, unicellular and multicellular organisms."

Continued overleaf

Table 2.3 continued

The following scientific inquiry and problem-solving skills are also included: ▪ "Plans and conducts an investigation on plants and animals – comparison. ▪ Analyse given data and findings to evaluate growth and behavioural issues among population."

(Department of Education, 2007b:37)

2.5.2 Systematics as part of population dynamics during problem-solving and scientific inquiry

Population dynamics is linked to systematics and in systematics learners gain knowledge of how different organisms are classified according to the Linnaean classification system. This means that learners should know into which groups organisms (for example animals and plants) are classified and the characteristics that underpin the classification in order to understand how and why populations will change.

The characteristics of each species determine in which taxon it is placed. If educators do not include some information about the characteristics of different taxa when they use an example of population dynamics in amphibians, learners will not understand why numbers fluctuate. Learners could fail to understand that amphibians are more vulnerable to pollution than reptiles, because this taxon is characterised by damp, permeable skin. Oxygen gets taken in through the skin and the oxygen then goes directly to the bloodstream. However, the skin also allows substances to move relatively freely into the body of the amphibian, which means that toxins get absorbed and concentrated in their fatty tissues. Thus, the characteristics of the frog influence the population dynamics of this group.

Systematics can also be used to inform decision making in conservation. Without inclusion of systematics during teaching, learners will not appreciate the nature or the extent of problems posed to them because a species must first be classified into the appropriate taxon before methods for conservation of that taxon can be identified. Thus, learners will fail to put the problem into perspective during problem-solving. Plants can be useful in the manufacturing of medicine. This is currently a growing topic in South

Africa and it is included in the NCS Life Sciences curriculum (Department of Education, 2003). Classification of plants is necessary to identify plant species with medicinal value. Woodland (2000:436) makes an incisive comment on this:

> "The study of diversity in plants can be an intellectual and practical challenge. To meet these challenges, the knowledge provided by contemporary systematists will become more in demand and may form the base of knowledge for preservation of all plant species."

Miller (2007:162) notes that populations change in their distribution, numbers, age structure and density in response to changes in environmental conditions. A problem-solving question based on population dynamics can be formulated for learners asking them to study populations in their natural environment. First, learners are required to classify the species to be investigated and determine why the different species form communities and live in a particular environment. Second, learners need to document how and why these species are adapted to their environment. Last, learners can be tasked to explain what the effect will be if one of the species were to become extinct.

Learners can answer all of these questions by using their knowledge of systematics, that is the classification of species and the characteristics of different taxa. Educators can require learners to apply their knowledge of population dynamics to answer questions about why the organisms live in groups in more detail. Resource availability and predation should feature in their answers. Unfortunately, unless educators choose to include systematics learners will not be able to classify the species because systematics is not dealt with as a separate unit in the NCS Life Sciences curriculum (Department of Education, 2003). Knowledge of the characteristics of the taxa will enable learners to solve problems on a higher cognitive level than application. Learners will be able to analyse, evaluate and synthesise the data that confront them. The guidance the curricula (Department of Education, 2003) and work schedules (Department of Education, 2007b) gives to the educators is not sufficient for educators who are unfamiliar with this aspect of the work. Finally, if learners are asked to do an inquiry in a certain area to determine the diversity there, they will not be able to do it without first classifying the taxa.

Educators who have interpreted the curriculum to require inclusion of systematics have established a base from which to build and they can link the new content of population dynamics and biodiversity to it.

According to the Department of Education (2002:61), the Life and Living strand for grades R to 9 focuses on life processes and healthy living, on understanding balance and change in environments and on the importance of biodiversity. In primary school learners have only studied systematics in a very basic manner where animals were categorised into invertebrates and vertebrates with reptiles, birds, fish, amphibians and mammals being the classes falling under vertebrates. Also included in primary school (foundation phase) is a reference to the classification of animals and plants which states that animals and plants can be grouped by their similarities.

Another factor to consider is that systematics is not included in the grade 8 and 9 curricula. This study only focuses on the Biodiversity, Change and Continuity sub-strand. Food chains, trophic structures and food webs are included in the grades 8 and 9 curricula as well as symbiotic relationships (mutualism, commensalism, parasitism) and the effects on food chains (population dynamics), but again the amount of information used in the classroom depends on the interpretation of the curriculum by the educator. Moreover, pollution, the effect of humans on nature and conservation are also included. These concepts can be linked to biodiversity. The core knowledge and concepts relevant to systematics included in the curricula for grade R to grade 9 are listed in Table 2.4.

Table 2.4: Core knowledge and concepts that relate to systematics in the Life and Living strand, under the Biodiversity, Change and Continuity sub-strand of the Revised National Curriculum Statement for grades R-9, Natural Sciences.

Biodiversity, Change and Continuity
Unifying statement: The huge diversity of forms of life can be understood in terms of a history of change in environments and in characteristics of plants and animals throughout the world over millions of years.

Continued overleaf

Table 2.4 continued

Foundation Phase (Grades R-3)
○ There is a large variety of plants and animals which have interesting visible differences but also similarities, and they can be grouped by their similarities.
Intermediate Phase (Grades 4-6)
○ No content on systematics
Senior Phase (Grades 7-9)
○ Biodiversity enables ecosystems to sustain life and recover from changes to the environment. Loss of biodiversity seriously affects the capacity of ecosystems and the earth, to sustain life. Classification is a means to organise the great diversity of organisms and make them easier to study. The two main categories of animals are the vertebrates and invertebrates, and among vertebrates the five classes are amphibians, birds, fish, reptiles and mammals.

(Department of Education, 2002:62-65)

2.6 Definition of biodiversity

According to Gaston and Spicer (1998:2) "Biological diversity means the variability among living organisms from all sources including, *inter alia,* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems." A definition by Miller and Harley (1999:222) is similar to the latter part of the above definitions, namely that biodiversity includes diversity within species, between species and of ecosystems. Mader (1998:9) adds that biodiversity is the "number and size of populations in a community." Mader (2004:926) further avers that biodiversity at its simplest level is the variety of life on earth and O'Riordan and Stoll-Kleemann (2002:9) declare that biodiversity means the varied characteristics of ecosystems.

The simple definition used for this study is an amalgam of the above definitions, namely biodiversity refers to all the different species within the different ecosystems. Lawson (2002:14) reminds us that Darwin described the various plant and animal species that he found and was profoundly struck by their overwhelming numbers and diversity. Like Darwin, the grade 11 Life Sciences learners are confronted with biodiversity. Without knowledge of biodiversity they cannot fully comprehend the number of species on earth, the reasons for the existence of different species and the reasons associated with species extinction. They might not be able to understand why certain species have larger populations than others (for example blue wildebeest compared to rare frogs). Ultimately, without knowledge of systematics, the structure into which all this content fits, cannot be comprehended.

2.6.1 Biodiversity as part of the grade 11 NCS Life Sciences work schedule

Although biodiversity is covered in the work schedule, no reference is made to biodiversity in the grade 11 NCS Life Sciences curriculum. The grade 11 work schedule accomodates content on biodiversity as specified in Table 2.5.

Table 2.5: Work schedule of the biodiversity unit in the Diversity, Change and Continuity strand of the grade 11 NCS Life Sciences.

The grade 11 work schedule for Life Sciences includes the following:

I. "Managing populations in terms of:
   - Biodiversity of plants and animals and their conservation.
   - Significance and value of biodiversity to ecosystem function and human survival.
   - Threats to biodiversity.
   - Diseases."

The following scientific inquiry and problem-solving skills are also included:
   - "Plans and conducts an investigation on plants and animals – comparison.
   - Analyse given data and findings to evaluate growth and behavioural issues among population."

(Department of Education, 2007b:37)

2.6.2 Systematics as part of biodiversity during problem-solving and scientific inquiry

From the aforementioned definitions, it is clear that biodiversity is a concept that goes hand in hand with population dynamics, and especially with systematics. Jones and Luchsinger (1986:2) alert us to the range of approaches applicable in systematics, that is:

> "Various approaches in systematics include classical taxonomy, which consists largely of museum research but often includes field work, and biosystematics, which involves ecological, cytological, and genetic

> investigations, and experimental studies of living populations in the field, experimental garden, laboratory, and greenhouse."

Teaching that organisms are divided into different groups and the reasons for this classification will enable learners to understand that some groups may become extinct more easily than others because of their different characteristics (systematics).

When learners understand how and where populations fit into an ecosystem, they should be able to explain why changes in the numbers in certain populations (population dynamics) lead to changes in the numbers of others (biodiversity). They might provide other reasons for the decline in some populations, not only because of competition for food but also because of predation or human influence for example (population dynamics). Learners should be able to solve problems such as what the effects will be on a terrestrial ecosystem if there is only one or no snake species present (biodiversity). Gaston and Spicer (1998:35) explain that population losses in particular, will tend to reduce the taxonomic, genetic and functional diversity of sites and perhaps the performance of ecosystems.

An example described by Miller (2007:191) illustrates the comment that if it is clear how and where populations fit into an ecosystem, learners should be able to explain what effects changes in the numbers of certain populations will have on biodiversity. Miller (2007:191) used the example of the gray wolf, also known as the eastern timber wolf, that roamed over most of North America to illustrate how one key species can influence the whole ecosystem. By 1973 only a few hundred gray wolves remained due to hunting, poisoning and trapping by humans. Ecologists recognised the important role gray wolves played in the ecosystem. In the absence of the wolves herds of elk, moose, deer and antelope expanded. Vegetation such as willow and aspen trees decreased, erosion increased and threatened the number of wildlife species such as beavers that help to create wetlands. Since 1995 gray wolves have been reintroduced into the Yellowstone National Park to help sustain the biodiversity of the ecosystem. The reintroduction of gray wolves spawned an increase in aspen trees, cottonwoods and willow trees, which help stabilise the stream banks and lower the water temperature to create a better environment for trout. This led to an increase in beaver numbers because they were searching for wood. The presence of wolves engendered an increase in the number of grizzly bears and other scavengers that feed on the leftovers of elk killed and eaten by the wolves. Coyote populations decreased causing an increase in the populations of smaller animals like mice and this provided more food for eagles and hawks.

2.7 Arguments in favour of integrating knowledge of systematics during scientific inquiry and problem-solving in population dynamics and biodiversity

The change in government in 1994 precipitated a change in the education system. The change was due to a worldwide tendency to introduce outcomes-based education which placed emphasis on outcomes and not on content. This led to the loss of certain basic content that is essential for successful problem-solving and scientific inquiry. Some of the concepts that can be used as building blocks to reach outcomes were neglected. (More information on the development of the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 is given in Chapter 5).

Symington and Tytler (2004:1403) argue that the key concern of advocates of scientific literacy is that the curriculum should prepare all students to engage with science in their adult lives. If this is true, there are implications for the curriculum. If the curriculum does not contain enough content on systematics, it means that students will not be able to engage with this topic in their adult lives. Stern and Roseman (2004:539) recommend that to become scientifically-literate adults, learners should know certain core concepts. To ensure this, curriculum materials should support learning and these materials should help educators to build their own content and pedagogical knowledge. Educators also need to challenge learners by continually providing opportunities for problem-solving and scientific inquiry to ensure that their capabilities and understanding improve.

A failure of educators to integrate systematics, biodiversity and population dynamics into their teaching could have a negative impact on conceptualisation and problem-solving for learners. When such learners need to engage in scientific inquiry or problem-solving they will neither have a broad base to analyse a problem nor will they take all the necessary factors into consideration to resolve or make sense of the issue. It is difficult to formulate a solution if one does not fully comprehend the contents and context within which the problem manifests itself. For example, without classifying the populations and taking its characteristics into consideration, it will be difficult to draw up a management plan for the populations or to determine the economic or aesthetic value of the populations. Another consequence is that when the learners enter tertiary institutions, they will not have the necessary existing content knowledge to link to new content. Furthermore, without knowledge of different inquiry skills like the use of a microscope or by following inappropriate procedures during an experiment, the necessary evidence could be lost. Therefore, the ability to apply new knowledge when doing scientific inquiry like fieldwork would be lacking. For instance, if the students are actively involved in planning and executing field surveys, will they be able to analyse and present the results?

As mentioned earlier the emphasis in the grade 11 NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 is on learning outcomes, not content. However, there has also been a shift in content, as well as addition and removal of content between the different grades in the FET phase. Popkewitz (1988:1-22; in Andersson and Franke-Wikberg, 1990:495) assumes that the school curriculum has been and still is formed through various social and professional interests trying to use schools for their own purposes. In other words, different role-players determine which learning outcomes should be emphasised in different school subjects. This could have contributed to the removal of systematics as a separate unit in the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006.

Conversely, this could also be a contributing factor for the reinstatement of systematics as a unit in the Life Sciences curriculum implemented in 2009. Systematics is included in the New Content Framework for Life Sciences (Department of Education, 2007a) as a single unit incorporating viruses, bacteria, protists, fungi, plants and animals. Another reason for the reintroduction of systematics in this curriculum might be that the curriculum developers realised that this content is crucial for learners to comprehend other concepts or to reach certain outcomes. In the New Content Framework for Life Sciences (Department of Education, 2007a:23-25), animal and plant systematics is linked to biodiversity. This knowledge might help educators to include problem-solving or scientific inquiry concerning the biodiversity concept. In addition, the inclusion of this content could provide learners wishing to pursue tertiary studies in plant science, zoology or biological studies with a better foundation of knowledge for these fields of study.

2.8 Arguments against the integration of knowledge of systematics during scientific inquiry and problem-solving in population dynamics and biodiversity

The National Curriculum Statement (Department of Education, 2005a:4) advises that the FET band is located between the General Education and the Higher Education and Training bands. This means that there must be a progression from General Education and Training (GET) to the FET band. The FET band gives access to Higher Education, which leads to different career options for learners. This is supported in the National Curriculum Statement (Department of Education, 2005a:4), where it is pronounced that there should be a solid foundation for lifelong learning and different career paths. Systematics was not included as a separate unit in the NCS Life Sciences curriculum (Department of Education, 2003) which means that learners who were interested in following such career paths would not have had a solid foundation. However, it should be remembered that systematics has been reintroduced in the New Content Framework for Life Sciences (Department of Education, 2007a).

Symington and Tytler (2004:1403) suggest that it has become widely recognized among scholars in science education that the major purpose of science in the compulsory years of schooling should be the development of scientific literacy rather than the preparation of students for further studies in science. The reasoning for this is understandable because too much content with little focus on literacy will hamper understanding fundamentally. There is, however, an alternative argument which runs that learners should be prepared for further studies because if a learner wants to embark on a career in biological sciences, but systematics is not part of the scientific literacy, then the learner will not be prepared for further studies (regarding skills and background knowledge) and will be unfairly handicapped due to this.

On the other hand, it can be argued that if the emphasis is on the development of scientific literacy, then a concept such as systematics should be included in the compulsory years of schooling which is not the case. A strong scientific literacy focus would better prepare learners to reach the learning outcome based on the construction and application of Life Sciences knowledge because they have the necessary content knowledge as reference, but this will not make them experts. Systematics, as mentioned earlier, can be used together with population dynamics and biodiversity to create a more holistic picture for learners. The New Content Framework for Life Sciences (Department of Education, 2007a:5) states that it is very important for educators to emphasise the links that learners need to make with related topics to help them to achieve a deep understanding of the nature and connectedness of life. Clearly, systematics needs to be incorporated as part of scientific literacy where it can be linked to conservation which is one of the aims emphasised in the 21st century.

The basics of systematics provide learners with a holistic overview that is important in many subjects in the biological sciences. The New Content Framework for Life Sciences (Department of Education, 2007a:5) shows that living organisms has a link to "other organisms" and to "huge diversity". With the exclusion of systematics as a separate unit these links cannot be fully explored, thus ignoring the holistic nature of Life Sciences. For example, microbiology cannot be placed into context if one is unable to distinguish the different domains. Another example is that it is difficult to make sense of the mechanisms prokaryotes use to process their DNA if you do not know about the evolutionary history (systematics) of organisms (in molecular biology). Specialisation topics are often brought in later but learners will be able to comprehend the content better if they have prior knowledge of systematics.

It must be realised that Life Sciences include all levels in all living things, from micro level (atoms) to macro level (biosphere). Hofmeyr (2007:29) suggests that the hierarchy of organisational levels in all living things can be regarded as layers of life, from biomolecules to populations of organisms. He describes these layers as the domains of different scientific disciplines, for instance biochemistry, physiology, population biology and ecology. The hierarchy of organisational levels in all living things is illustrated in Figure 2.1.

Figure 2.1 The hierarchy of organisational levels in all living things

The division between these study fields means that most scientists only concentrate on one level in this hierarchy with its own terminologies and methods. This is reflected in grade 11 in the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 where population dynamics and biodiversity were included, with the exclusion of systematics as a separate unit. This hampers a fuller understanding of life and living things. Population dynamics is taught as a separate unit with its own terminologies and scientific skills and the same applies to biodiversity. Systematics is excluded, but it could have been incorporated into population dynamics and biodiversity to illustrate the relatedness between these concepts and provide a more holistic picture of Life Sciences. Hofmeyr (2007:29) uses the following to highlight a similar opinion:

> "A biochemist, for example, can manipulate one enzyme to make a plant more resistant to a pathogenic organism, but there is no way to predict the consequences at the ecological level, where the pathogen may be food for a predator in a food chain."

Tobin (2005:586) mentions that one of the educators' involved in his research regarded a curriculum orientated toward a preparation for university entrance as irrelevant for most students since it would not connect well with their prior knowledge and interests and would have minimal transformative potential. The knowledge and content aspect was discussed earlier in this section so that the discussion here centers on the practical preparation of learners. An individual cannot apply problem-solving or inquiry skills without having a proper understanding of the task at hand and taking all factors into consideration (due to prior knowledge) and then reaching a solution. For example to determine the size of a population learners need to know which method to use for a particular species (the characteristics of the species determines which method to use), which steps to follow and how to do the calculation. Educators must require learners to do problem-solving and scientific inquiry to reach the outcomes specified in the curriculum (Department of Education, 2003) but if learners do not have the necessary prior knowledge to apply, the outcomes cannot be successfully achieved. Similarly, regarding tertiary education, if learners enter university without prior knowledge of certain content and skills they would have minimal transformative potential concerning higher level skills, knowledge and inquiry. Knowledge acquired in school should prepare learners for university, or at least give them a base to carry on with at university. However, it can be argued that if learners are scientifically literate, they would be able to perform certain practical skills. On the other hand, it is possible that scientifically literate learners might not have acquired the relevant practical skills.

According to Popkewitz (in Andersson and Franke-Wikberg, 1990:496) the notion of indispensable and useful knowledge, as defined by universities, also influences the content of the school subjects. This is because tertiary institutions make changes to learning material to suit the needs identified in certain economic sectors and it is possible that this could affect the content of school subjects. Popkewitz (in Andersson and Franke-Wikberg, 1990:497) submits that:

> "The curriculum has been formed through a systematic selection favoring the economically, politically and culturally dominant groups in society."

McEneaney (2003:235) follows another approach by looking at the influence of the economic, political and cultural arguments on curriculum development by arguing as follows:

> "I identify different logics that potentially undergird the rapid and worldwide diffusion of a scientific literacy approach in mass educational systems. Though there is overlap and interweaving, these logics generally center on economic, political, and cultural arguments."

This could be the case for the school curriculum and, in a lesser way, for tertiary institutions.

2.9 Summary

In this chapter the meanings of substance, syntax, systematics, population dynamics and biodiversity were presented. The content of population dynamics and biodiversity included in grade 11 in the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 was also provided. The interrelationships between population dynamics and systematics as well as between biodiversity and systematics were discussed. Arguments in favour and against the integration of knowledge of systematics during scientific inquiry and problem-solving in population dynamics and biodiversity were articulated.

The aim of the chapter was to familiarise the reader with the different terminologies used and how these concepts relate to each other and how these concepts can be used interactively. The next chapter places emphasis on scientific inquiry and problem-solving as modes of inquiry in population dynamics and biodiversity as well as on the importance of content knowledge and prior learning.

Chapter 3

Scientific inquiry and problem-solving as modes of inquiry in population dynamics and biodiversity

3.1 Introduction

The grade 11 NCS Life Sciences curriculum (Department of Education, 2003) was developed with the emphasis on outcomes (inclusive of skills) and not on the content. Scientific inquiry and problem-solving are two skills (syntax) incorporated into the grade 11 Life Sciences curriculum. The portfolio files of learners must include a certain number of activities related to scientific inquiry and a certain number of problem-solving activities. Educators must provide the opportunity for learners to develop these skills which should be effectively applied by learners by using their prior knowledge to develop a better understanding of the concepts or processes involved in Life Sciences.

Concerning population dynamics and biodiversity learners may experience difficulty in mastering these skills and comprehending the content (concepts and processes) because systematics is not included as a separate unit in the grade 11 NCS Life Sciences curriculum (Department of Education, 2003). Educators may not choose to interpret the curriculum in such a way that they include relevant concepts related to systematics in their teaching of this content. So there is a possibility that the learners would not be able to take all the relevant factors into consideration when conducting a scientific inquiry or solving a problem.

3.2 Defining problem-solving and scientific inquiry

Definitions of problem-solving abound. Olivier, Greyling and Venter (in Gouws, Kruger and Burger, 2000:124) define it as a process of identifying a problem, an obstacle or an inability to act: it involves thinking of possible solutions and testing and evaluating these solutions. For Albrecht (in Gouws, Kruger and Burger, 2000:124) problem-solving simply means a state of affairs you must change in some way to get what you want. The aforementioned definitions include some aspects identified by Dewey as a complete act of thought. The aspects identified by Dewey and quoted by Lawson (2002:157) are:

"1) Sensing the problem or question
2) Analysing the problem
3) Collecting evidence
4) Interpreting the evidence
5) Drawing and applying conclusions."

Concerning scientific inquiry, Carin, Bass and Contant (2005:121) state that inquiry can be thought of in two ways. First, inquiry refers to the diverse ways in which scientists investigate nature. Second, it is a teaching-learning method in which learners develop knowledge and understanding of scientific ideas and how scientists study the natural world. The second conception is more applicable to this research. Scientific inquiry includes all process skills (methods) used to study certain concepts and processes. Some of the process skills of science outlined by Carin, Bass and Contant (2005:39) are observing, measuring, classifying, inferring, hypothesising, controlled investigation, predicting, explaining and communicating. In this research scientific inquiry and problem-solving are deemed to be process skills.

Anderson (in Carin, Bass and Contant, 2005:121) asserts that scientific concepts need to be explicitly introduced and taught to learners. For example, when learners understand that there are a number of different species within the mammalian group and have explored reasons for it, new concepts and principles (threats to different mammalian species, conservation issues and value of mammalians in an ecosystem) relating to this can be explained to them. Learners can be given different activities to ensure they understand and fully comprehend concepts such as systematics and biodiversity.

3.3 Problem-solving and scientific inquiry as practical skills

Gouws, Kruger and Burger (2000:124) record the valid point that knowledge makes it easier to solve a problem. Without knowledge the nature of the problem cannot be defined, neither can all the factors that influence the problem be recognised. Furthermore, Gouws, Kruger and Burger (2000:62) assert that cognitive abilities enable learners to assign more profound meaning to future learning content, people and their own abilities and shortcomings. When content knowledge is applied during scientific inquiry and problem-solving, activities can be completed with fuller comprehension. Ellis (2004:24) notes that cognitive theorists place emphasis on problem-solving and that learning is viewed as a process of gaining or changing insights, views or outlooks, as individuals make meaning of previously learned facts. When educators confront learners with a problem that will require prior knowledge to solve, the problem might be solved more easily and in more detail.

It is important that the necessary content knowledge is covered with learners, because new knowledge can be linked to prior knowledge, which ensures that further learning takes place. According to Bruner (in Ellis, 2004:24), the acquisition of knowledge is an active process in which meaning is acquired by connecting the incoming facts to previously acquired knowledge. While solving problems and engaging in scientific inquiry (for example practical work, microscopy work, dissection or fieldwork), learners must know what to look for, and when evidence emerges from the data they must have the prior knowledge to interpret it and see it as possible evidence for solving the problem. Kaplan (1976:vii) explains that for students to be successful in finding a solution to a scientific problem they must be presented with some facts, they must derive other facts by means of their own observations and experiments and they must be able to synthesise this data into a meaningful picture.

Moreover, Kaplan (1976:349) has explained that for each major question there are a number of sub-questions that must first be answered. A major question could ask why nearly all species on earth have been able to exist for thousands or million of years while other species became extinct. The sub-questions could be to identify the factors that could have caused the extinction of species; to name the factors threatening the existence of species today; and to single out the characteristics which enabled certain species to survive for so long. Many species have become extinct because of competition for food or habitat reduction or predation or catastrophe or climate change to name a few reasons. Today, because of human activity, increasing numbers of species are on their paths to extinction. This leads to the disruption of equilibrium or establishment of equilibrium in communities. Gaston and Spicer (1998:35) have commented that the extinction of species equates to loss of all local populations, typically following a marked decline in overall abundance. If the relationships between organisms have not been taught, it will be difficult for learners to use the data gathered to solve problems related to population dynamics and biodiversity.

Brownell and Hendrickson (1950, in Ausubel, 1968:84) long ago wrote that meaningful generalisation can only be acquired as a product of problem-solving activity and to master verbal concepts and propositions learners must have had prior experience with the realities to which these verbal constructs refer. Smith supports this by quoting Bruner (Bruner in Smith, 2002:3):

> "The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer....If earlier learning is to render later learning easier, it must do so by providing a general picture in terms of which the relations between things encountered earlier and later are made as clear as possible."

Learners need to apply their theoretical knowledge to practical work. In doing so learners develop a general picture of the relationship between content and practical work. If learners are provided with a classification key as part of a scientific inquiry activity, it becomes easier for them to understand the use of classification keys to classify an unfamiliar organism. Learners will not be able to classify organisms under a microscope or in nature if they are not familiar with their characteristics.

Thus, the educator need to make the relationship between systematics, population dynamics and biodiversity clear to learners for them to be able to apply their knowledge during scientific inquiry and problem-solving. Because systematics is not included as a separate unit in the NCS Life Sciences curriculum (Department of Education, 2003), the onus is on educators to ensure that the necessary content is covered to make sure that learners have the necessary knowledge to apply during scientific inquiry and problem-solving. This could be the reason for the inclusion of systematic as a single unit in the Life Sciences curriculum (Department of Education, 2007a) implemented at the beginning of 2009.

3.4 Ausubel on content knowledge

Concerning the theoretical stance of this study the focus falls on the value of useful knowledge for further development. This assumes a theoretical framework in which certain prior knowledge is a prerequisite for further conceptual development and understanding.

This framework can be aligned with the work of the well known educational psychologist, Ausubel. Ausubel believes that cognitive development will be more effective when learners are provided with opportunities to link their prior knowledge to new topics and concepts. Kearsley (2009a:1) mentioned that according to Ausubel,

> "...learning is based upon the kind of superordinate, representational, and combinatorial processes that occur during the reception of information. A primary process in learning is subsumption in which new material is related to relevant ideas in the existing cognitive structure on a substantive, non-verbatim basis."

Ausubel uses the concept of advance organisers to explain how educators can use prior knowledge of learners and link new content to it. These advance organisers contribute to the quantity as well as quality of what learners are taught, because prior knowledge is useful in understanding new content. For example, learners have prior knowledge that factors like competition and predation cause reduction in the number of certain populations. The educator can use this prior knowledge in an example and, for instance, link the reduction of a population of hares due to predation to the new concept of extinction of a species.

In addition, advance organisers are used to bridge the gap between what learners know and what they need to know before they can successfully learn the task at hand (Ausubel in Curzon, 1985:64). This implies that new concepts and knowledge should be linked to prior knowledge. The NCS Life Sciences curriculum (Department of Education, 2003) is structured in such a way that learners are not able to link prior knowledge (systematics) to new concepts (population dynamics and biodiversity). The focus in the curriculum

(Department of Education, 2003) is on the mastering of broader curricula aims (outcomes) rather than on the understanding of specific concepts.

In the biodiversity unit only the naming of the different kingdoms is required, there is no reference to the characteristics of the different taxons. Learners will not be able to understand biodiversity at a high level of comprehension without prior knowledge of systematics. In order to manage an environment, the populations should be classified. Only then will it be possible to determine the threats to and value of the diversity of species within an environment. Similarly, for the study of population dynamics the mortality rate of reptiles and amphibians under similar conditions will be different. Learners will find it difficult to identify the reasons for the differences in mortality rates, without prior knowledge of systematics. Educators should include content of systematics prior to commencement of teaching biodiversity and population dynamics. This prior knowledge of systematics can then be used to help learners understand biodiversity and population dynamics as a whole. The principle of this argument is supported by Fraser, Loubser and Van Rooy (1993:48) who state that the mastering of content is further facilitated when meaning is given to the essentials (facts, concepts and principles) and that knowledge of the basic insights facilitates comprehension of the whole.

The basic steps toward comprehension can be fulfilled in this way. Fraser, Loubser and Van Rooy (1993:134), underline this statement by pointing out that “the learning of elementary concepts is essential before attempts are made to master more complicated and secondary concepts.” An example where this principle is used is found in a spiral curriculum. In such a curriculum there is a progressive increase in the amount as well as the level of difficulty of the work. This means that some topics and themes are repeated in the different grades each year, but the work is done in more detail. The learners’ knowledge and way of thinking (from identifying to explaining to understanding to problem-solving) is expanding and developing over time. Biology has, for many years, been taught in this way – teachers start for instance at the most simple form of life and work their way to the most advanced species (Fraser, Loubser and Van Rooy, 1993:136).

A similar statement about the structure of the curriculum is made in Curzon (1985:65) by Ausubel who suggests that class learning can be improved through use of the technique of 'progressive differentiation' meaning that the most general, inclusive concepts of a subject discipline should be taught first, followed by the less inclusive concepts, which leads to teaching of specific information. An example could be the teaching of animal and plant systematics which leads to the learners' understanding the classification of animals and plants. The teaching of biodiversity could follow the teaching of systematics allowing biodiversity to make more sense to learners. What's more, learners will better understand why conservation of biodiversity is important and that different management plans must be used for different species. The reason is that learners should understand that there are different groups of plants and animals and be able to understand why, for instance, there will be a loss in biodiversity if a group, like reptiles, becomes extinct.

Appropriate background knowledge of concepts and principles is essential for problem-solving. Ausubel, (in Curzon, 1985:62) argues that "(t)he principle (*sic!*) factors influencing 'meaningful learning and retention' are the substantive content of a learner's structure of knowledge and the organisation of that structure at any given time." Learners will find the content of the Diversity, Change and Continuity strand easier to grasp if they are shown how systematics, population dynamics and biodiversity are related to each other. Their knowledge should be structured in such a way that they are able to use content knowledge of all three concepts when doing problem-solving or scientific inquiry. Learners must be able to use their prior knowledge with related situations to deal successfully with the new problems.

3.5 The role of prior learning in problem-solving and scientific inquiry

One of the most widely recognised taxonomies of educational objectives – that of Bloom – can be connected to prior learning. Wood (2001:51) observes that Bloom's six-level taxonomy helps teachers determine the relative difficulty of their instructional objectives. All six levels of the taxonomy are applicable in this research (see Table 3.1).

Table 3.1: Bloom's levels of cognitive thinking.

Cognitive Levels	Level Student Activity
Knowledge	Remembering facts, terms, concepts, and definitions.
Comprehension	Explaining and interpreting the meaning of material.
Application	Using a concept or principle to solve a new problem.
Analysis	Breaking material down into parts to see interrelationships.
Synthesis	Producing something new from component parts.
Evaluation	Making a judgement based on criteria.

(Duch, Groh and Allen, 2001:50)

Level one is knowledge, the facts and base level knowledge (terms) of the work. Level two is comprehension, which is the learners' understanding of the work. Learners must understand the work by explaining or giving examples of certain phenomena. The third level is application which includes problem-solving and process skills. This level will entail higher level questions regarding population dynamics. Analysis and synthesis, together with evaluation, constitute the higher levels of the taxonomy. Analysis and synthesis influence activities in problem-solving and scientific inquiry. Duch, Groh and Allen (2001:49) comment that a problem's questions should challenge students to develop higher-order thinking skills, moving them beyond the lower cognitive levels of knowledge and comprehension to the higher levels where they analyse, synthesise and evaluate. Evaluation comprises comparisons and decision making based on reasoned argument.

This hierarchy endorses the need for learners to be exposed to content knowledge before they can understand certain phenomena. Only when they understand will learners be able to apply knowledge during problem-solving and scientific inquiry. Bloom's taxonomy confirms the importance of prior knowledge. Comments by Ausubel (1968:538) support this view that without background knowledge of concepts and principles no problem-solving is possible irrespective of the learner's degree of skill in discovery learning. Ausubel (1968:538) goes further by asserting that without background knowledge learners cannot even begin to understand the nature of a problem confronting them. Kearsley (2009a:2) reiterates two of Ausubel's principles of learning:

> "The most general ideas of a subject should be presented first and then progressively differentiated in terms of detail and specificity. Instructional materials should attempt to integrate new material with previously presented information through comparisons and cross-referencing of new and old ideas."

According to Piaget (in Monteith, Postma and Scott, 1988:125), one of the factors affecting cognitive development is experience and without experience learners will not be able to develop their thoughts. Moreover, Maree and Ebersöhn (2002:178) contend that "the effective performance of work duties requires knowledge, ability, skills, creative thinking, etcetera, which are all part of cognitive behaviour." Educators can create opportunities for learners to gain experience and perform their work more effectively by allowing them to conduct experiments or study models. This can also be done by applying their prior knowledge to the task at hand. If learners understand that all organisms are divided into taxons and classes (systematics), they will understand that there are structures or hierarchies in the Life Sciences. Learners will also be able to fully comprehend the place and importance of biodiversity and population dynamics in Life Sciences and other biological domains. It will become clear to them that although concepts seem to be units on their own, concepts are linked to one another. This will help them to link their knowledge of systematics to population dynamics and biodiversity. Maree and Ebersöhn (2002:272) see comprehension as being:

> "When one can only remember or fully use ideas that you understand and that one must check the logic behind the ideas."

In the constructivist paradigm it is assumed that intellectual engagement (learning) influence social and cultural development. Learners construct new knowledge through prior learning and cultural perspective. Thus, prior learning can be linked to the constructivist approach. Intelligent thoughts include self-monitoring of learning and thinking. To understand something is the prime principle and understanding supports the transfer of knowledge which empowers learners to apply their knowledge and make an analysis or evaluation or synthesis depending on the task confronting them. Duch, Groh and Allen (2001:101) make a similar point:

> "Complex situations involving multiple concepts based on the real world or some novel setting the students have not previously encountered, lend themselves to this: questions can be asked that require students to recognise the concepts involved (analysis), to use those concepts in answering the questions (application), to judge the relative merits of different explanations, and/or to pull several ideas together to make predictions (synthesis)."

The constructivist approach also links to the work of Bruner. Kearsley (2009b:1) mentioned that Bruner supports learning as an active process in which learners construct new ideas or concepts based upon their current or past knowledge. Learners select and transform information, construct hypotheses and make decisions, always relying on a cognitive structure to do so.

3.6 Content knowledge

Content-orientated theorists are concerned with the identification of the major sources that influence the development of curriculum content (Glatthorn, Boschee & Whitehead, 2006:81). Certain general outcomes are determined, learning activities and content are then selected that will challenge learners' to reach their maximum potential. An educator is regarded as a facilitator of curricula, who interprets content and uses it in certain ways to reach the outcomes as stated in the curriculum. Educators should follow this way of teaching in the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006. Although the curriculum is outcomes-based, content remains an important medium used to achieve the outcomes. Educators can provide learners with sufficient content knowledge to ensure that learners reach the outcomes. The same applies to the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009, even with the reintroduction of systematics into this curriculum.

3.7 Conceptual framework for this study

The conceptual framework used in this study was based on the Cultural-Historical Activity Theory (CHAT). Engeström and Miettinen (1999:1) explain that activity theory is a commonly accepted name for this line of theorising and research initiated by the founders of the cultural-historical school of Russian psychology, Vygotsky, Leont'ev and Luria in the 1920 and 1930s.

Various authors stipulated in Foot (2001:62) that,

> "First, activity theory is deeply contextual and oriented at understanding historically specific local practices, their objects, mediating artifacts, and social organization. Second, activity theory is based on a dialectical theory of knowledge and thinking, focused on the creative potential in human cognition. Third, activity theory is a developmental theory that seeks to explain and influence qualitative changes in human practices over time."

Robertson (2008:819) explained that the existence of an activity is motivated by transforming an object into an outcome by engaging it through mediating artifacts. Engeström (1999:380) stated that an activity system constantly generates actions through which the object of the activity is enacted and reconstructed in specific forms and contents – but being a horizon, the object is never fully reached or conquered.

The CHAT perspective is useful for understanding curriculum development because it allows the researcher to capture and study the complexities involved in curriculum development as well as the dynamics of the school environment and factors affecting it. Activity is seen as a social practice performed by a subject, where the doing is orientated or directed at an object (Kuutti, 1996:27; Engeström, 1999:380). The activity that is referred to in this study is curriculum development. According to Engeström (1999:380) the object (the curriculum development environment) is reconstructed during the activity, but being a 'horizon', the outcome (the ideal curriculum) is never fully achieved.

The relationship between the subject (curriculum developers), the curriculum that is envisaged as outcome is illustrated in Figure 3.1.

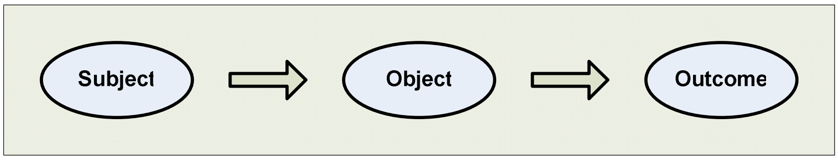

Figure 3.1 The basic structure of an activity system (adapted from Capper & Williams, 2004:10).

Foot (2001:65) described that Engeström expanded on the activity system model and included three additional components that,

> "explicate the social structure of activity; 1) rules that regulate the subject's actions toward an object, and relations with other participants in the activity; 2) the community of people who share a interest in and involvement with the same object; and 3) the division of labour – what is being done by whom toward the object."

This expanded model is illustrated in figure 3.2 below.

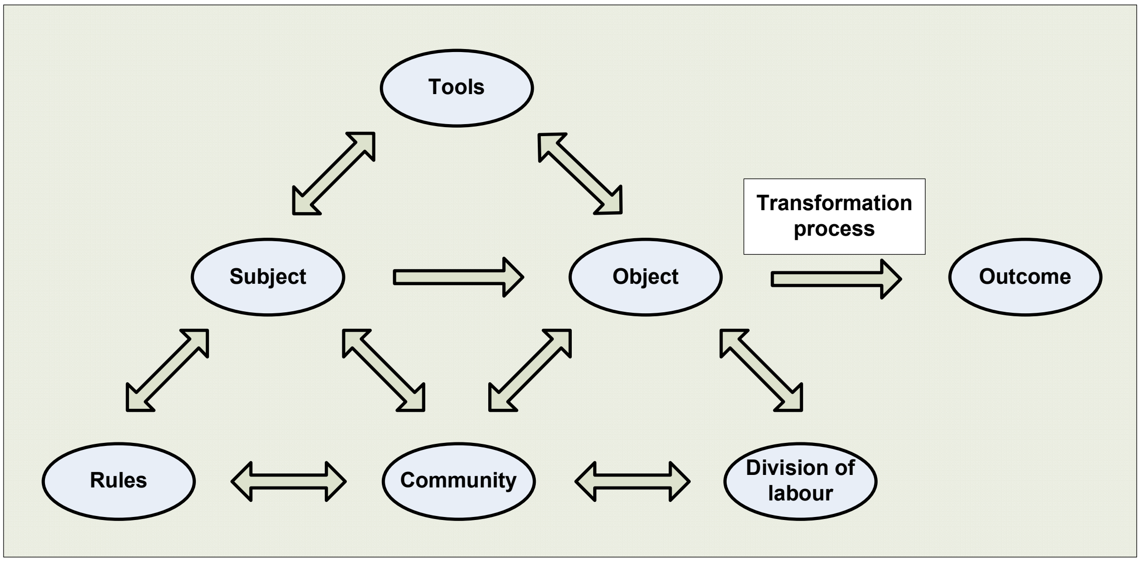

Figure 3.2 An expanded model of an activity system (Capper & Williams, 2004:10).

The subjects (the curriculum developers) do not work in isolation, but they operate in a context that is influenced by social, historical and political factors. Capper and Williams (2004:9) point out that the nature of our social relationships are the product of cultural and historical traditions and experiences, and those cultural and historical perspectives define not just how we work, but also why we work. The activity is also constrained by rules such as policies and work schedules. The curriculum developers performing the activity have to work with many stakeholders that have an interest in this activity. These stakeholders represent the scientific community, such as Government Departments, the provincial Education departments, experts in the subject and in curriculum development, educators and even the learners that will use the curriculum. Within the community of interested parties, a division of labour will influence the way that the activity is performed. The division of labour places the focus on the educators' teaching and own learning and professional development as well as the responsibilities of the other parties involved in curriculum development and the implementation thereof.

When looking at the abovementioned statements the outcomes of the object (curriculum) should be the achieving of the outcomes stated in either the NCS Life Sciences curriculum implemented in 2003 or those stipulated in the New Content Framework Life Sciences curriculum implemented in 2009. These outcomes include the Life Sciences educators' professional development and pedagogical content knowledge development and the effective teaching of population dynamics and biodiversity with a focus on problem-solving and scientific inquiry with the exclusion or inclusion of systematics depending on which curriculum is part of the system. The researcher believes that educators must decide which content and sections of systematics should be added to the content already included in the curriculum to ensure that learners understand population dynamics and biodiversity. Tools that the subjects have available to help them achieve the intended outcome include subject content, content knowledge, human resources such as curriculum developers, experts and educators, physical resources and tools such as existing curricula that have been implemented in other countries, textbooks and models of curriculum development.

Yamagata-Lynch (2003:111) argued that components in an activity system not only mediate each other for the subject to attain the object but can mediate each other to stop the subject from attaining the object. It is important to consider the influence tools have on the object to reach the outcomes. As stated above the subject content can be seen as a tool, but the researcher hypothesise that the focus of the development team was on outcomes and not content. This means that the tool was not optimally used to guide the curriculum development team's way of thinking during the development of the NCS Life Sciences curriculum (Department of Education, 2003). Therefore the lack of content led to deficiencies in this curriculum. Furthermore, it is hypothesised that the prior knowledge required by the learners to fully comprehend new concepts and the prior knowledge (academic background) of the educators were not taken into consideration when developing this curriculum. Therefore, activity theory could be used to explore the relationship between the educators, curriculum developers, subject matter experts, the Life Sciences curriculum and the substance and syntax content.

The value of applying CHAT to curriculum development is that it provides a framework in which curriculum development can be better understood and contextualised in terms of social, cultural, historical and political events. This context could explain why changes came to be made even though these changes did not always prove effective in improving the curriculum. Activity theory indicate that changes to a curriculum, such as exclusion of systematics as a separate unit from the NCS Life Sciences curriculum, could result in unforeseen consequences occurring in other areas of the curriculum (the teaching of population dynamics and biodiversity). My point of view regarding curriculum development and learning is similar to that of Billet (2003:18) regarding vocational learning,

> "…in order to improve the kinds of experiences and outcomes that are provided to its students or learners, the bases of the goals and content of curriculum and instruction for vocational learning may need to be revised.…curriculum frameworks and documentation need to be understood as an expression of national need, rather than something able to account for the diversity of vocational practice within a country."

With each curriculum being developed there is the hope that it will be the ideal curriculum. However, Foot (2001:67) stated that contradictions are present in every collective activity and indicate emergent opportunities for the activity development. However, once the curriculum gets implemented its shortcomings are exposed. This leads to opportunities for more development and continuous change within the field of curriculum development.

3.8 Summary

Problem-solving and scientific inquiry form an integral part of the NCS Life Sciences curriculum (Department of Education, 2003). Educators can use these skills to help learners comprehend the learning content. Learners must use their prior knowledge during problem-solving and scientific inquiry to develop their understanding and knowledge of the concepts and processes. Educators have the responsibility to create a number of different activities to ensure that the outcomes and applicable skills and knowledge are achieved.

This chapter defined problem-solving and scientific inquiry; problem-solving and scientific inquiry were discussed as modes of inquiry in population dynamics and biodiversity; and the importance of content knowledge and prior knowledge was emphasised. The conceptual framework of the research was outlined. The following chapter describes the methodology used in this study. The chapter informs the reader about the data collection methods used to gather the necessary evidence.

Chapter 4
Methodology

4.1 Introduction

Research can be approached quantitatively, qualitatively or by a mixed-methodology (multiple-methodology) approach. Quantitative research uses numeric data and presents it in an explanatory manner to reach conclusions. It is a scientific approach because situations are explained in terms of facts and real cause and effect. Henning, Van Rensburg and Smit (2004:3) explain that the focus in a quantitative study is on control of all the components in the actions and representations of the participants – variables are controlled and the study is guided with an acute focus on how variables are related. The philosophy of this approach is that conclusions are true and observations are objective because the observer is open–minded and has minimum influence on the research.

Quantitative research makes use of numerical data, statistical applications and experimental designs that are not interpreted beyond what the numbers state. According to Smit (2001:65):

> "The research purpose in quantitative research endeavours is to establish relationships and to explain the causes of changes in measured social facts. This aim is in contrast with the purpose of understanding the social phenomenon from the respondents' and participants perspectives, as in qualitative research."

This view is supported by Denzin and Lincoln (2005:10) and Hittleman and Simon (2006:53) who add that variables should be mathematically measured and adherents to this approach stress that data should be repeatedly verified.

In qualitative research insights are gained through discovering meanings by improving our comprehension of the whole. Henning, Van Rensburg and Smit (2004:3) say the following about this approach:

> "In qualitative study the variables are usually not controlled because it is exactly this freedom and natural development of action and representation that we wish to capture."

There might be some use of numerical data as long as the main focus is open-ended. Information is gathered by means of interviews, document analyses and observation to name a few. Qualitative research explores the richness, depth and complexity of phenomena. According to Strauss and Corbin (1990, in Neill, 2006:1) qualitative research, broadly defined, means any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification.

The third approach is a combination of the above two approaches and is called mixed-methodology (multiple-methodology) research. Creswell (1998:177-178) states that one way in which the paradigms may be mixed is in their use of theory or methods. Researchers conducting research by means of mixed methodology (multiple-methodology) use qualitative and quantitative data collection methods and present the data in numerical ways as well as in descriptive ways. Schulze (2003:13) cautions that since researchers must alternate between qualitative and quantitative paradigms, this mixed methodology is better suited to the experienced researcher with a sophisticated knowledge of both paradigms.

In this study a qualitative approach is followed, the purpose of which Myers (2002, in Neill, 2006:3) characterises as:

> "The ultimate aim of qualitative research is to offer a perspective of a situation and provide well-written research reports that reflect the researcher's ability to illustrate or describe the corresponding phenomenon. One of the greatest strengths of the qualitative approach is the richness and depth of explorations and descriptions."

Qualitative research is used to investigate the qualities (properties or characteristics) of particular phenomena and not necessarily the quantities (measurements or percentages). According to Del Barrio, Gutierrez, Hoyos, Barrios, Van der Meulen and Smorti (1999:1):

> "The term qualitative is applied to several procedures of data-collection as much as to different procedures of data analysis. In relation to data collection, the qualitative methods include non–structured procedures from observation to interview, self reports or written narratives. In relation to data analysis, an analysis is qualitative whenever there is not a numeric translation of data beyond the translation to absolute or percentage frequencies."

Creswell (1998:15) claims that qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. While Woods (1999:2) expounds that qualitative research is concerned with life as it is lived, things as they happen, situations as they are constructed in the day-to-day, moment-to-moment course of events. Hittleman and Simon (2006:65) emphasise that qualitative research is characterised not by the use of numerical values but by the use of text – written words – to document variables and the inductive analysis of the collected information.

It is clear that although writers provide different definitions of qualitative research, they convey similar ideas. Qualitative research is done to explain certain events or phenomena by making use of various data collection methods, excluding any numeric data or numeric translations and by presenting its data in a descriptive, explanatory manner. Some use of numerical data is acceptable as long as the main focus remains open-ended.

This study does not make use of numerical data or any statistical values. The research sub-questions will be answered from the respondents' perspectives and the data will be gathered from document and text analysis as well as classroom observations. The data are considered to represent the deeper meanings of the phenomena being studied. Besides, the researcher uses the freedom to explore new topics, ideas or information which were not identified at the outset of the study.

4.2 Why qualitative research?

The topic chosen lends itself to qualitative research because it needs to be explored and explained in detail. It is not easy to identify variables and the answers to the problem are not straight forward. Henning, Van Rensburg and Smit (2004:6) have commented that "the researcher makes meaning from the data by seeing the bigger picture and by converting the raw empirical information into what is known in qualitative research as a thick description …." In order to gain the necessary information, qualitative research fits this investigation better because document and text analysis (FET curriculum, work schedules, textbooks and learners' workbooks), classroom observations and interviews with educators were conducted. Also, a curriculum developer, an expert in systematics and an expert in ecology were interviewed and there was communication via email with another curriculum developer. The interviews with the educators and curriculum developers were conducted twice, the first being based on the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 which excluded systematics as a separate unit and the second round on the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009 in grade 10 which included systematics as a single unit. According to Henning, Van Rensburg and Smit (2004:6), the three main categories of data collection in qualitative research are observation, interviewing and artefact and document studies.

According to Myers (2002, in Neill, 2006:3), a criticism of qualitative research is that since our humanness obtains throughout the research process, it is near impossible to escape subjective experience: everybody has own opinions regarding certain matters. But, as stated in the section on ethics of research, the researcher tried to maintain as unbiased as possible by allowing the collected data to guide his findings and conclusions.

On the other hand, Myers (2002, in Neill 2006:3) mentions that one of the strengths of the qualitative approach is the depth to which explorations are conducted and descriptions are written. Qualitative research relies on reasons behind various aspects of behaviour. Simply put, it investigates the why and how of decision making, compared to the what, where and when of quantitative research.

4.3 Data collection

This section will be discussing the sampling method used to identify the respondents for this study, the methods used to gather the data and reasons for using these methods. The ethical considerations will be discussed and the validity and reliability of the research will be presented.

4.3.1 Sampling method

De Vos, Strydom, Fouché and Delport (2005:328) point out that in qualitative studies non-probability sampling methods are used, particularly theoretical or purposive sampling techniques are used rather than random sampling. To select the participants for this research, purposive sampling was used. According to Henning, Van Rensburg and Smit (2004:71) purposive sampling looks at people who fit the criteria of desirable participants. Furthermore, De Vos, Strydom, Fouché and Delport (2005:328) comment that clear identification and formulation of criteria for the selection of respondents is cardinally important because respondents will be the sources of data. Therefore, if the respondents do not adhere to the criteria of the research, a minimum amount of data will be gathered.

Various sources were used to gather the required information and according to Watkins (2006:45) this triangulation of data refers to research where data is collected over different time frames or from different sources. Triangulation of data is well suited to this study's purposes.

In addition to purposive sampling, convenience sampling was also used. This means that participants who could be found most conveniently were drawn into the sample. Thus, conveniently located schools in Gauteng were approached. Maree (2003:39) defines convenience sampling as a method used when the population elements that can be found most conveniently are drawn into the sample. Watkins (2006:48) notes that convenience sampling does not identify a subset of a population and makes use of participants who are readily available. Thus, schools teaching the content envisaged by the Diversity, Change and Continuity strand and which gave the necessary consent, were used in the study.

4.3.2 Semi-structured interviews

One of the many methods which can be used when conducting qualitative research, namely semi-structured interviews, was used. In semi-structured interviews the researcher has a set of questions, but if a new idea arises from information provided by the respondent, the researcher can ask questions relating to it. The interview schedules are included in Appendix B. De Vos, Strydom, Fouché and Delport (2005:296) explain that in semi-structured interviews although the researcher has a set of pre-determined questions on an interview schedule, the interview is guided by the schedule rather than be dictated by it, giving the researcher more freedom to explore new phenomena than is the case in structured interviews.

In this research the semi-structured interviews did enable the interviewer to clarify some information provided by respondents as the interviews progressed. Another benefit of this type of interview was that respondents brought up issues that the schedule did not consider. Leedy, Newby and Ertmer (1997:199) observe that semi-structured interviews include closed-form questions with probes designed to obtain additional, clarifying information. The procedure allows the researcher to better understand the respondent's point of view.

Semi-structured interviews are one type of interview, others are structured interviews and unstructured interviews. Structured interviews include questions decided upon before commencement of the interview. The interviewer sticks to the questions and does not deviate. Unstructured interviews, on the other hand, are interviews in which the researcher asks questions as the interview progresses. The researcher has a set of questions and asks random questions to different respondents. Merriam and Associates (2002:12) inform that:

> "Interviews range from highly structured, where specific questions and the order in which they are asked are determined ahead of time, to unstructured, where one has topic areas to explore, but neither the questions nor the order are predetermined."

Henning, Van Rensburg and Smit (2004:70), refer to Warren's division of interview research into three phases, namely:

> "Finding the respondents and setting up the interview in accordance with the overall research design, conducting and recording the interview and reflecting on the interview and working with, or analysing and interpreting the data."

These phases are identifiable in the procedures followed in this research.

Information was gathered by conducting semi-structured interviews with four educators, who teach Life Sciences to the grade 11 learners at two different secondary schools in Gauteng. These two Afrikaans medium schools were former model C schools. The educators interviewed were three females and one male. Two females are young educators with ten years and less experience each. The other two educators, a male and a female, are both heads of their Life Sciences departments and each has more than 17 years of teaching experience. This ensured a more representative sample of teachers, regarding sex, age, background and type of school. In order to ensure anonymity, the following pseudonyms are used in Chapter 5:

- Female, head of the Life Sciences department (school 1) – Ms A who has a BSc with zoology and entomology as main subjects and obtained a Higher Education Diploma (HED).

- Female, educator (school 1) – Ms B is a BA (Life Orientation) graduate who, took biology as an extra subject and she also has a Higher Education Diploma (HED).

- Male, head of the Life Sciences department (school 2) – Mr C has a BSc Honours in botany and a Higher Education Diploma (HED).

- Female, educator (school 2) – Ms D studied BSc (Human Movement Science) with physiology as a main subject and has a post graduate Certificate in Education.

Two female curriculum developers were interviewed. Both were involved in the development of the grade 11 NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006. Both currently work at universities. One has been actively involved in Life Sciences education as an examiner for the grade 12 Gauteng Department of Education examination. She has also presented papers at a number of conferences and has written numerous scientific articles and textbooks. She is a well-known Life Sciences educator who is involved in curriculum development with a particular interest in Life Sciences. The other curriculum developer has been involved in biology curriculum development as a research focus since 2005 and she has a solid publishing record.

A pseudonym was given to each curriculum developer, to identify them easily and to ensure anonymity (Chapter 5).

- Curriculum developer 1 – Ms X is a curriculum developer with a BSc Honours in Zoology, a Masters in Curriculum Development and Evaluation and a Masters in Science Education.

- Curriculum developer 2 – Dr Y is a curriculum developer with a BSc Honours degree in Biological Sciences and a PhD in Zoology.

The researcher also interviewed an expert in the field of systematics and an expert in ecology. Both experts in ecology and systematics who were interviewed for this study were females and they had been involved in their specialised areas for many years. One is currently working at a university in the Botany Department and the other one in an institution dedicated to the study of biodiversity.

Pseudonyms were given to the experts to identify them and to preserve their anonymity (Chapter 5):

- Expert in ecology – Prof E
- Expert in systematics – Dr S

Interviews were originally conducted in 2008 with emphasis on the exclusion of systematics as a separate unit from the NCS Life Sciences curriculum (Department of Education, 2003) and the effect it has on the teaching of population dynamics and biodiversity. Follow-up interviews were conducted to determine how the reintroduction of systematics as a single unit in the New Content Framework for Life Sciences (Department of Education, 2007a) changed the way these topics were taught.

The data was tape-recorded, transcribed and analysed. De Vos, Strydom, Fouché and Delport (2005:298), advise that the researcher should record interviews and that tape-recording provides a more complete record than do notes taken during an interview. The interviews were transcribed by listening to the tapes and typing the dialogue. Transcriptions were logically analysed to capture common concepts related to the interview questions. These concepts were then clustered to define the factors applicable to the research sub-questions. Each factor therefore embraces certain commonalities reported in the transcripts. The factors which were uncovered were then used to answer the sub-questions and to determine whether the assumptions made prior to the study were valid or not. Concerning analysis, Merriam and Associates (2002:14) explain that:

> "…data analysis is essentially an inductive strategy. One begins with a unit of data (any meaningful word, phrase, narrative, etc.) and compares it to another unit of data, and so on, all the while looking for common patterns across the data. These patterns are given names (codes) and are refined and adjusted as the analysis proceeds."

Some examples of the concepts identified during the analysis of the interviews were preparation for teaching, time allocation and resources, systematics as part of population studies and biodiversity, interpretation of curriculum and restriction of skills. A typical example of commonalities that was uncovered was interpretation of the curriculum and systematics as part of population studies and biodiversity.

4.3.3 Document and text analysis

The research also involved the analysis and evaluation of the FET policy document and the FET Life Sciences curriculum and work schedule, provided by the Gauteng Department of Education. The documents for the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 and those for the Diversity, Change and Continuity strand of the New Content Framework for Life Sciences (Department of Education, 2007a:23-25) implemented in 2009 were studied. According to Merriam and Associates (2002:13) the strength of documents as an information source lies in the facts that they already exist in the situation; they do not intrude upon or alter the setting in ways that the presence of the investigator might do; and they do not depend on human co-operation.

The content of the grade 11 NCS Life Sciences curriculum (Department of Education, 2003) was studied with emphasis on systematics, population dynamics and biodiversity because these are the concepts specifically related to the research question. The researcher studied the old NATED 550 Biology curriculum (Department of Education, n.d.), NCS Life Sciences curriculum (Department of Education, 2003) and the New Content Framework for Life Sciences (Department of Education, 2007a). By doing this it was possible to determine which content has been taken out, added, shifted between grades or is new in the different grades. This enabled the researcher to piece together evidence about the research problem.

The workbooks of learners in the grade 11 NCS Life Sciences curriculum were also studied by using a workbook evaluation tool (see Appendix C and more detail on this workbook evaluation tool is included in section 4.3.6). Ten workbooks were studied per school, equal numbers of girls and boys per school were involved and they ranged from learners who struggled to top achievers in the grade 11 Life Sciences (as indicated by the educators). This was done to determine whether or not educators include knowledge of systematics as prior knowledge to master some concepts in population studies and biodiversity. It was also done to determine the links between content knowledge (substance) of systematics, population dynamics and biodiversity during scientific inquiry and problem-solving in grade 11 Life Sciences. Because the portfolio files of the learners did not contain any content within the Diversity, Change and Continuity strand, they were excluded. The two textbooks (Clitheroe, Doidge, Marsden, Van Aarde, Ashwell, Buckley and Dilley, 2006 and Grobler, n.d.) used in the schools were studied and their content and activities in the Diversity, Change and Continuity strand were compared.

4.3.4 Classroom observation

Merriam and Associates (2002:13) mention that observation is the best technique when an activity, event, or situation can be observed first-hand; when a fresh perspective is desired; or when participants are not able or willing to discuss the phenomenon under study. The reasons for conducting classroom observations were to observe first-hand whether the grade 11 Life Sciences educators integrated knowledge of systematics during the teaching of population dynamics and biodiversity, to get an indication of the learners' prior knowledge of systematics, and to assess whether this concept was integrated during the teaching of population dynamics and biodiversity. The classroom observation tool is included in Appendix D and is discussed in more detail in section 4.3.6.

Observation can be done while taking part in *all* the activities, that is a participating observer, by observing and taking part in *some* activities or by only observing and not being part of *any* activities. In this study the researcher only observed in the classroom and did not take part in any discussions or explanations. This was done to ensure that the researcher had minimum influence on the classroom activities.

The classroom observations were conducted during times when the relevant lessons were being taught in class. Time frames were obtained in advance from the educators. Consent for participation was obtained from the Gauteng Education Department, the principals, educators, parents or guardians and the learners.

4.3.5 Ethical considerations

According to Saunders, Lewis and Thornhill (2000:130), ethics is the appropriateness of one's behaviour in relation to the rights of those who become the subject of your work, or are affected by it. In research, it is important to remember that the respondents are the most important part of the study. The respondents must remain anonymous, which means that their names must not be used and they must only be used in a study if they give their full consent. Leedy and Ormrod (2001:107-108) comment on this issue in the following way:

> "Most ethical issues in research fall into one of four categories namely, protection from harm, informed consent, right to privacy, and honesty with professional colleagues."

Participants were told in advance about the nature of the study to be conducted and they were given the choice of either participating or not participating. Informed consent letters (see Appendix E) describing the nature of the research as well as the nature of the required participation were presented to participants as well as to their parents or guardians as applicable. Participants were given the right to withdraw from the study at any time because participation was strictly voluntary. Prior to commencement of the study the researcher applied to the Gauteng Department of Education to obtain permission to conduct the research in Gauteng secondary schools and the permission was granted. The research proposal was also presented to the Ethics Committee of the University of Pretoria and this study was given the consent to continue as planned.

During collection and analysis of the data, the researcher was as unbiased as possible. Hittleman and Simon (2006:66) state that "the qualitative researcher must attempt to maintain a non-judgmental bias throughout the study." Accordingly, the researcher was open to other possibilities and attempted to have no preconceived ideas. When the researcher was not totally clear about an answer given by a participant, the participant was asked to explain what was meant, thus ensuring that the information collected reflected the participants' opinions.

The information elicited from participants was used in such a way that nobody will be able to trace it back to a particular participant. All the information was handled with confidentiality and participants remain anonymous and the participants' information was used in an honest and unbiased way. The information gathered is low risk because it is about modules and policies which were analysed and evaluated. The information acquired by the semi-structured interviews and classroom observations was handled with similar care.

The findings are reported in a complete and honest fashion without misrepresenting what has been done or intentionally misleading others as to the nature of the findings. The researcher has not fabricated data to support a particular conclusion, no matter how seemingly "noble" that conclusion may be.

Participants who asked for feedback on the research process and its conclusions were supplied with what they requested. Only the specific participant had access to the information provided by him or her. All participants were allowed to read through the transcribed version of their interview to ensure that it recorded what they said and meant. Thus, the participants would only get feedback on the information provided by them. All of these conditions were stated in the consent letters. However, nobody required any feedback.

4.3.6 Validity and reliability estimations within a qualitative study

Prior to commencing the discussion on validity and reliability it should be noted that crystallisation and trustworthiness are terms more frequently used in qualitative research. Maree and Van der Westhuizen (2009:35) explain that crystallisation refers to the practice of 'validating' results by using multiple methods of data collection and analysis. According to Golafshani (2003:601) examination of trustworthiness is crucial to ensure reliability in qualitative research. Seale (1999, in Golafshani, 2003:601) is of the opinion that the "trustworthiness of a research report lies at the heart of issues conventionally discussed as validity and reliability." In this study the terms validity and reliability will be used, because trustworthiness relates to both these terms. Furthermore, because crystallisation embraces triangulation, the phenomenon captures validity as well. This implies that as value is added through the application of triangulation strategies, our understanding of a certain component of reality changes and grows.

Leedy, Newby and Ertmer (1997:32) state that validation is concerned with the soundness and effectiveness of the measuring instrument. When applied to this research it means how well the methodology measures that which is stated in the research question. To ensure validity as far as possible the interview schedule was given to experts to refine the questions and after the interviews had been conducted coding and recoding was done to group similar factors together. Document and text analysis (section 4.3.3) were done to identify the themes and possible shortcomings in the documentation. This is a way to validate the arguments and research. Workbooks and textbooks were studied and classroom observations conducted to add more evidence to the aforementioned data collection methods. Thus, triangulation was achieved by using multiple data collections. The following statement by Merriam and Associates (2002:25) support the validity of the research:

> "…qualitative researchers are the primary instruments for data collection and analysis, interpretations of reality are accessed directly through observations and interviews…internal validity is considered a strength of qualitative research."

Maree (2003:108) stated that reliability is the extent to which a test measures consistently that which it is measuring. The definition given by Leedy, Newby and Ertmer (1997:5) is similar, "Reliability is the consistency with which a measuring instrument performs."

As stated in sections 4.3.3 and 4.3.4 respectively, a learner workbook evaluation tool and a classroom observation tool were used in this study. Both tools were evaluated by experts for their applicability. These tools were used to gather information which can be used to answer the research question and some of the sub-questions. Each tool was broken down into categories to identify the strand (theme), topic and activity of the lesson taught in class or content in the learners' workbooks. Furthermore, the tools were used to determine whether there was evidence of systematics, scientific inquiry and problem-solving during teaching or in the learners' workbooks. The other categories of the leaner workbook evaluation tool were the type and aim of activity (such as worksheet, experiment, research project, simulation), group work or individual work and practical (models, experiments) or theoretical (written work) activities. The other categories of the observation tool were the method of teaching (how information was taught), resources used (such as transparencies, textbooks or models), which concepts and content was emphasised and the learners' involvement in activities (such as completing worksheets, group work, experiments). Table 4.1 gives evidence enhancing the validity and reliability of the conducted research.

Table 4.1: Summary of the strategies for enhancing validity and reliability in qualitative research and their role in this study.

Strategy	Description	Evidence from the study
Triangulation	Using multiple investigations, sources of data, or data collection methods to confirm emerging findings.	Document and text analysis, classroom observations and semi-structured interviews.
Peer review/examination	Discussions with colleagues regarding the process of study, the congruency of emerging findings with the raw data, and tentative interpretations.	Discussions with study supervisor and co-supervisor.
Researcher's position or reflexivity	Critical self-reflection by the researcher regarding assumptions, worldview, biases, theoretical orientation, and relationship to the study that may affect the investigation.	The researcher tried to be as unbiased as possible during the research and used the information to guide himself to the findings.
Audit trail	A detailed account of the methods, procedures, and decision points in carrying out the study.	Recordings of interviews and transcribed evidence of interviews conducted. Evidence from workbooks studied and classroom observations conducted. Evidence of textbooks studied and document and text analysis. Email correspondence with curriculum developer.
Rich, thick descriptions	Providing enough description to contextualise the study such that readers will be able to determine the extent to which their situation matches the research context, and hence, whether findings can be transferred.	The thesis includes the description to contextualise the study for the reader.

(Adapted from Merriam and Associates, 2002:31)

4.4 Summary

This chapter presented three research approaches that can be followed. Emphasis was placed on the differences between the approaches and reasons were given for conducting the research qualitatively. The methods used to collect data, namely semi-structured interviews, data and text analysis and classroom observations were explained. The application of these methods in the study was described. Finally, the ethical considerations and the validity and reliability of the research were discussed. Reference was made to the interview schedule and the tools used for data collection. The next chapter presents, describes and interprets the results of the data collection and analysis procedures.

Chapter 5

Results of the document and text analysis, semi-structured interviews and classroom observations

5.1 Introduction

The methods used to gather the required information for the research were discussed in the previous chapter. This chapter reports on the data following screening and its use as evidence to address the research question, sub-questions and associated interview questions. The evidence is used to validate assumptions made at the outset.

The chapter is structured according to the three data collection methods. First, there is a discussion on the results of the document and text analysis, followed by treatment of the responses to the semi-structured interviews conducted with the educators, curriculum developers and experts in systematics and in ecology and finally the findings of the classroom observations are reported. The discussion of the semi-structured interviews is linked to each research sub-question and the associated interview questions.

5.2 Document analysis

The grade 11 NCS Life Sciences curriculum (Department of Education, 2003), the work schedule, textbooks used by the two schools and the content of the learning material were analysed. Information was also extracted from the NATED 550 Biology curriculum (Department of Education, n.d.) and the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009.

5.2.1 Changes to the NATED 550 Biology curriculum

Table 5.1 indicates the changes in grade 10, 11 and 12 content that occurred in the FET phase with the implementation of the NCS Life Sciences curriculum (Department of Education, 2003) in grade 10 in 2006. Some content was removed, some remained intact, other was moved between grades and some new content was added.

Table 5.1: Rearrangement of content when Biology changed to Life Sciences in 2006 for grades 10 to 12.

CONTENT CHANGES	GRADE 10	GRADE 11	GRADE 12
Content REMOVED from the different grades		Bryophytes, Pteridophytes, Angiosperms, Gymnosperms, Coelenterata, Platyhelminths, Annelids, Arthropods, Vertebrates	Biochemistry: Water, Macro- &micro-nutrients. Organic compounds (carbohydrates, proteins, enzymes, lipids), vitamins. Water relationships in plants: transpiration, guttation. Growth hormones.
Content REMAIN in the different grades	Cell structure (osmosis). Tissues (plant & animal). Related diseases e.g. cancer. Biospheres, biomes, ecosystems, living and non-living factors, nutrient cycles, energy flow, parasitism, e.g. bilharzias.	Micro-organisms: viruses, bacteria, protists, fungi with related diseases, e.g. rabies, HIV, etc. N.B. There is a shift in emphasis! Remember, things are included by implication.	
Content MOVED between the different grades	From grade 11 to 10: Mitosis. From grade 12 to 10: Photosynthesis Respiration Nutrition Gaseous exchange.	From grade 10 to 11: Anatomy and Physiology: support – skeleton Transport systems – blood and lymph. From grade 12 to 11: Excretion Co-ordination (nervous & chemical) Population studies, growth graphs, fluctuations in populations, social behaviour, e.g. predation, competition, managing populations.	From grade 11 to 12: Nucleic acids Chromosomes, meiosis Genetics and related diseases e.g. Down's Syndrome Reproduction
NEW content added to the different grades	Biodiversity of plants & animals, significance & value of biodiversity. History of Science, threats to biodiversity.	Human influences on environment, effects of pollution on human physiology and health (allergies), air, land and water-borne diseases.	Origin of Species, evolution theories, natural selection, macro-evolution & speciation, fundamental aspects of fossil studies, Cradle of Mankind – S.A., evidence of evolution of populations, popular theories of mass extinction.

(Adapted from Department of Education, 2005b)

The researcher's concerns regarding these changes were discussed in Chapter 1.

5.2.2 The New Content Framework for Life Sciences implemented in 2009

Table 5.2 compares the content included in the Diversity, Change and Continuity strand of the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009 with the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 and the NATED 550 Biology curriculum (Department of Education, n.d.).

Table 5.2 provides evidence that some of the content included in the latest Life Sciences curriculum (Department of Education, 2007a) was previously included in the NATED 550 Biology curriculum. This content was mostly related to the classification of organisms, animals and plants into groups. Content on parasitic worms and ectoparasites is the other similarity between these two curricula.

Content of the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009 which was also included in the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 is animal and plant biodiversity, threats and value of biodiversity, influence of humans on biodiversity and the environment, forestry, ectoparasites, the five-kingdom classification and the role of Linnaeus in classification, fossil information and evolution.

The table also shows the content added to the New Content Framework for Life Sciences (Department of Education, 2007a) that was not included in the previous two curricula (NATED 550 Biology curriculum (Department of Education, n.d.) and NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006). Most new content was based on either the classification of organisms (three-domain system with kingdoms in each domain, history of life on earth, naming things in science using Latin) or on life's history (key events in life's history for which there is evidence from southern Africa, the role of South African scientists in the discovery of the first living coelacanth, the sixth extinction, fossil tourism). Other new content is diversity of life and endemic species, distribution maps of species, interpreting a phylogenetic tree representing the evolutionary history of animals, the role of invertebrates in agriculture and ecosystems as well as the sustainable use of animals in South Africa. Finally, content on modifications of basic body plans and biogeography have been included.

Table 5.2: The content of the Diversity, Change and Continuity strand of the Life Sciences curriculum implemented in 2009 compared to that of the previous curricula.

Content changes	**Life Sciences curriculum implemented in 2009**		
	Grade 10	**Grade 11**	**Grade 12**
Content SIMILAR to NATED 550 Biology curriculum	Classification of organisms into groups: Bacteria, protists, fungi, plants and animals. (Included in grade 11 NATED 550) Classification systems: Two-kingdom (Included in grade 11 NATED 550)	Plant diversity: Bryophytes, Pterophytes, Gymnosperms, Angiosperms. Animal diversity: Porifera, Cnidaria, Platyhelminthes, Annelida, Arthropoda, Chordata, Mollusca, Echinoderms. Parasitic worms and role of arthropods as ectoparasites.	
Content SIMILAR to NCS Life Sciences curriculum implemented in 2006	Classification systems: Five kingdom Linnaeus and his role in classification systems. Ectoparasites The impact of humans on biodiversity and the natural environment. (Included in grade 11 in NCS) Fossil formation and methods of dating, life's history. (Included in grade 12 NCS)	Plant and animal diversity in South Africa. Threats to biodiversity (in grade 10 as well) Value of biodiversity (in grade 10 as well) Forestry – economic importance and impact on ecosystem.	Evolution Origin of an idea about origins Evolution by natural selection Darwin's theory of evolution by natural selection. Formation of new species Human evolution Evolution in present times Alternative explanations

Continued overleaf

Table 5.2 continued

Content changes	**Life Sciences curriculum implemented in 2009**		
	Grade 10	**Grade 11**	**Grade 12**
NEW content not included in the NATED 550 Biology curriculum and the NCS Life Sciences curriculum implemented in 2006	History of classification, as information increases classification changes. Naming things in science, using Latin. History of life on earth Classification systems: Three-domain system with kingdoms in each domain Key events in life's history for which there is evidence from southern Africa. The role of South African scientists in the discovery of the first living coelacanth. The rate of extinction on the earth at present is higher than at any time in the past. The present time has been called the sixth extinction. Fossil tourism is a source of income and employment in some fossil localities.	Diversity of life and endemic species. Distribution maps of species. Interpret a phylogenetic tree representing the evolutionary history of animals. Role of invertebrates in agriculture and ecosystems. Sustainable use of animals in South Africa Modifications of basic body plans Biogeography	

(Department of Education, 2007a:11 -12, 23-25, 34-35)

5.2.3 Learning material provided to learners

The textbooks used by educators and learners at the two schools involved in the research were scrutinised to extract the content they contained for the Diversity, Change and Continuity strand. Table 5.3 documents the content envisaged in the grade 11 NCS Life Sciences curriculum (Department of Education, 2003) and work schedule (Department of Education, 2007b) as found in the two textbooks.

Table 5.3 below shows that the curriculum is not very specific about the content envisaged for population studies and biodiversity. However, the curriculum does provide better guidance regarding practical work to be done than does the work schedule. The work schedule provides additional information regarding the content that needs to be taught. The content of the two textbooks relates better to the work schedule than to the curriculum. The two textbooks contain approximately the same content, although the second textbook places biodiversity under the environmental studies strand. Detail about the practical activities are included in the following paragraphs.

The learning material provided to learners was studied and divided into two topics, namely population studies and biodiversity. The resources used during lessons in both schools were the textbooks used by learners as chosen by the heads of the departments (Ms A and Mr C), transparencies, additional textbooks, activities developed by the educators and photocopied handouts. Other resources included wall charts, a biodiversity handout taken from a local newspaper, *Beeld,* pictures downloaded from the Internet (Google) and a biodiversity poster introducing learners to the diversity and classification of organisms. The resources used during the mark-and-recatch method lesson at school 1 were the textbook, learner books, markers, large and small glass containers, paper, pens, mealies and a bowl. A memorandum was the only resource used in school 2 by Ms D during the session in which the biodiversity activities were marked. During one of the biodiversity lessons at school 1, learners took notes while the educator explained the work. The analysed content included the work learners had done under each topic, whether it came from the textbook, was written down from transparencies or from photocopied handouts. The learning tasks gathered under each curriculum topic are recorded in Table 5.4.

Table 5.3: Content and practical work prescribed by the grade 11 Life Sciences curriculum and work schedule compared with the content of two textbooks used for population studies and biodiversity.

Curriculum content specification [1]	**Work schedule content specification** [2]	**Content in textbooks**	
		Textbook 1 [3]	**Textbook 2** [4]
	"Population studies	* "Population studies Learning outcome (LO) 1, 2 and 3	* "Population studies"
"Characteristics of populations"	Characteristics of populations Outline characteristics of populations in terms of habitat, size, density and distribution."	Characteristics of populations • Population changes • Population growth patterns Population control • Carrying capacity • Population density • Predatory depletion"	
"Population growth and population fluctuation."	"Population growth, fluctuations and limiting factors. Fluctuations of populations as influenced by limited resources: population size and growth, cells, unicellular and multicellular organisms."	"Reproduction strategies and population growth. • Growth and the regulation of human populations (LO 2 and 3) Human population growth • Introduction • K- and R-strategy species Factors influencing population growth • Fertility, mortality and natality Food for the world's population • Problems with monocultures Future growth of the world's population • HIV, AIDS and population growth • Is there carrying capacity for humans?"	* "Population habitus • S-and J-growth curves Survival curves • K- and R-strategy Parameters that influence population growth • Fertility, mortality, natality, immigration, emigration, migration, sex ratio, genetic material, distribution patterns, age distribution."

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Table 5.3 continued

Curriculum content specification [1]	**Work schedule content specification** [2]	**Content in textbooks**	
		Textbook 1 [3]	**Textbook 2** [4]
	"Define population by referring to cells, unicellular and multicellular organisms. Define species with reference to shared characteristics and reproductive ability.		"Definitions • Population, species, population dynamics, demes, species, population density/size, biomass, growth and parameters.
		"Determination of population size • Direct methods • Indirect methods"	Determining of population size and density • Direct and indirect techniques.
"Limiting factors"	Factors influencing population size: Density-independent factors (earthquakes, volcanos, earth slides, tornados, droughts, flood and extreme temperatures that affect biomes, ecosystems and habitats). Density-dependent factors (births, migration, resources, death and human developments)."		* Determining of population size (LO 1 and 3) Density-independent factors • Only named – weather, temperature, droughts, floods, volcanic outbursts. Density-dependent factors • Competition, predation, territoriality, toxic metabolic products and diseases."

Continued overleaf

Table 5.3 continued

Curriculum content specification (1)	Work schedule content specification (2)	Content in textbooks	
		Textbook 1 (3)	Textbook 2 (4)
		• "Social behaviour	* "Social behaviour of animals Courtship, aggression, parental care, altruism, hierarchical order, extrusion, group structure, group co-operation, polymorphism, inculcate, instinctive behaviour and conditioning.
"Managing populations"	"Managing populations	* Management of populations (LO 2 and 3)	* *Environmental studies strand* * Biodiversity
	Biodiversity of plants and animals and their conservation.		How to prevent species from extinction.
	Significance and value of biodiversity to ecosystem function and human survival food.	Biodiversity and populations • Importance of biodiversity	*Environmental management (LO 1, 2 and 3) Biodiversity • Value of biodiversity for ecosystems. • Medicine and biodiversity • Ecotourism and biodiversity.
	Threats to biodiversity"	• Threats for biodiversity"	Why does biodiversity prevent the extinction of species? • Animals already extinct in South Africa. • The most endangered species in South Africa."

Continued overleaf

Table 5.3 continued

Curriculum content specification [1]	Work schedule content specification [2]	Content in textbooks	
		Textbook 1 [3]	**Textbook 2** [4]
	"Diseases."	"Population management and diseases • The spread of diseases in populations.	* "The spread of diseases • Spread through water (sanitation), air (tuberculosis and flu) and soil (parasitic worms and sleeping sickness). • Diseases, causes, symptoms, treatment and management.
		• Management of the distribution of diseases in populations."	The management of diseases • Tuberculosis contracted by lions and buffalos. • Quarantine • Vaccination and legislation."

Continued overleaf

Table 5.3 continued

Curriculum content specification [1]	**Work schedule content specification** [2]	**Content in textbooks**	
		Textbook 1 [3]	**Textbook 2** [4]
"Planning, conducting and investigating plants and animals – a comparison.	"Plans and conducts an investigation on plants and animals – comparison.		
Analysis of given data and findings to evaluate growth and behavioural issues within a population.	Analyse given data and findings to evaluate growth and behavioural issues among population."	Analyse given data and findings to evaluate growth and behavioural issues among population.	Analyse given data and findings to evaluate growth and behavioural issues among population.
Measurement of population growth using different techniques.			
Collection and analysis of data on specific community diseases that could impact on the population vigour dynamic.		Collection and analysis of data on specific community diseases that could impact on the population vigour dynamic.	Collection and analysis of data on specific community diseases that could impact on the population vigour dynamic.
Analysis and evaluation of any specific human behaviour that could influence population growth.		Analysis and evaluation of any specific human behaviour that could influence population growth.	Analysis and evaluation of any specific human behaviour that could influence population growth.
Collection and analysis of data on evolutionary trends in a population (e.g. human beings)."			

[1](Department of Education, 2003:39)

[2](Department of Education, 2007b:37)

[3](Clitheroe, Doidge, Marsden, Van Aarde, Ashwell, Buckley and Dilley, 2006:210-244)

[4](Grobler, n.d.:112-126; 138-146)

Table 5.4: Learning tasks completed by the learners in their workbooks or textbooks for population studies and biodiversity.

Learning Tasks for School 1	**Learning Tasks for School 2**
Strand: Diversity, Change and Continuity **Topic:** Population studies **Activities:** What is a population? Survival curves (R- and K strategies) Population parameters Population management (capacity, density-dependent and – independent factors as well as competition)	**Strand:** Diversity, Change and Continuity **Topic:** Population studies **Activities:** J- and S-growth curves Survival curves (K- and R-strategies)
Teaching strategies of the population studies activities comprise • Mostly work written from transparencies. • The activities were mainly done from the textbook, except two activities – a practical about the mark, recatch method and an open-book test. The activities were chiefly theoretical and done individually as well as within a group. • There was no evidence of content relating to or knowledge of systematics. • The evidence of scientific inquiry was the mark, recatch method practical and the problem-solving evidence of a number of activities. Graphs and questions – R- and K- strategy species (LO 1 and 2), calculations and questions – mark-and-recatch method (LO 1 and 2), reading passage and questions – summative assessment (LO 1 and 2) and the open book test.	**Teaching strategies of the population studies activities comprise** • Mostly work written from transparencies. • The activities were all theoretical, done from the textbook and done individually. • There was no evidence of content relating to or knowledge of systematics, except for a reference to the red data list. • There was no evidence of scientific inquiry and the problem-solving evidence comprises the red data list and activities on the drawing and interpretations of growth graphs. Graphs and questions – human age groups (LO 1, 2 and 3), red data list – question on the list – reasons for possible extinction and management of these species (LO 1, 2 and 3).

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Table 5.4 continued

Learning Tasks for School 1	**Learning Tasks for School 2**
Strand: Diversity, Change and Continuity **Topic:** Biodiversity **Activities:** What is biodiversity? Types of biodiversity (genetics, species, ecosystem). Threats to biodiversity (loss of habitat, pollution, trade in wildlife, poaching and hunting as well as exotic species) Conservation of South African biodiversity (red data book, protected areas, biodiversity legislation as well as government and management programmes)	**Strand:** Diversity, Change and Continuity **Topic:** Biodiversity **Activities:** Why does biodiversity prevent the extinction of species? Medicine and biodiversity Ecotourism and biodiversity Animals which have already become extinct in South Africa The most endangered species in South Africa How to prevent species from extinction Environmental management The value of biodiversity for ecosystems The spread of diseases (spread through water (sanitation), air (tuberculosis and flu) and soil (parasitic worms and sleeping sickness), (Diseases: causes, symptoms, treatment and management). Management of diseases and (tuberculosis contracted by lions and buffalos, quarantine, vaccination and legislation)
Teaching strategies of the biodiversity activities comprise • Most work was written from transparencies and the activities taken from the textbook; the activities were primarily theoretical and done individually as well as in groups. • There was no evidence of content relating to or knowledge of systematics or scientific inquiry, only of problem-solving. Drawing and interpretation of graphs and research – human population growth (LO 2), reading passage, questions and research – effects of HIV/Aids on population growth in South Africa (LO 2 and 3).	**Teaching strategies of the biodiversity activities comprise** • Mostly theoretical activities completed individually by the learners as well as in groups. All the activities were completed in the textbooks, not in the learners' work books. • Content relating to or knowledge of systematics was included in the handout on biodiversity which included classification of micro-organisms, protists, fungi, animals and plants in their classes. There was one activity on scientific inquiry, a debate about rhino horns (LO 1 and 3) and two activities on problem-solving, questions about the management of sea tortoises (LO 2 and 3) and a reading passage and questions about the Kavango-Zambezi crossborder park (LO 1, 2 and 3).

Table 5.4 clearly shows that different work was completed in the two schools. This is because no specific textbook was prescribed by the education department. Nonetheless the information presented above conveys a similar holistic picture of population studies and biodiversity. The educators followed the prescribed textbook used in their school and the curriculum allowed them to use their own initiative and some of their own content where they deemed it necessary.

The use of different *textbooks* in the two schools is evident from the different activities performed. For textbook 1 (Clitheroe, Doidge, Marsden, Van Aarde, Ashwell, Buckley and Dilley, 2006) the population studies topic was broken down into more activities and content, whereas the biodiversity topic consisted of fewer activities and content. Textbook 2 (Grobler, n.d.) was the opposite with more activities and content under biodiversity and less under the population studies topic. Most of the tasks learners had to complete from textbooks 1 and 2 were theoretical and were individual tasks. Both textbooks focused more on problem-solving activities than on scientific inquiry. However, textbook 2 contained two more scientific inquiry activities than textbook 1. No reference was made to content or knowledge of systematics in textbook 1. In textbook 2 the red data list was the only reference made to content or knowledge of systematics. The learners using textbook 2 completed all the biodiversity activities from the textbook. The learners using textbook 1 completed only some of the biodiversity activities in the textbook, but completed activities from transparencies too. The textbooks contained similar types of activities, reading passages with questions on them and a number of activities involving interpretation of graphs of population growth. The focus for biodiversity in textbook 1 was on human populations and on human diseases, whereas textbook 2 concentrated more on animals and game reserves. Textbook 2 spotlighted the background of extinction, species extinction and the value of biodiversity while textbook 1 addressed the types of biodiversity, threats to biodiversity and biodiversity-focused legislation. Textbook 2 included more content which can be applied by learners during activities than did textbook 1. One can confidently assume that learners using textbook 2 will get a better and broader understanding and knowledge of biodiversity than learners using textbook 1. However, learners using textbook 1 will gain a better understanding and knowledge of population dynamics than learners using textbook 2 because the latter only includes content on growth curves. Educators using textbook 1 need to include additional information on population definitions, population parameters and population management, content already included in textbook 2.

The *workbooks* of the sample of ten learners were analysed. These workbooks ranged from those belonging to weak academic learners to the better achievers. The Life Sciences marks of the learners were used as criteria to distinguish between the weak academic learners and the best achievers. Half of the workbooks were those of girls and the other half were those of boys. The content in the learners' workbooks was used to source the information provided in Table 5.4.

Ms B explained that the Diversity, Change and Continuity strand was taught in lesser detail due to the time allocated to the strand and also to ensure there was sufficient time available for revision and for preparation for *examinations*. This preparation involved doing similar activities to those included in the examinations. These activities inter alia, graph interpretations, hypothesis testing and the evaluation of research conducted in order to identify ways of improving the research. Ms B said that pass rates were still important for schools, even now that the curriculum has changed. Although the curriculum has changed, there must still be time set aside for revision and examination preparation. Ms D is of the opinion that if learners do not have the knowledge to apply to questions regarding environmental and water pollution or about species or pollination experiments, they would have little or no idea of what the second examination paper was about. Mr C pointed out that all the content-related questions are in paper 1 (Structure and Control of Processes in Basic Life Systems and Tissues, Cells and Molecular Studies strands) and all the reading and interpretation questions are in paper 2 (Environmental Studies and Diversity, Continuity and Change strands). Without knowledge of these concepts, learners will not be able to answer the questions properly. However, this could be a problem related to lack of problem-solving and thinking skills rather than lack of knowledge.

Following this discussion on the results of the documents analysis, are the responses to the semi-structured interviews conducted with the educators, curriculum developers and experts in systematics and in ecology.

5.3 Semi-structured interviews

Semi-structured interviews were conducted with four educators, two curriculum developers, an expert in systematics and one expert in ecology. Section 5.3.1 and its subdivisions will address the 12 questions posed to the educators in the interviews. Section 5.3.2 and its subdivisions look at 14 questions posed to the curriculum developers and in section 5.3.3's subdivisions the 6 questions posed to experts in systematics and in ecology are covered.

5.3.1 Interviews with educators

The information collected during the semi-structured interviews with the educators is recounted below and organised according to five sub-questions and the associated interview questions.

5.3.1.1 How do educators interpret the curriculum when selecting content knowledge (substance) of systematics when preparing to teach population dynamics and biodiversity?

In addressing this sub-question, three interview questions were posed to the respondents.

How do you prepare for teaching population dynamics and biodiversity?

When preparing, Ms A studied the curriculum to determine which content needed to be covered. In addition to the prescribed textbook, she used a number of other textbooks to collect additional information which was given to the learners in handouts (as examples or activities). Alternatively, the information was transferred onto transparencies for learners to copy. This additional information can also be gathered from the learners' workbooks. She remarked that there is no single textbook that covers all the work in the curriculum. Ms B explained that the learners were required to underline the most important parts in their textbook because some work in the textbook was irrelevant. It appears that Ms B does not allow for much variation in the activities she provides.

Mr C explained that he determined what the outcomes are and how he wanted to reach them (by means of group work, individual work, worksheets or practical) in advance. Applicable examples were used to teach learners and to explain concepts to them. Ms D the opined that the Diversity, Change and Continuity strand's work required a lot more effort than the other strands to ensure that learners had new applicable activities daily. She used the Internet and other textbooks to provide learners with additional information because the learners' textbook contained insufficient information. Once again, the additional information was visible in the learners' workbooks. Ms D prepared more for the Diversity, Change and Continuity strand than for any other strand. She had to do a lot of reading to acquire more information on topics like biodiversity because her physiology background did not include this content.

It was noticeable that the younger educators prepared in a similar way as the head of department, who also teaches Life Sciences to grade 11. Both young educators mentioned that the heads of department have more subject knowledge owing to their greater experience, therefore enabling them to provide the younger educators with additional information. The younger educators appeared to regard the two heads of department as their mentors.

Is the time and resources adequate for the teaching of population dynamics and biodiversity?

Resources like additional textbooks and material for practical sessions were easily acquired and the practical sessions made the work more interesting for learners. The educators had access to the Internet and used it to gather additional information. Ms B commented that she does not know how schools without these resources and haltered by the restrictions of the current curriculum guidelines are able to teach their learners. She stated further that the learners were not going on field trips because of the department's guidelines with regards to paperwork and the ratio of educators to learners. There is too much time-consuming paperwork and for every 40 learners on a fieldtrip, one educator must accompany them. Also there was only one practical session (mark-and-recatch method) conducted for the Biodiversity, Change and Continuity strand.

Two of the educators, Ms A and Ms D, felt that the time allocated to population studies was sufficient whereas the other two educators felt that it was insufficient, especially if the work required being taught in detail. Ms B said that the allocated time for this section of the work was insufficient and that the work was rushed and not done in detail. In order to adhere to the allocated time, the educators taught the concepts of population studies without great detail. Mr C used the example that learners only had to understand the factors affecting populations such as density and density-independent factors and the influence these factors have on each other. He would have liked to spend more time on population dynamics.

Ms D argued that the time in class is probably enough for the work required but she felt that the work should progress more logically. The foundation for population dynamics and biodiversity should have been created in grade 10 so that these two concepts could be more understandable for learners in grade 11. She pointed out that learners are taught population dynamics in grade 11, not prior to grade 11 and never again after grade 11.

Do you adhere to the prescribed curriculum or do you use your own initiative when teaching population dynamics and biodiversity?

The educators experienced the grade 11 Life Sciences work schedule as vague and not specific or clear enough. Ms D stated that the curriculum guidelines are very broad and unclear. The example she used was that the curriculum required one to teach biodiversity, but did not indicate what aspects related to biodiversity ("different ecosystems or what?"). It only indicated which factors influence biodiversity, for example diseases and it is up to the educator to decide what the important factors are. Some of the content taught in great detail in the previous (NATED 550 Biology) curriculum was incorporated by the educators into the new curriculum to ensure that learners have the knowledge to provide the answers to all the activities.

Ms B noted that content which would be dealt with at a later stage, for example in the following grade, was explained in more detail than other content. Ms D pointed out that population dynamics is only included in grade 11 (refer to previous sub-question), this possibly being the reason why the curriculum and work schedule did not refer to population dynamics in much detail. Her concern was that educators do not know in how much detail they have to explain the work. Apparently, during 2007 educators completed the grade 11 curriculum to the best of their capabilities. Towards the end of 2007 the model examination papers were received and these were used as guides for the detail to be included in the content. She concluded that the curriculum should guide educators by providing more detail regarding what is expected of learners and what is expected of educators to teach learners.

However, educators used their own initiatives when the Diversity, Change and Continuity strand was taught. The educators used examples not included in the textbook to try to make the work more relevant and interesting to the learners. Ms B attempted to make the work easier for learners to understand by linking her examples to a river close to the school, a place learners could associate with in their own environment. She could not take them to the river for ecological studies, not because she had to adhere to departmental guidelines but because of time limitations. The time limitations concerned the length of the class periods and the restricted time available to do something different from the curriculum and still be able to finish with the work on time for revision and examamination.

Mr C believed that educators could not teach in the way the curriculum advised. He reasoned that learners would not have the ability to master problem-solving or scientific inquiry activities without the necessary content knowledge. To make the work more understandable and usable for learners, he uses knowledge of systematics in problem-solving in teaching population dynamics and biodiversity. He expressed this as follows:

> "Today we did an activity in class where we worked with a list of endangered species, each under a different systematic group. In other words, reptiles, birds etcetera. We then discussed, gave reasons and asked questions as to why these organisms are on this list and what influence it will have if these organisms become extinct. This is an example of how we did it. Look, I don't think it is necessary to cover this in that much detail because it isn't prescribed in the curriculum. However, in order to understand and use the whole classification system, it may be necessary to have a basic knowledge about why these organisms are classified in this way and in which group each organism fits. This will help learners to have a better overall understanding of it." (Edited and translated from original Afrikaans transcriptions).

Mr C felt that he was moving outside the curriculum, but he kept to the time allocated and the learners understood the work quicker and better. He defined himself as a "concept educator" and used examples to familiarise learners with certain concepts. Thus, Mr C explained concepts by means of using examples. "I prefer to explain concepts, I am not a definition educator". By this Mr C meant, for example, that he preferred not to define biodiversity, but rather to ask learners if there are different animals and plants. Then he would choose the rhino as an example and ask learners how many different types of rhinos they know. This led learners to understand that although there are different animals and plants, there is also diversity within a particular genus, like the black and the white rhino. By doing this learners grasp biodiversity better.

5.3.1.2 How do educators interpret the curriculum in order to integrate content of systematics with population dynamics and biodiversity content knowledge (substance) when planning or designing problem-solving or scientific inquiry tasks?

In addressing this sub-question, a single interview question was posed to the respondents.

What is your opinion of the following statement? Scientific inquiry and problem-solving relating to science process skills are minimised in the teaching of population dynamics.

Three of the educators (Ms B, Mr C and Ms D) indicated that problem-solving and scientific inquiry were minimised during the teaching of population dynamics. The reason given was that the strand was covered at the end of the year (the fourth term) when all the portfolio work was already completed and the probability that an interesting task like research or a case study would be conducted, was slim. Another reason was that activities to develop learners' skills regarding graphs were easy to accomplish, but the learners were not able to plan practical work or research projects due to lack of time and skills. According to Ms B, learners did not know how to draw conclusions from information or draw up a questionnaire.

It was also evident that learners had not covered population dynamics in much detail. Mr C indicated that planning had to be thorough to ensure that the content was not only covered at knowledge level, but also at higher cognitive levels (comprehension, application, analysis, synthesis and evaluation) as well. Mr C stated that the Cells, Tissues and Molecular Studies as well as the Processes in Basic Life Systems strands were taught in more detail ("more content is covered") and more time was allocated to and spent on these strands. Learners were also required to apply more skills when these two strands were taught – microscope work and research projects to name a few – in addition to problem-solving and scientific inquiry.

Mr C suggested that the previous (NATED 550 Biology) curriculum covered the knowledge much better while the new (NCS Life Sciences) curriculum only covers the basics of the work. Mr C mentioned that if learners do not have enough content knowledge it affects their understanding of population dynamics and biodiversity. He argued that the absence of content knowledge affects learners' way of approaching problem-solving and scientific inquiry.

Ms A stated that learners must have prior knowledge of procedure to understand the mark-and-recatch method. She explained that learners must know certain precautionary guidelines to apply this method, otherwise the animals sustain injuries. If animals were marked incorrectly, their movement and behaviour could be affected. Also, learners could apply the wrong method to determine a certain population's size. Ms B explained that learners who did not complete the activity but just copied the answers down from the board while the others marked it, did not understand the work. The learners who used the textbook as resource, understood the work and finished the scientific inquiry activity in time. Some learners marked the population twice, whereas other learners did not know which numbers fitted where in the calculation. Knowledge of systematics would quite likely play a role here and help learners to identify which animals must be handled in a particular manner due their characteristics. This could assist learners in determining which method to follow in determining a population's size.

5.3.1.3 How do educators integrate the science process skills and scientific inquiry (syntax) related to systematics when teaching population dynamics and biodiversity?

In addressing this sub-question, the following interview question was posed to the respondents:

Do you refer to systematics when teaching population dynamics and biodiversity? Explain.

Systematics was originally excluded as a separate unit from the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006. From the interviews it became evident that two of the educators (Ms A and Ms B) felt that systematics is irrelevant for learners and consequently these educators did not refer to it during population studies. Reasons given were that the focus at the end of the year was on preparing the learners for the examinations in the limited time available for revision. They (Ms A and Ms B) were at one that devoting time to systematics in the curriculum is unfeasible given the limited time allocated to the work already comprising the curriculum.

The other two educators (Mr C and Ms D), especially Mr C, linked systematics to some examples used in class and during problem-solving to reach certain outcomes. The example he used was an activity sheet on which a number of endangered animals were classified in different systematic groups, for instance reptiles and birds. The learners and the educator then discussed why these organisms were on this list and what the effect the extinction of one organism would have on other species. He is convinced that knowledge of systematics definitely has had an influence on learners' understanding of population dynamics or biodiversity. He contends that it is not necessary to understand the whole classification system and how to use it, but that basic knowledge of why organisms are classified and which organisms fit in which group helps learners to understand this work much better. He also argued that the life processes of the organisms as, well as their place in the ecological system, are important should one look at problems such as pollution and the accumulation of toxic substances like DDT. He explained that he uses examples like references to the accumulation of DDT and asks questions like which trophic levels play the biggest role in the ecological system. This was done because he wanted learners to realise that if the base (producers) of the trophic levels become extinct or scarce, the tertiary consumers will be affected most. Learners understand the work easier through the use of these types of examples. Another example he used was about people being worried about vultures and eagles becoming extinct. Once again he explained that it was due to DDT accumulation. He wanted learners to understand it in this way and stated that when learners heard producers and linked it to knowledge of systematics, they would realise that it is plants which are the most important link in this whole process. He also wanted learners to recognise that it is plants which influence elephants and lions so loved by everyone. Although Ms D used the handout dealing with biodiversity (including classification of micro-organisms, protists, fungi, plant and animal classes) in class, the response provided by her during the interview was not applicable to the context of this interview question.

5.3.1.4 What are the links between content knowledge (substance) of systematics, population dynamics and biodiversity?

In addressing this sub-question, two interview questions were posed to the respondents.

If the learner does not have knowledge of systematics, does it affect the understanding of population dynamics or biodiversity or even problem-solving?

Ms D stated that she and her colleague (Mr C) provided learners with a broad idea of what biodiversity entails without them having to know the classification of the animals or organisms. The learners did not understand everything about biodiversity that was taught to them. She added that the inclusion of the knowledge of systematics would probably have helped the learners to understand population dynamics or biodiversity.

Ms A recorded that it was evident that knowledge of systematics might have influenced the study of biodiversity, but not necessarily population dynamics. She used the examples of aloes and pines. She referred to the uses of aloes which are succulents and pointed out the influence of pines on the environment. She also indicated that this knowledge was missing and that learners were not very familiar with the way pines reproduce. Her first statement can be linked to the value of aloes and the effect of pines on the environment, both topics being linked to content of biodiversity. Her latter statement can be linked to biodiversity and population dynamics – if the way pines reproduce is understood, pine populations can be managed accordingly. She felt that the exclusion of systematics had an influence on learners' understanding of biodiversity and that knowledge of population dynamics is important for the influence it has on biodiversity.

Ms B felt that the inclusion of knowledge of systematics would make a difference to the way learners solve population dynamics and biodiversity problems in the Diversity, Change and Continuity strand. According to her, learners would not learn the content by heart but it would be part of their thought process. She stated that knowledge of systematics would have made problem-solving easier for them. She explained that if learners know how an animal lives, they would know how pollution influences the animal and they would not need to study the influences pollution has on different animals.

How will the understanding of content and knowledge of systematics influence tertiary studies in a similar field?

Mr C argued that in the new (NCS Life Sciences) curriculum the emphasis was moved from content and systematics to environmental awareness and world issues. Due to the reduction in the content of Life Sciences learners will be aware of a gap between what they know and what is required at university level.

The educators (Ms A, Ms B, Mr C and Ms D) agreed that an understanding of content and knowledge of systematics would make it easier for learners in biological studies because they would have gained a basic idea of the number of and differences between species. Learners would have the advantage of understanding that there is a vast number of species and differences between the species due to the characteristics that categorise them into distinct groups. Regrettably, population studies and biodiversity work was not taught in detail requiring no depth of inquiry so that learners would probably lack the prior knowledge needed at tertiary level.

Ms A thought that learners who wanted to study a first degree in botany, zoology or microbiology would have to do much self study when dealing with systematics because they lack prior knowledge of it. She also felt that if the desired qualification is an application degree learners would be prepared, but if learners need in-depth prior knowledge of content they are destined to struggle.

Ms B is of the opinion that the content and knowledge of systematics makes it easier for learners who continue with tertiary studies in a biological area. She stated that prior knowledge assists in understanding new work. She used the example of monocotyledonous and dicotyledonous plants, but it should be noted that in tertiary studies the terms Magnoliopsida and Liliopsida are used. If these terms are used in school lessons, prior knowledge will ensure that a student attending a lecture will have an idea about the topic, whereas students without the related prior knowledge will have difficulty to follow the lecture and will have to rely on self study. This situation could occur unless the lecture is adapted to the students' needs.

5.3.1.5 Why has systematics been reintroduced into the Life Sciences curriculum implemented in 2009 and what differences has the reintroduction of systematics into the Life Sciences curriculum caused?

In addressing this sub-question, five interview questions were posed to the respondents. As stated in Chapter 4 interviews were conducted in 2008 and 2009. In order to gather data regarding this sub-question, the interviews were conducted in 2009. The questions were based on the New Content Framework for Life Sciences (Department of Education, 2007a) and emphasis was placed on the reintroduction of systematics in this curriculum and the effect it has on the teaching of population studies and biodiversity. At the time of the second interview Ms B was not involved in teaching this new Life Sciences curriculum (Department of Education, 2007a) and could not provide information in this regard.

Is your approach, concerning the Diversity, Change and Continuity strand, different since the reintroduction of systematics?

According to Ms A, it was a pleasure to do this section of the work during 2009, because learners were able to understand where the different organisms originated. Learners also had a better idea of the hierarchical development of organisms, from the simplest to the most complicated organisms. She pointed out, however, that the topic of systematics covered in their textbook only made up one chapter of the entire syllabus. Mr C and Ms D agreed that because more is expected of the learners, their approach as educators has changed.

How will you use systematics to make the basic principles of the Diversity, Change and Continuity strand more understandable?

Ms A commented with special reference to biodiversity, that the section on systematics is essential for explaining the importance of the sustainability of biodiversity. Mr C and Ms D explained that examples were taken from systematics and used to explain biodiversity so that population and genetic diversity could be better understood.

What influence does the inclusion of systematics have on problem-solving and scientific research, if any? (With regards to: advantages, disadvantages, the effects on activities and learners' approach to problem- solving and scientific research).

Ms A thought that when investigating aspects such as water pollution, learners should be able to use their prior knowledge of the systematic development of organisms – for example from blue-green algae to higher order plants such as water hyacinths – to solve problems relating to the pollution. She also stated that by referring to the development of organisms throughout the explanation, learners acquire a better understanding of food chains or food pyramids.

According to Mr C and Ms D the learners' approach to problem-solving and scientific inquiry improved because they were skilled in problem-solving. The advantage these two educators saw was that learners had more insight regarding problem-solving and scientific research since systematics had been included in the curriculum, but they agreed that the time to teach this section of the curriculum was limited.

What is your opinion about the inclusion of systematics in the curriculum implemented in 2009?

Ms A believes that the inclusion of systematics is a good idea because learners are now able to form a complete picture of the development of organisms. She added that the inclusion of systematics is advantageous to the explanation of the importance of biodiversity. Mr C and Ms D stated that systematics fitted in with the current content and the examples were also more applicable to the learners' daily lives, but time constraints remain a problem. Mr C further explained that animal and plant systematics linked well to population studies and biodiversity because "populations are compiled from species and all the taxonomic groups."

What other concepts in the curriculum are improved through the inclusion of systematics in the Diversity, Change and Continuity strand, if any?

Ms A noted that the organisation of living organisms, which is included in the Life Processes strand, has been made more understandable when looking at the development of unicellular to multicellular organisms. Mr C and Ms D agreed that the study of most concepts in the curriculum has improved by the inclusion of systematics, except, perhaps, the physiology themes.

From the interviews conducted with the educators it was evident that the educators used the curriculum (Department of Education, 2003) and work schedule (Department of Education, 2007b) as guides. A variety of resources were used to provide the learners with additional information. Some of the educators felt that the time was insufficient to teach population studies and biodiversity in detail. The educators used their own initiative to develop activities and did not only adhere to the curriculum (Department of Education, 2003) or work schedule (Department of Education, 2007a). According to them the curriculum (Department of Education, 2003) and work schedule (Department of Education, 2007b) were vague and not specific enough. Problem-solving and scientific inquiry were minimised in the teaching of population dynamics and biodiversity. There was some evidence that the educators included content or knowledge of systematics during the teaching of population studies and biodiversity. Half of the educators felt systematics would help learners to understand population studies better. On the other hand, all four educators were of the opinion that systematics is a necessity for the understanding of biodiversity. The reintroduction of systematics in the new Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009 was seen as a good idea, because knowledge of systematics helped the learners to comprehend other concepts like different body plans, evolution and biodiversity better. The next section will provide the responses of the curriculum developers on the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 and the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009.

5.3.2 Interviews with curriculum developers

The information gathered during the semi-structured interviews with the curriculum developers is discussed according to two sub-questions and fourteen associated interview questions. Before commencing with the discussion of the questions and answers it is necessary to sketch the following background about the development of the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006.

It became evident from the interview with Ms X that the biggest problems in Biology as subject are attributable to the inclusion of too many complex concepts and terminologies in the curriculum. This was the case in the NATED 550 Biology curriculum (Department of Education, n.d.). The NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 was meant to make Biology relevant to more learners. Consequently, according to Ms X, the subject's name was changed to Life Sciences, a more up-to-date term to which learners can more comfortably relate.

Members of the curriculum team were selected from two provincial education departments, two universities, two universities of technology, the South African Certification Council (SAFCERT) and the National Professional Teachers Organisation of South Africa (Naptosa). These individuals were regarded as experts in the Life Sciences. The members from the two education departments were Life Sciences subject facilitators. The members from the universities and universities of technology were expected to provide the content-related expertise. Naptosa represented the interests of Life Science teachers. The curriculum team changed over time with new people entering the process.

The curriculum developers interviewed for this study were unsure whether there had been a specialist on population dynamics and biodiversity included in the curriculum team. It was also remarked that, except for one person, nobody on the committee had an academic background beyond undergraduate courses in Biological Sciences. However, all the members were life scientists and the university representatives were lecturers in Life Sciences. The convener had done quite a lot of work on curriculum development in other countries, like Botswana. She also served on a number of working committees and she is a leading biology educator with experience in curriculum development in South Africa.

Ms X submitted that the members involved in the development of the NCS Life Sciences curriculum (Department of Education, 2003) were apparently selected on the basis of their reputations. Ms X only entered the process when the tenth draft was being prepared and she remained until the end of the curriculum development process. One of the reasons she gave for joining the curriculum development team at that stage was a feeling that the Life science team "was getting a little bit lost along the way." She was also convinced that the team needed someone with a fresh outlook since they had already been through ten drafts. The team needed someone to help them to determine whether the designed draft was meeting the outcomes envisaged by the process.

Ms X was also involved in the development of the National Curriculum Statement for the GET phase. She served on the original curriculum development team for the GET phase from the initial phases. According to her, the experience she gained from this was a likely reason she was asked to join the curriculum development team of the Life Sciences FET phase. Also, she surmised the people who invited her had done courses under her tutelage. Her background as a Biology teacher in a white suburban school and in Soweto and her involvement with in-service training of Life Sciences teachers in Soweto and in teaching Life Sciences at a teachers' education college in Soweto.

Dr Y was quite likely selected due to her interest in Biology curriculum development and her reputation in curriculum development. She also commented extensively on the first draft of the NCS Life Sciences curriculum which was implemented in 2006. Late in 2006 she published a paper critiquing the content structure of this Life Sciences curriculum (Department of Education, 2003).

The curriculum (Department of Education, 2003) was developed over a period of about three years. An outline of the prerequisites of the curriculum was presented to the committee after which they compiled the curriculum accordingly. They were told how many outcomes there should be, what the assessment criteria should look like regarding design and the basic skills necessary at each grade level. There were some very specific requirements on how the curriculum was to be set out. Ms X believed that something that really shaped the thoughts of those involved in the development of the curriculum was the notion derived from the reaction to the previous C2005 that "content does not count" (Doidge, Dempster, Crowe and Naidoo 2008:2). The curriculum development team needed to work toward specifying the outcomes and assessment standards and then select appropriate contents accordingly.

The curriculum committee met and considered three outcomes linked to a content framework along with inquiry and science skills that related to the content framework, but they were reluctant to include too much detail in the curriculum. Ms X puts it like this:

> "…but you will see in this "old new" curriculum that there is a reluctance to put too much detail. A reluctance to specify what inquiry you need to do relating to what content, because that would be being as prescriptive as the old NATED 550 curriculum."

The curriculum team also reviewed the Scottish, Australian and New Zealand curricula as well as the schemes and strands linked to each curriculum. The committee noticed that Structure and Control of processes in Basic Life Systems and Diversity, Change and Continuity tended to be themes. The team used these themes and various books during the development of the curriculum. The committee posted questions and suggested structures on the Internet to which they received suggestions and critique.

A committee consisting of representatives of the University of Witwatersrand and the University of Johannesburg met to study the curriculum and make suggestions. The University of Cape Town and the University of Western Cape also convened groups who put forward useful suggestions. Dr Y explained that the major endeavour was to make the curriculum interesting and relevant to learners, and to make it possible for teachers to teach it. The subject advisors were very aware of the limitations imposed by the teaching force, particularly the large numbers of teachers who were not qualified to teach Biology. Regarding the development of the Diversity, Change and Continuity strand, Ms X explained that the development team tried to keep the content in the NCS Life Sciences curriculum as similar as possible to that of the previous (NATED 550 Biology) curriculum and they did not wish to change content too extensively because teachers would not be able to cope. The population study section was part of the previous (NATED 550 Biology) curriculum and the curriculum team felt it remained relevant. This was important in relation to population dynamics and the factors affecting population structures. Due to the inclusion of predation, competition and territoriality in the previous (NATED 550 Biology) curriculum, there was some elaboration on social behaviour in the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006. Social behaviour, as well as predation and competition, were linked to the density-dependent factors of population structures. Biodiversity was becoming a major issue at university level and therefore issues of biodiversity needed to be addressed in the curriculum. Ms X stated that natural biodiversity rarely exists now because, it has been altered by humans. She also stated that when looking at the management of populations to ensure the maintenance of biodiversity, one can look at population dynamics and natural ecosystems and how people have changed these ecosystems.

As explained previously in section 1.2, systematics originally formed part of the NATED 550 Biology curriculum (Department of Education, n.d.). However, systematics was excluded as a separate unit from the grade 11 NCS Life Sciences curriculum (Department of Education, 2003) because of the resistance from educators. The NATED 550 syllabus expected educators to explain bacteria, fungi, mosses, ferns, gymnosperms and angiosperms in terms of their structure, nutrition, life cycle and ecological uses. Similar expectations were imposed on educators regarding the explanation of the animal kingdom. According to Ms X, the educators "agonised" about this and the learners found it boring and hated it. She explained the situation as follows:

> "The life cycle of the moss or the fern or a pine just made no sense to them as they could not see the value of learning all of this intricate detail and complicated terminology and it was like this endless procedure of terminology and a bit of ecology and a bit of irrelevance…."

5.3.2.1 What are the links between content knowledge (substance) of systematics, population dynamics and biodiversity?

In addressing this sub-question, nine interview questions were posed to the respondents.

What should the main elements and components of population dynamics be in terms of substance and syntax in the grade 11 Life Sciences curriculum?

Although not a population dynamics expert, Ms X maintained that the content covered population dynamics sufficiently. With regard to syntax, she stated, "Ja, I think it is very iffy…there is virtually nothing put in there". She believed that there were more creative ways of doing population dynamics than fieldtrips or fieldwork. The examples she used were ecology-related television programmes like 50/50, models that can be made with little bits of cardboards and sweets, and population dynamics games which can be used to get the basic concept across. She also realised that the concept would remain abstract if it was not made real. Dr Y declined to answer directly, but referred the interviewer to the Life Sciences content document for an answer.

Explain how and where the content of the Diversity, Change and Continuity strand is interlinked with the other strands in the curriculum.

According to Ms X, the Diversity, Change and Continuity strand the Environmental Studies strand link well to one another. An example mentioned by Ms X is the links between structures in populations and disturbed environments. She explained that these disturbed environments alter populations and this has an effect on biodiversity. Another example she named is alien invaders such as the water hyacinth and how it affects the rest of the organisms in the water environment. She mentioned that one can look at the role of population dynamics in altering the environment and then talk about the need for biodiversity. The same applies to the effect of abiotic/biotic influences, density-dependent and-independent factors on population dynamics and the environment.

Bacteria, protists and fungi could have been included in the Diversity, Change and Continuity strand, but they were not. Ms X recalled a conversation the curriculum team had about the place of bacteria, protists and fungi because it was quite difficult to find a suitable section of the curriculum where these should be included. To create a balance of content in the Tissues, Cells and Molecular Studies strand, bacteria, protists and fungi were included in this section. The curriculum team tried to ensure that there was an opportunity to study these lower groups before human physiology and plant physiology were taught. Ms X commented that it was not a logical place to put this section (bacteria, protists and fungi) of the work, but the team wanted to keep all these organisms together because systematics per se had been excluded from the curriculum. Thus, molecular studies (DNA structure) were linked to viruses and cells were linked to bacteria. Protists and fungi were linked to "low forms of molecules, cells or at a very low level of tissue structure." She explained as follows:

> "This was probably the easiest place to put it and because it is so important, certainly in terms of application to humans and bio-technology, this section could not have been excluded."

How was time allocated to the strands?

The national curriculum team, which included the curriculum developers, was not involved in the allocation of time to the strands as this was done by another committee. The amount of time spent on the Diversity, Change and Continuity strand was irrelevant according to Ms X who pronounced as follows:

> "I don't care if they don't spent as much time on it, it is really about, how they have processed the information on the environment, how they have processed the information on population dynamics and the importance of biodiversity as well as how they can use that."

Do you think problem-solving and scientific inquiry skills are adequately addressed in the Diversity, Change and Continuity (especially in population dynamics and biodiversity) strand in relation to the other strands? Give reasons for your answer.

Ms X and Dr Y agreed that the descriptions of inquiry and problem-solving skills in the curriculum and work schedule were insufficient. Ms X felt that inquiry and problem-solving skills were hardly addressed in the work schedule, that the descriptions were not well-thought and it seemed as if the persons involved had no idea what to include. These vague skills descriptions led to educators not knowing what to do. There were no clear suggestions for tasks that could be performed. Ms X proposed examples useful for skills descriptions, including a good movie to view about investigating the population dynamics of wild dogs. Learners could have analysed competition and predation as well as their influences on the dog population. An investigation using different sampling methods could have been conducted on a population and the procedure included in the description. Dr Y expounded as follows:

> "If you look at the Learning Programme Guidelines (LPG), under LO1 in the knowledge strand Biodiversity, you find two general suggestions for scientific inquiry and problem-solving skills, which do not change from grade 10 to 11 to 12. LO3 likewise shows very little change across the grades. This seems to indicate that the developers of the LPG had some difficulty trying to generate ideas for LO1 and LO3. If you look at the Assessment Syllabus, you find that LO1 and LO3 have disappeared, and everything is listed under LO2."

What is your opinion regarding the exclusion of systematics from the curriculum?

Ms X answered that for the majority of learners the content of systematics became an unexciting process, involving vast numbers of concepts and terminologies, which they experienced as a meaningless exercise in which they could not see how it all fits together.

As a result, the curriculum committee met and considered the views of the educators on this aspect because, according to the interviewee, there was general concern that "teachers did not want to teach that stuff anymore." Although the educators were comfortable with some of the content – like the fascinating life cycle of the tapeworm – it could be problematic for learners having to learn many of these details without understanding them and studying the tapeworm's anatomy all beyond the context of their own lives. Ms X's feeling toward systematics was that although learners needed to understand the structure of the biological world and that systematics were important and have a place, the way systematics was dealt with in the past was unacceptable. Botany has become a global topic for discussion because a very negative connotation has been attached internationally to the concept recently. Apparently, plant science has a more scientific connotation. Ms X felt that this undertone filtered through to the systematics, especially to the life cycles of plants. For a future biologist systematics has great relevance, but for the majority of the grade 12s in the biology examinations it remains irrelevant. According to Ms X, plants as well as the understanding of systematics were relevant to the curriculum. She maintained that systematics had to be taught in a way that grade 12 learners leaving school without the intention of entering the world of biology will be able to understand the importance of systematics.

Dr Y believes that systematics was being left out of grade 11 because of the pressure placed upon learners to commence with grade 12 work as early as possible in the grade 11 year. Many learners found it boring and could not see the relevance of the section to their daily lives. She also commented that "modern Biology does not teach systematics as a trot through a series of phyla and classes, but uses systematics to illustrate principles such as descent with modification. It also underpins conservation, because unless you can classify the organisms in a threatened environment, you cannot conduct an environmental impact assessment."

Do you believe if Botany and Zoology systematics had been included, the learners would have been able to understand the concepts in population studies and biodiversity better? Is problem-solving and inquiry therefore dependent on a better understanding of systematics?

Ms X reiterated that she was not an expert in population studies but did not think that systematics was necessary for understanding population studies. When looking at issues of biodiversity, she was not sure whether systematics was essential for understanding biodiversity. She used to the crocodile (reptile) as an example:

> "You talk about what is the big issue now, about the changing bacteria…. You do not need systematics for that. You need to understand the structure and physiology of the crocodile. And you see the level at which systematics was done was simply how many toes they have on each foot, you know. What did that help you in understanding biodiversity? Sure, they have a scaly body and that might make them different from frogs and how frogs survive in the environment but that sort of thing was never done."

For Ms X it was more about taking different groups of animals and studying their structure and physiology in greater detail and using fewer examples. She believed that it will enable the learners to discuss population dynamics and biodiversity because there were only a few examples. Learners would also understand how their unique structure allows them to live in a particular environment. She is of the opinion that if one wants to include animal and plant systematics it has to be done in an appropriate way, something not done in the past.

Dr Y stated that general environmental awareness and knowledge of one's natural environment are dependent on an awareness of systematics, but not necessarily on an in-depth knowledge of systematics. Being able to identify the organisms in one's environment raises awareness of the extent of biodiversity and with that comes an appreciation and valuing of biodiversity. She commented that this is very important if we want to slow down the current rate of extinction.

Please comment on the following statement: "The grade 11 Life Sciences curriculum leaves room for interpretation from the educator, which influences the use of content knowledge when teaching population dynamics." Do you feel the educators and the learners would benefit from more detailed guidance in terms of the curriculum content?

The curriculum developers had different opinions regarding this issue. Ms X stated that it was an involved issue because the more detail that was given, the more detail educators included and this led to an enormous content workload to be covered by the educator in a limited period of time. She explained that the purpose of the curriculum is to provide broad concepts and educators must take the initiative to use this freedom given to them. According to her, there was enough content to develop a curriculum from the information provided and she would not have liked more detailed guidance. She commented that textbooks could be used to add examples to the concepts and to develop courses. Educators who do not have a background concerning some concepts can also use those books.

Dr Y alleged that most educators in certain parts of the country have very little knowledge of Biology beyond their own school study. This curriculum left these educators without sufficient guidance. She also mentioned that some educators were using the Assessment Syllabus to guide their teaching because it provided more detail.

Some of the educators are of the opinion that due to the difference in content of exam paper 1 (strands: Structure and Control of Processes in Basic Life Systems and Tissues, Cells and Molecular Studies) and exam paper 2 (strands: Environmental Studies and Diversity, Change and Continuity), the content in the Diversity, Change and Continuity strand is rushed in even a shorter amount of time to revise the learning material of the strands included in exam paper 1. What is your opinion of this?

There is much more content for the learners to learn in preparation for the first examination paper. Ms X asserted that the second paper required a lot of interpretation regarding population diversity, but in order to interpret the information there were basic concepts the learners needed to know. The view is that the approach to examination paper 2 is more idealistic. She liked the different ways in which the examiners approached examination paper 2 and commented that this provided a more holistic view of the subject. This paper included interpretation questions, like graphs, case studies and problem-solving. On the other hand, she stated that the first examination paper has questions based on very specific, interesting content.

Ms X preferred that learners learn the basic concepts and not spend a large amount of time on those basic concepts, but be able to interpret case studies and information presented to them. She used the example of an insect population which became extinct in a unique grassland area due to the building of the Gautrain route and asked whether this really mattered. She explained that the learners could use the content they learnt on biodiversity and debate this issue.

Would systematics have had a more prominent influence on population dynamics and biodiversity had it been part of the grade 11 Life Sciences curriculum?

Ms X acknowledged that the study of systematics is not necessary in order to understand population dynamics because it can be taught by using a few examples. However, believes that systematics is important to an understanding of the section on biodiversity and if included it would have had a more prominent influence on biodiversity.

According to Dr Y "knowledge of systematics makes the identification of organisms a lot easier, but one can also approach identification in a 'need-to-know' fashion." She mentioned that some trail guides (rangers) in game parks are able to identify a large number of organisms in their environment without any formal knowledge of systematics. She explained that systematics has significant value for making sense of the diversity of life and looking at patterns within the diversity. Or in her words:

> "The impact is then on descent with modification, because there are a limited number of core body plans in all of life and every extinct or extant

> organism is a variation on that body plan. It is such a powerful demonstration of the links between organisms, both in time and in space."

5.3.2.2 Why has systematics been reintroduced into the Life Sciences curriculum implemented in 2009 and what differences has the reintroduction of systematics into the Life Sciences curriculum caused?

In addressing this sub-question, five interview questions were posed to the respondents. As was the case with the educators, in order to gather data regarding this sub-question, the interviews were conducted in 2009. The questions were based on the New Content Framework for Life Sciences (Department of Education, 2007a) and emphasis was placed on the reintroduction of systematics in this curriculum.

Would there be an improved link between problem-solving, scientific inquiry and a better understanding of animal and plant systematics? (In other words, to what extent, if any, has the inclusion of systematics improved addressing problem-solving and scientific inquiry skills?)

Ms X observed that the skills of problem-solving and conducting scientific inquiry are not, in themselves, necessarily improved by the inclusion of systematics. She explained that if scientific inquiry and problem-solving are conducted within the context of understanding diversity and change, for example "working out why animals and plants have particular systems, adaptations, similarities and differences", then an understanding of systematics helps.

Dr Y declared that the inclusion of systematics ensured that learners used higher order thinking skills. Learners have to use the information from body plans and then map it onto a phylogenetic tree to emphasize that basic body plans provide information about the evolution of animal phyla. She also commented on the Linnean classification system addressed in Grade 10. "The cognitive skills for understanding and using the Linnean hierarchy are very powerful and useful in other branches of science (for example the periodic table)."

Is there supposed to be a sequence in the development of the Diversity, Change and Continuity strand? If yes, how?

Ms X sees that there is supposed to be a sequence in the development of the Diversity, Change and Continuity strand. According to her, the big picture of biodiversity is looked at thus, "what is here now (life on earth), how we have grouped and then classified organisms and on what basis." Following this, how this biodiversity came about in terms of the history of life on earth is explored. She stated that the study of climatic and geological events that created conditions under which some organisms succeeded and diversified and others become extinct, is also included.

According to Dr Y, in the structuring of the Diversity, Change and Continuity Strand, the curriculum development team considered it necessary to establish strong foundations on which to build the theory of evolution by natural selection. The team introduced the ideas of the long history of life in grade 10, because learners had already encountered fossils in natural sciences. The introduction to the very broad diversity of life within the kingdoms was then linked to the history of life. "We hoped that learners would gain an awareness of deep time", she declared.

Ms X mentioned that the enormous biodiversity in South Africa is explored in broad terms in grade 11. According to her, learners are required to examine biodiversity for only one group or phylum for them to become familiar with at least one group of South African organisms. She outlined this precedure thus:

> "We look at features that distinguish plant and animal groups or phyla from an evolutionary perspective. So once again, we pick up on the idea that evolution results in biodiversity and we understand the links through studying systematics."

Dr Y stated that plant and animal diversity was introduced in grade 11, but the focus was on identifying the basic body plans of a sample of phyla, selected because they represent major divisions of animals or plants. "The animal body plans were then plotted onto a phylogenetic tree to show how one can interpret the body plans as reflecting the history of the animal kingdom." She also pointed out that modifications of a body part for particular modes of life, such as the "vertebrate forelimb, or orchid flowers, or appendages of insects, where the same basic structures can be identified" were included. The grade 11 curriculum also included biogeography. The curriculum team chose distribution of ratites (a diverse group of large flightless birds of Gondwanan origin for example the ostrich and emu) as the example, but Dr Y felt, in retrospect, that they could have better chosen large mammalian herbivores (antelope in Africa, kangaroo in Australia, llama in South America).

Ms X observed that the focus in grade 12 is on how biodiversity arose, for example the evolution by natural selection. Dr Y supposed that the curriculum team felt that once these foundation blocks (mentioned in grade 10 and 11) were in place, learners would be able to comprehend the theory of evolution by natural selection. Therefore, artificial selection and some genetics were included in grade 12 to show that natural selection was really selection for the best-adapted genotype. Some ideas about how speciation occurs and some evidence for evolution in insects and bacteria were also included in grade 12.

Why were plant and animal systematics included/reintroduced into the Life Sciences curriculum that was implemented into grade 10 in 2009?

Ms X mentioned that systematics was reintroduced in the context of evolution and for understanding biodiversity. The curriculum team never intended that it should be dealt with in the detail in which it was formerly covered, "rather that when we encountered organisms, we had some way of understanding of where they 'fit', some idea of connections and differences."

Dr Y provided two reasons for the reintroduction. First, almost all plants and other animals besides humans were excluded from the previous NCS Life Sciences curriculum implemented in 2006 and it was deemed necessary for learners in South Africa to be made aware of the diversity of life in their country. She explained that:

> "In order to make sense of that diversity, it is necessary to learn the basics of systematics so that the learner knows where each species "fits" in the broad spectrum of diversity."

Second, Dr Y contends that because systematics lends itself very readily to an evolutionary approach to biodiversity, the teaching of systematics and body plans provide information about the evolution of animal phyla.

What is your opinion regarding the inclusion of systematics in this curriculum?

Ms X believes that systematics has its place in small doses and that the inclusion of systematics has led to a better understanding of the similarities and differences in structure and function in different organisms.

Dr Y agrees that the inclusion of systematics has succeeded and that concepts such as evolution, biodiversity and body plans can be better understood in the light of it. However, she also mentioned when conducting workshops with teachers in 2009 she found that they thought they are going back to the "old syllabus". Such a frame of mind would be hard to break.

What was the effect of the inclusion of systematics on the Diversity, Change and Continuity strand?

According to Ms X, systematics shifted the emphasis from a superficial understanding of classification to a more detailed and hopefully clearer understanding of the link between evolution and biodiversity and the reasons for classifying organisms in certain ways.

Dr Y stated that it would not be possible to teach evolution unless learners have some understanding of body plans. The example she used was that the diversity of life is not just a random array of different kinds of living organisms, but that a limited number of basic types can be identified and all living organisms are variations of those types. She also explained that the exclusion of systematics from the previous NCS Life Sciences curriculum was not a good idea because systematics is a foundation for biology. She emphasised her opinion by saying that "One cannot possibly understand the scale of biodiversity without knowing the basics of systematics." Dr Y also stated that the application of the Linnean system enabled a learner to categorise objects, thus making memory more potent.

5.3.3 The opinions of experts in ecology and systematics

The information elicited during the semi-structured interviews is arranged here according to a single sub-question and six associated interview questions.

5.3.3.1 What are the links between content knowledge (substance) of systematics, population dynamics and biodiversity?

In addressing this sub-question, six interview questions were posed to the respondents:

What is the link between systematics, population dynamics and biodiversity?

Prof E asserted that a background of systematics was necessary to understand biodiversity. She stated further that population dynamics could stand alone and separately from biodiversity and systematics and that knowledge of populations dynamics can only be applied to one species at a time. It is important to her that learners realise that when one works with population dynamics, one works with one species which has fluctuations in its numbers. She also mentioned that in biodiversity one works with a number of species and the fluctuations in their numbers. She emphasised that all the different species are equally important. This statement means that all species are equally important in the ecological world, whether it is anatomically a large species like the elephant or a small species like a honeybee. Each species contributes in its own way to the environment in which it exists.

Can you supply me with examples that will highlight the dependability of population dynamics and biodiversity on the prior knowledge of systematics? If yes, give examples.

Prof E stated that problem-solving and scientific inquiry in population studies could be done without knowledge of systematics. Further, she said that problem-solving and scientific inquiry in biodiversity could be done without knowledge of systematics, but then it must be clear to the learner what the term "species" means. However, the learner would not have a conception of the size of the diversity, viz:

> "For the learner it is going to be a numbers game. It is not going to bother him if we have 24 000 blue gum tree species or not. There is not going to be a pattern or classification. Yes, one will be able to understand the principle but the comprehension is still lost." (Edited and translated from Afrikaans).

She indicated that the problem with diversity can be illustrated using our national parks as examples. She explained that when looking at one area in a national park, one can say that there are a certain number of species and when looking at another area there is a similar number of species. However, the one area may include rare species and the other area consists of useful species and weed species. She explained biodiversity and systematics as follows:

> "With regards to diversity, it is the number of species, diversity has aspects that are kind of similar, whether it is a malaria mosquito or a black rhino, both count. On the contrary systematics is not going to state that the malaria mosquito is less important than the black rhino. In systematics a lot of other factors are also relevant. There's a relationship between the aspects and as you know black and white rhinos do not have similar genes. One can also add aspects like the scarcity or abundance of groups in South Africa or even aspects that stand out. You can add the final influence. It is not necessarily systematics, but can be added to the systematics framework." (Edited and translated from Afrikaans).

Dr S explained that when conducting an inquiry about an environment, knowledge of systematics is needed. A survey needs to be done on the different species in the environment. The survey would then be used to determine whether there was enough food and shelter available for the animals. Furthermore, the environment needs to be mapped to determine where species are located and to which family they belong. This would help to determine the carrying capacity of the environment. In order to manage the environment, information needs to be provided on the number of grazers and browsers in the environment. Then one has to determine which other species feed on the same plant species. Hence, the carrying capacity of the environment is very important and the species component needs to be known for which knowledge of systematics is needed.

Is prior knowledge of systematics necessary for the successful teaching of population dynamics and biodiversity?

According to Prof E, prior knowledge of systematics was not necessary to understand population dynamics. In the case of biodiversity, it is important for her that a learner must see diversity in terms of different organisms, the background of plants and animals and the ordering of taxa. She elucidated thus:

> "To me the whole systematic system is important. It is also important for them to know at which level we are working in examining this. If they don't know what they are working with or what the background is. Why did we look at the species and not the families? Those type of concepts." (Edited and translated from Afrikaans).

She explained that the term species is very important, especially because South Africa has a rich biodiversity. She reminded that we have proteas, grasses and trees, but then again within the protea there are different species. She capped this with:

> "They must know the system before they are really able to understand. I do not expect them to have an expanded knowledge of systematics but they must at least be able to recall examples and have a bit of knowledge concerning biodiversity and what it really is". (Edited and translated from Afrikaans).

Prof E believes that learners should first have a basic knowledge of systematics as foundation as this enables them to understand the purpose of these (population studies and biodiversity) concepts. They would then also understand the role of conservation and the reasons for it.

Dr S indicated that learners would have no idea of the types of plants and animals that exists if they have not walked in the grasslands and seen for themselves the number of species. She also indicated that learners would only value biodiversity if they have classified species. She explained that management can only be applied if one can determine which species exist in an area.

What is your opinion on the exclusion of systematics from the school curriculum?

Prof E lamented that the exclusion of systematics has really left a gap in the curriculum, whether it was interesting or not, because everyone can see variation in the organised system around them. Everybody can see the different types of animals and plants around them and the systems in which these plants and animals live. She continued:

> "It is difficult for me to believe that students don't need to know these concepts one struggles with. Millions of rands are spent on these important aspects such as alien invasive species, that water aspects are based on. One also has to understand these types of things in terms of systematics." (Edited and translated from Afrikaans).

Prof E explained that it is important for an ecologist to identify plants and it is not necessary to be able to identify it to species level. The plant could be identified within a particular group and thanks to its characteristics it could be classified later at species level. She stated, however, that the ecologist did not need to have systematics at school level, but that means more work on systematics at tertiary level to overcome difficulties in grasping it.

Dr S sees it as tragic that we are surrounded by numerous plant and animal species and we only have knowledge of the human species. According to her, the whole spirit of discovery is gone and we only know of those species that are seen every day.

What will the effect of the exclusion of systematics from the school curriculum be on tertiary studies in Life Sciences?

According to Prof E, systematics is still taught at tertiary level. There is a third year theoretical and practical course in botany at the University of Pretoria dealing with systematics. She surmised that at university level the lecturers assume that students have a certain level of prior knowledge of systematics. A student without prior knowledge of systematics would definitely struggle if he/she decided to follow a course in Life Sciences at university level. She adds:

> "Although it is not necessary to identify the family to which these plants belong every time, it makes life easier when looking at certain characteristics to understand the principles and to know where it belongs because of these characteristics. I more or less know what I'm going to look for and expand on. Therefore, it is definitely necessary at university level." (Edited and translated from Afrikaans).

Dr S said that systematics was becoming more and more unpopular at university level and experts in the field of systematics and taxonomy are becoming scarcer.

Are problem-solving and scientific inquiry in population dynamics and biodiversity dependent on the understanding of systematics?

Prof E feels that systematics must not be seen as an add-on to population studies or biodiversity, but that systematics must be seen as an entity, namely

> "I don't want to see it as a sub-division. It stands on it own and if you understand what it entails then population dynamics and biodiversity make much more sense. Then it is possible to understand that one works with one species concerning population. With regards to biodiversity one considers the whole framework and attempts to quantify it to reality." (Edited and translated from Afrikaans).

She added that there are a lot of methods to study systematics and she sees systematics as a prerequisite for commencing with the other concepts.

According to Dr S, the understanding of biodiversity is dependent on animal and plant systematics. She explained that in order to classify invader plant species, the plant species need to be identified. According to her, taxonomy forms the basis of this. The example she used is:

> "I came across a good example recently when I was at a holiday resort in Lydenburg. It was high on the mountain and there were, among others, blesbucks, springbucks and ostriches on top of the mountain. Everybody said it was a beautiful place, but I observed that there were only wattles. Then the first ostrich started dying and everybody wondered why this was happening. The reason was that the ostriches didn't eat wattles. These people have such insufficient knowledge that they did not even realise that these animals need food from the plants that grow naturally in the area." (Edited and translated from Afrikaans).

Further, she stated that invader plants must be identified and then methods to eliminate the species need to be applied, without harming the natural plant species around them.

5.4 Classroom observations made during teaching of population studies or biodiversity lessons to grade 11 NCS Life Sciences learners

This section changes track and reports on the observations in the classroom by structuring the information according to 3 sub-questions.

Classroom observations were made by the researcher during lessons taught under the Diversity, Change and Continuity strand. The content of the lessons comprised population studies, biodiversity and social behaviour of animals. The researcher used a worksheet as observation tool to guide the observations. The worksheet listed aspects to receive attention in the observations. Each observation feature was divided into the strand, topic and activities. Components were grouped to distinguish between the activities and to show under which strand and topic they were conducted. Table 5.5 sets out the topics and activities.

Table 5.5: Classroom observations conducted during the teaching of the Diversity, Change and Continuity strand in two schools.

Observation	School	Topic	Activities
1 and 2	1	Population studies	Mark-and-recatch method (Peterson index) – practical
3 and 4	1	Population studies	Biodiversity (introduction, revision and continuing with content)
5 and 6	1	Population studies	Social behaviour – mating behaviours and behavioural effects based on preservation, conservation and sustainability
7	2	Population studies	Population studies (introduction)
8 and 9	2	Population studies	Biodiversity (introduction and continuing with content)
10	2	Population studies	Biodiversity
11	2	Biodiversity	Marking of work
12	2	Population studies	Biodiversity in ecosystems

Prior to commencement of the practical session (mark-and-recatch method) in school 1, the educators (Ms A and Ms B) revised the content with the learners. Instructions were given to the learners about the practical and the worksheet. The worksheet was provided to give guidance to ensure the learners applied the calculations and method correctly. The learners used their textbooks for further guidance as well as the activities they completed. No additional information was provided to the learners as the textbook content and activities in the learners' workbooks were seen to be sufficient.

The duration of the lesson periods at school 1 were between 35 and 40 minutes. The time was sufficient for the lessons observed. Ms B should have allocated two periods for the practical session on the mark-and-recatch method because one period was too short for learners to complete the practical in. This resulted in most of the learners not knowing what to do in the practical or not understanding the reasons for doing the practical. This was evident from learners' comments to the educator at the end of the practical and their incorrect application of the method during the lesson.

In comparison, Ms A used two periods for the same lesson. Most of the learners did not read the instructions and so had lots of questions about what had to be done. It was a very lively class and one of the groups took much longer to complete the task than the other groups took, but there was sufficient time and all the groups finished the practical with time to spare. The majority of the groups applied the work correctly.

The duration of the lesson periods of school 2 was between 30 and 35 minutes. The time was sufficient for the lessons observed. In contrast to school 1, the classes observed were smaller with fewer than 30 and 20 learners respectively. At school 2 the learners remained very quiet in class while the educators were teaching. However, when the learners were given an opportunity to ask and answer questions or for group discussions, there was a good deal of interaction between learners and educators.

Activities formulated in the textbook, in handouts and on transparencies were completed by groups as well as individually by the learners in both schools. The learners asked questions during the lessons and answered to the questions asked by the educators. This type of interaction was more visible in school 2 than school 1. Group discussions were held and learners took notes during some of the lessons. This happened in both schools, but the learners in school 2 took part with more enthusiasm in their group discussions. In school 1, very few learners took part in group discussions. Learners in both schools underlined passages in their textbooks highlighted by the educator as being important.

The information recorded during the classroom observations is discussed below according to three sub-questions.

5.4.1 How do educators interpret the curriculum when selecting content knowledge (substance) of systematics when preparing to teach population dynamics and biodiversity?

The researcher wanted to find out how educators selected content knowledge (substance) associated with systematics when teaching population dynamics and biodiversity. During the population studies lesson the four educators (Ms A, Ms B, Mr C and Ms D) explained the content according to the information in the textbook. If required, additional information was used. The four educators also explained the content by referring to the content covered in the previous lesson. They used their own practical examples and graphs.

Regarding the biodiversity lesson, Ms B planned to start the lesson by using a television programme as a launching point. At the start of the lesson she explained that:

> "You probably saw on shows like *50/50*, *Animal planet* etcetera that biodiversity is the new 'hoehaa' word." (Edited and translated from Afrikaans).

She planned to explain biodiversity with reference to examples like the Kruger National Park. During the social behaviour lesson, Ms B did not make it clear to the learners how social behaviour fits in with regards to population studies and biodiversity. Ms B dominated the lessons and there was not much learner-teacher interaction. In her introductory lesson to biodiversity, she did not give the learners the opportunity to get involved in discussions and the learners were not given any opportunity to ask questions after she had explained the work.

The educators at school 2 (Mr C and Ms D) allowed a lot of interaction with the learners. Both educators explained the content by posing questions to the learners and answering questions asked by the learners. Both educators explained the content with an open textbook, sometimes by reading selected sections from the textbook and handouts (Internet resources dealing with biodiversity on earth and a *Beeld* article: "Biodiversiteit al vinniger agteruit") and by posing questions on the information. The two educators expanded on learners' answers. They also decided to refer to content covered earlier by means of questions like what will happen if pollution increases (during the population studies lesson) or by just referring to threats of biodiversity (during the biodiversity lesson). Mr C also used examples of the ghost frog, black rhino and hunting during the biodiversity lesson. In using these examples, he explained to the learners the effect of hunting on biodiversity as well as the importance of conserving a small animal like the ghost frog and a big animal like the black rhino. He also used examples like Pavlov's dogs, dolphins and termites to explain biodiversity in ecosystems.

Although Ms D prepared thoroughly for the biodiversity lesson by reading additional material, it was evident that she had limited knowledge about the topic (biodiversity), due to the fact that learners' questions relating to certain groups of animals, for example mollusks (systematics), could not be answered. She also showed uncertainty, when answering questions relating to biodiversity issues such as the detainment or rehabilitation of animals and the effects it has on the animals. In the lesson during which the biodiversity activities were marked, Ms D interacted with the learners and asked them to provide their answers to the questions. She also read the correct answers (from her memorandum) to the learners.

5.4.2 What are the main elements and components of population dynamics and biodiversity in the grade 11 Life Sciences curriculum in terms of substance and syntax?

This section deals with the main elements and components of population dynamics and biodiversity in the grade 11 NCS Life Sciences curriculum in terms of substance and syntax.

Educators in both schools used the work schedule (Department of Education, 2007b) and learners' textbook as guide to determine which concepts and content to include. Concepts and content on which emphasis was placed in population studies lessons in school 1 (Ms A and Ms B) were carrying capacity, density-dependent and-independent factors, competition, territoriality, predation and the ratio of prey to predator. In school 2 (Mr C and Ms D), the focus was on definitions of population studies, population, deme (with reference to Kruger National Park lions and Zimbabwean lions as example), species, population density, population size, rarely/densely populated, biomass, population growth and population parameters. Factors affecting population size, namely mortality, natality, emigration, immigration, fertility and others like sex ratio, genetic material, age distribution and distribution patterns were also covered.

In the introductory biodiversity lesson in school 1 (Ms A and Ms B), the concepts and content on which there was emphasis was the definition of biodiversity, the types of biodiversity (genes (roses), species (dolphins) and ecosystem) and the importance of biodiversity. Ms B made reference to television programmes such as *50/50* and documentaries on channels such as *Animal Planet*. Ms A included the development of primitive organisms (plants – used *Rhizopus* which was discussed earlier in the year as example) to more advanced animals (mammals as example). She linked cell respiration and photosynthesis to the importance of biodiversity. The threats to biodiversity were explained during another lesson by Ms A, namely loss of habitat (mining, invasive birds), pollution (cars), wildlife trade (abalone, rhino horn and cycad), wildlife hunting (hunting and photographing of animals) and exotic species (black wattle, pines – lower pH, no nests in exotic trees and no tree growth in soil under tree). The red data book was also mentioned by Ms A when discussing conservation of South African biodiversity.

In school 2 (Mr C and Ms D) the following concepts and content were concentrated on in the introductory biodiversity lesson: the definitions of monoculture, specialisation, and ecotourism (Knysna and Kruger National Park as examples), effects if species become extinct, pioneer plants and succession, how biodiversity prevents species from becoming extinct and medicinal plants ("super bugs" were used by Mr C as an example). Mr C placed emphasis on the definition of endemic and on threats to biodiversity. Ms D placed no emphasis on species which became extinct or on the endangered species or on the prevention of species from becoming extinct (content which was included in the textbook). The effect of biodiversity on the environment and on food chains (butterflies and flowers were used by Ms D as examples) was also discussed. The effects of biodiversity on specialisation, exotic plants and their effect on indigenous plants (water, food and space were used as examples) were taught, definitions of medicinal plants as well as the use of medicinal plants and ecotourism (Ms D used seals in Namibia as example) were explained. Reference was also made by both educators (Mr C and Ms D) to biodiversity and climate, the list of the earth's biodiversity (number per class), estimates of biodiversity on earth, the loss of biodiversity, conservation of biodiversity, the reserves for conservation of biodiversity and the red data list.

Conservation issues also formed part of the biodiversity lessons. The concepts and content on which Mr C placed emphasis were the conservation of ecosystems, ethical issues, money funding (ghost frog versus black rhino), political issues concerning conservation, threats (factors) to the survival of animals. There was also reference to the life cycles of the animals. Ms D covered these issues during the marking of the biodiversity activities.

During the social behaviour lesson in school 1, examples of different animal social behaviour were mentioned. Concepts and content explained in more detail by Ms A were altruism (blue crane), hierarchy (hyena), group work (dolphins and lions), polymorphism, inculcation and conditioning (linked to natural selection) as well as the different forms of competition (zebra graze on top grass and blue wildebeest on bottom grass).

In school 1 (Ms A and Ms B), the practical lesson (mark-and-recatch method) had a two-fold purpose: the learners were challenged with problem-solving (doing calculations) and scientific inquiry (applying the mark-and-recatch method). Thus, the concepts and content covered by the practical were the different uses of this method and the application of the formula. Reference was made to activities 11 and 12 in the textbook which are based on this mark-and-recatch method and its application. Ms A emphasised the instructions of the practical and on the method to be followed by reading and explaining it to the learners prior to commencement of the practical. She referred to the fish example she had used in class to explain the indirect method of determining population size.

Concerning biodiversity lessons in school 2, problem-solving was done as a handout exercise which called for learners to answer questions about the World Conservation Union. Other activities included in the textbook, were problem-solving questions on the life cycle of sea tortoises, questions on ethical issues such as the black rhino's horn and questions about the Kavango-Zambezi crossborder Park.

The social behaviour lesson observed in school 2, required learners to conduct research by searching for examples of social behaviour and bringing them to class for discussion. This was a scientific inquiry activity. During the biodiversity lesson, evidence of problem-solving and scientific inquiry was apparent. Mr C sketched two scenarios in class, the relationships between foxes and rabbits and foxes and diseases. The learners discussed these two scenarios in class, that is problem-solving. Afterwards, learners worked on four activities in class, one activity with a reading passage and graph (growth curves - LO 1 and 2), two activities with a graph, questions and scientific inquiry (human population growth - LO 2) and one activity with a reading passage and questions (HIV/AIDS - LO 2 and 3).

5.4.3 What are the links between content knowledge (substance) of systematics, population dynamics and biodiversity?

It was important to establish the links between content knowledge (substance) of systematics, population dynamics and biodiversity during the scientific inquiry and problem-solving lessons in grade 11 Life Sciences. This section discusses this issue. It highlights how educators integrate content of systematics with population dynamics and biodiversity content knowledge (substance) when planning or designing problem-solving or scientific inquiry tasks.

There was little evidence of the use of examples of systematics in the population studies lessons. In one of these lessons, Mr C linked the term species to systematics by using examples from the class Aves. He explained to the learners that when looking at birds different species can be identified for example parrots, lovebirds and eagles to name a few. Learners studied the five-kingdom classification system in grade 10 and continued with it in grade 11, but the educators made no reference to the classification in their respective lessons. The researcher believes that this prior knowledge of systematics is needed to understand population studies lessons better.

It was evident that the experienced educators (Ms A and Mr C) used content and knowledge of systematics more than the less experienced educators (Ms B and Ms D). Ms A briefly mentioned the development of primitive organisms to developed organisms during one of her biodiversity lessons. She started with the fungi (*Rhizopus species*) and ended with the mammals explaining to learners how organisms evolved to become more specialised and adapted to the environment. She explained that the characteristics of species enable them to stay alive in a certain environment. These characteristics also determine whether a species is more developed than other species or not. In the biodiversity lessons at school 2 (Mr C and Ms D), the content and knowledge of systematics were included in a handout (classification of micro-organisms, protists, fungi, plant and animal classes). Mr C used the content of a *Beeld* handout ("Biodiversiteit al vinniger agteruit") to illustrate that amphibians are more sensitive to habitat destruction than birds and he referred to the previous lesson on Darwin and survival of the fittest (inbreeding of dogs was used as an example). Content of systematics was also included in a biodiversity lesson by comparing the conservation of amphibians to mammals. Climate control's role in the sustainability of biodiversity was explained and this was linked to respiration. During the marking of the biodiversity activities, Ms D mentioned aspects of systematics – different animal groups and species were used.

In the social behaviour lesson, Ms A referred to the mating of birds (ostriches) as an example of courtship. This type of knowledge and content could be linked to systematics as the class Aves uses courtship during reproduction.

From the classroom observations it can be seen that educators in both schools used the work schedule and learners' textbook as guide to determine which main elements and concepts to include in the teaching of population dynamics and biodiversity. The content was mainly explained by the educators according to the information in the textbook. If required, additional information was used, which in some occasions led to the inclusion of content or knowledge of systematics. Furthermore, the educators used their own practical examples during teaching of population dynamics and biodiversity.

5.5 Summary

In order to gather the data three main data collection methods were used, namely document and text analysis, semi-structured interviews and classroom observations. The document and text analysis provided information on the content and practical activities included in the Diversity, Change and Continuity strand of the NCS Life Sciences curricula (NCS Life Sciences curriculum and New Content Framework for Life Sciences) and in the learners' workbooks and textbooks. The semi-structured interviews provided the opinions of the educators, curriculum developers and experts in systematics and in ecology on the content (substance) and practical (syntax) components of the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006. Furthermore, the semi-structured interviews give the comments of the educators and curriculum developers on the reintroduction of systematics in the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009. Finally, the classroom observations brought clarity on which content and practical skills are incorporated during the teaching of population dynamics and biodiversity.

The evidence provided in this chapter, will be used to piece together a holistic picture to reach the conclusion for the research topic. The discussion and conclusion are provided in the next chapter.

Chapter 6

Analysis, discussion and conclusion

6.1 Introduction

This chapter provides information about the response to the sub-questions posed and the assumptions made at the outset. The information was acquired by means of the literature review, semi-structured interviews, document and text analysis and classroom observations.

Before reporting the findings, an overview of the problem, sub-questions and aim of the investigation is given. In terms of the conceptual framework (CHAT) it was hoped that the implementation of the NCS Life Sciences curriculum (Department of Education, 2003) would provide an ideal curriculum. However, because systematics was excluded as a separate unit in this curriculum (Department of Education, 2003) implemented in 2006 for grades 10 to 12 educators cannot explain and interpret certain interactions and integrations of population dynamics and biodiversity effectively. This exclusion is surmised to have an influence on problem-solving and scientific inquiry in population dynamics and biodiversity. To determine whether this is true, the main elements and components of population dynamics and biodiversity were identified and evidence was gathered about how educators select and integrate content of systematics, as well as how the integration of problem-solving and scientific inquiry were related to systematics when teaching population dynamics and biodiversity. The possible links between knowledge of systematics, biodiversity and population dynamics were studied. As stated in section 3.7, the educators are stakeholders in the continued development of the curriculum and their input will influence both the implementation and the further development of the curriculum. The changed Life Sciences curriculum, known as the New Content Framework for Life Sciences (Department of Education, 2007a), implemented in 2009 reintroduced systematics as a single unit under the Diversity, Change and Continuity strand. This research studied why systematics has been reintroduced into the Life Sciences curriculum. In terms of the CHAT model, the objective of curriculum development was studied with a focus on the experiences and contributions of educators and curriculum developers as role players, the constraints and the rules (such as the policy) under which the development took place. The main purpose of this study is, therefore, to determine what influence the exclusion of systematics as a separate unit from the Life Sciences curriculum implemented in 2006 had on the teaching of population studies and biodiversity.

This chapter is structured as follows: First, the 6 sub-questions and the related 9 assumptions made at the outset of the research are discussed, this section is followed by reporting on the major findings, then the recommendations from the research are listed, followed by possible topics for future research, the limitations of the study and finally the chapter ends with the conclusion.

6.2 Sub-questions and assumptions

The information gathered during the research is assessed for each of the 6 sub-questions and the related 9 assumptions.

6.2.1 Main curriculum elements and components of population dynamics and biodiversity

What are the main elements and components of population dynamics and biodiversity in the grade 11 Life Sciences curriculum in terms of substance and syntax?

The content included in the work schedule and in the two textbooks is quite similar, although there are some minor differences (recall Table 5.3). The curriculum provides an outline of which concepts need to be covered and the work schedule provides a detailed breakdown of the curriculum. According to Department of Education (2005b:5), the work schedules are documents that reflect what teaching and assessment will take place in the 32 to 36 weeks of school. Assessment of the textbook content determined that the textbooks could be improved by including more content on population dynamics and biodiversity (section 5.2.3). Learners using textbook 2 (Grobler, n.d.) are given a broader understanding and knowledge of biodiversity than learners using textbook 1 (Clitheroe, Doidge, Marsden, Van Aarde, Ashwell, Buckley and Dilley, 2006), while learners using textbook 1 get a broader understanding and knowledge of population dynamics than learners using textbook 2. Textbooks 1 and 2 do not cover population dynamics and biodiversity sufficiently. This is the reason why educators had to add additional content that learners had to include in their workbooks. This ensured that additional content knowledge of population dynamics and biodiversity was addressed (section 5.4.2). The activities proposed in both textbooks mostly relate to problem-solving, with only a few on scientific inquiry (Table 5.4).

Classroom observations showed that the educators (Ms B, Mr C and Ms D) tried to progress too rapidly through the content so that learners seemed to struggle with the content. This was especially so in a practical on population dynamics regarding the mark-and-recatch method in Ms B's class (section 5.4). Insufficient time was allocated for completing the activity, compounded by a lack of understanding by learners and an inability to apply it. Although the educators emphasised different topics, depending on their way of teaching and the prescribed textbook being used, the overall view of population studies and biodiversity was similar.

The educators all maintained that the population dynamics content in the curriculum (Department of Education, 2003) and work schedule (Department of Education, 2007b) was vague and that they were unsure about the amount of detail on the topic to be covered. All four educators agreed that less content was contained in the NCS Life Sciences curriculum (Department of Education, 2003) compared to the previous NATED 550 Biology curriculum (Department of Education, n.d.). They agreed further that the basics of population dynamics were covered. However, there were mixed feelings among the educators about the time allocated to population studies: Ms B and Mr C felt that insufficient time was allocated to do the work in detail, but Ms A and D felt that enough time was allocated (section 5.3.1.1). Furthermore, they all (Ms A, Ms B, Mr C and Ms D) concurred that learners must have certain prior knowledge in order to understand specific concepts in population dynamics and biodiversity or to do problem-solving and scientific inquiry (section 5.3.1.2, section 5.3.1.4 and section 5.3.1.5). It seemed as if the educators felt that the learners did not have that prior knowledge. Various authors have emphasised the value of prior knowledge. Bruner (in Ellis, 2004:24) stated that the acquisition of knowledge is an active process, and that meaning is acquired when incoming facts are connected to previously acquired knowledge. According to Chrisen and Murphy (1991:2) prior knowledge is an important component of the learning process and it is a major factor in comprehension. Ausubel (1968:538) earlier explained that without background knowledge of concepts and principles, no problem-solving is possible, irrespective of the learner's degree of skill in discovery learning. The curriculum developer Ms X, who is not a population dynamics expert, was satisfied with the content of population dynamics included in the work schedule. Her opinion about the practical work was that more creative ways of teaching population dynamics should be followed, like making use of television programmes and game playing (section 5.3.2.1).

The contention made at the outset was that there is insufficient prior knowledge related to systematics, included in the teaching of population dynamics and biodiversity with only the main concepts receiving attention (section 1.3.3). The above findings support this assumption. In terms of the CHAT model, the lack of consideration for prior knowledge contributed to the development of an inadequate curriculum. Content knowledge should have been an important tool that provided input in the activity, but this was neglected in favour of a focus on outcomes. This resulted in insufficient consideration of the prior knowledge needed to understand population dynamics and biodiversity.

6.2.2 Integration of systematics in task planning or design

How do educators interpret the curriculum in order to integrate content of systematics with population dynamics and biodiversity content knowledge (substance) when planning or designing problem-solving or scientific inquiry tasks?

The semi-structured interviews and classroom observations established that during class presentations three of the educators (Ms A, Mr C and Ms D) used or referred to systematics, although Ms A did it only as part of the introduction to biodiversity (section

5.4.3). The young, less experienced educator (Ms B) did not use knowledge of systematics in her teaching of population studies and biodiversity. However, in her interview Ms B commented that knowledge of systematics would help learners to solve problems in population dynamics and biodiversity (section 5.3.1.4). Educators (Ms A, Mr C and Ms D) in both of the schools included content of systematics in their lessons in the Diversity, Change and Continuity strand, but more formal activities were included in the learners' workbooks in school 2. Ms B, Ms D and Mr C felt that knowledge of systematics would have helped learners to understand population dynamics and biodiversity better (section 5.3.1.4). Document analysis of the learners' workbooks showed that school 2 included content of systematics in the population studies and biodiversity part of the work (Table 5.4). This content included activities from the textbooks as well as additional photocopied handouts provided by the educators (Mr C and Ms D). The Learning Programme Guidelines for Life Sciences (Department of Education, 2007b:14) mentions that educators are required to work beyond the reach of the textbook. The resources used to obtain additional content and to find examples to make the work more interesting for learners included additional textbooks, the Internet and the *Beeld* newspaper (section 5.2.3). These examples were used as a link to the content envisaged in the work schedule. Other resources included wall charts and transparencies. Even as early as the 1980's, Rogers (1983:239) indicated that facilitative educators provide all kinds of resources that can give students experiential learning relevant to students' needs. It should be emphasised that resources should not only be used to improve teaching and learning in general, but it should also be used to enhance content.

Therefore, the assumption made that most educators do not use knowledge of systematics when teaching population dynamics and biodiversity is incorrect (section 1.3.3). Three educators used systematics, although some educators referred to it more often (Mr C and Ms D) than others (Ms A). This implies that the exclusion of systematics as a separate unit from the curriculum has left a void that these educators tried to fill by virtue of their acquaintance with the field of specialisation, their training or classroom experience.

Another assumption made was that the grade 11 Life Sciences curriculum leaves room for interpretation by the educator and this influences the use of systematics when teaching population dynamics and biodiversity (section 1.3.3). Analysis of the NCS Life Sciences curriculum (Department of Education, 2003:39) and the work schedule (Department of Education, 2007b:37), confirmed that there is room for interpretation by the educator. The four educators agreed but pointed out that they would have preferred more detailed guidance (section 5.3.1.1). In the context of the conceptual framework (CHAT), this represents a tension between the intentions of curriculum developers and the needs of educators. The NCS Life Sciences curriculum (Department of Education, 2003:5) holds that the kind of educator envisaged is one who fulfills the various roles outlined in the Norms and Standards for Educators (Department of Education, 2000). These include being interpreters and designers of learning programmes and materials. Ms X, the curriculum developer, was satisfied with the curriculum and felt that more detailed guidance was unnecessary. According to her, the broad concepts are included and the educators must use the information in the curriculum to develop their own curricula (section 5.3.2.1). The assumption appears to be valid.

The background training of the educators plays a role in the teaching of population dynamics and biodiversity. As with learners, the prior knowledge educators have plays a role in their teaching. This was illustrated by the two educators (Ms B and Ms D) who did not take plant and/or animal science as subjects in their tertiary studies. Ms B did not make any reference to systematics and Ms D also seemed very uncomfortable and unsure when content linked to systematics was covered in class (section 5.4.1). Bruner (1960:32) explained that designing curricula in a way that reflects the basic structure of a field of knowledge requires the most fundamental understanding of that field. The more experienced educators (Ms A and Mr C), who had background training relevant to systematics, referred to systematics which aligned with certain concepts in biodiversity. They (Ms A and Mr C) also used a wider range of examples to teach population studies and biodiversity. In school 1 Ms A briefly referred to the content of systematics, whereas in school 2 Mr C and Ms D taught content of systematics in detail in one of the biodiversity lessons. Mr C even referred to systematics during population dynamics lessons (section 5.4.3). Nagel (1996:6) avers that when a constructivist approach to teaching and learning is followed, the teacher will assist learners throughout the learning process by providing examples, activities and experiences that help learners acquire knowledge, organise this knowledge and make connections between the new knowledge and prior learning to create personal meaning. Some content and knowledge of systematics appeared in the handouts given to the learners. In one of the handouts at school 2 (Mr C and Ms D) micro-organisms, protists, fungi, plants and animals were categorised into their different groups (Table 5.4).

Educators have indicated that they use a number of sources to guide their planning. These include the model examination papers that are made available towards the end of the year (section 5.3.1.1), the Assessment Syllabus (section 5.3.2.1), work schedules and textbooks (section 5.4.3). Under qualified educators of which there are many (section 5.3.1.1) may not be able to interpret the curriculum and other sources to successfully teach population dynamics and biodiversity. This evidence validates the assumption that the background training of the educator influences his/her interpretation of the curriculum when teaching population dynamics and biodiversity, especially the inclusion or exclusion of systematics content (section 1.3.3).

6.2.3 Integrating science process skills and scientific inquiry related to systematics

How do educators integrate the science process skills and scientific inquiry (syntax) related to systematics when teaching population dynamics and biodiversity?

Verduin (1996:7) asserts that the most important quality of generating new knowledge is that it demands higher-order thinking that goes beyond factual consumption, memorisation and regurgitation frequently encountered in our regular schools not only in the elementary and secondary levels but also in higher education. In the interviews, it became evident that three of the four educators (Ms B, Mr C and Ms D) agree that practical skills like problem-solving and scientific inquiry are minimised in population dynamics (section 5.3.1.2). The main reason given by the educators is that portfolio work had already been completed, so that learners were not interested in the content of population dynamics and biodiversity as they were preparing for the final examinations by focusing on the type of questions included in examination paper 2. It must be noted that the content covered in the Diversity, Change and Continuity strand formed part of examination paper 2. This paper is based on interpretation questions and learners had to apply their knowledge in this examination (see Department of Education, 2009). The examination comprised inter alia reading passages on which questions are then based (case studies) and the drawing of graphs and sketches followed by questions on them. The two curriculum developers, Ms X and Dr Y, agreed with the educators that the prescribed practical part of the curriculum in the work schedule is insufficient (section 5.3.2.1).

The learners' portfolios did not include any content about the Diversity, Change and Continuity strand. The reason was that the portfolio files had already been handed in for moderation before the final strand's work commenced. Hence, portfolio files were excluded from the study. Scrutiny of the learners' workbooks and textbooks evidenced that most of the activities were problem-solving activities and few were scientific inquiry activities (Table 5.4). The classroom observations confirmed that the educators only used problem-solving probes, although scientific inquiry was involved – learners applied the mark-and-recatch method and they had to bring pictures of endangered species to class (section 5.4, section 5.4.2 and section 5.4.3). Learners worked in groups and individually to complete worksheets and practical sessions to reach the desired outcomes.

Regarding this research sub-question, the assumption made was that scientific inquiry and problem-solving relating to science process skills (syntax) are limited or restricted in the teaching of population dynamics and biodiversity (section 1.3.3). The findings reveal that this assumption is valid. Linek, Sampson, Gomez, Linder, Torti, Levingston and Palmer (2009:403-411) alleged that high-quality science education is lacking in America due to the need for ongoing professional development related to curriculum, appropriate resources and teaching strategies. However, in South Africa in terms of 'Norms and Standards for Educators' (Department of Education, 2000), educators fulfill the roles of interpreter and designer of material (section 6.2.2). This means that if scientific inquiry and problem-solving are restricted in the teaching of population dynamics and biodiversity, the onus is on the educators to create more opportunities for learners to apply these skills. This also means that learners do not get enough exposure to higher level skills in population studies and biodiversity. In South Africa professional development related to the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 is called for. The activity of curriculum development requires that different role players should contribute to the development of an ideal curriculum that all educators are able to implement. The failure of the curriculum development team to assess the ability of educators to implement this curriculum hinders the successful implementation of this part of the curriculum that requires learners to become involved in problem-solving and scientific inquiry.

6.2.4 Selecting substance of systematics in population dynamics and biodiversity lesson preparation

How do educators interpret the curriculum when selecting content knowledge (substance) of systematics when preparing to teach population dynamics and biodiversity?

The aim of the NCS Life Sciences curriculum implemented in 2006 is to develop a high level of knowledge and skills in learners (Department of Education, 2003:3). It also specifies the minimum standards of knowledge and skills to be achieved at each grade and sets high, achievable standards in the Life Sciences (Department of Education, 2003:3). Because it specifies the minimum standard of knowledge and skills, broad descriptions are used. Conversely, the work schedule (Department of Education, 2007b) provides more detail concerning teaching and assessment that needs to take place. Consequently, the work schedule was used by the four educators (Ms A, Ms B, Mr C and Ms D) as a guide to see which content must be covered and planned accordingly (section 5.3.1.1). Planning per term, day and outcome was seen as an important part of preparation by Mr C. All four educators (Ms A, Ms B, Mr C and Ms D) made use of examples when teaching and resources were not restricted to the prescribed textbooks.

Other resources used were additional textbooks related to the field of Life Sciences, the Internet (articles related to the field of biodiversity), the *Beeld* newspaper ("Biodiversiteit al vinniger agteruit"), wall charts and transparencies. In both schools, most of the activities in the learners' workbooks were done from the textbooks. Only a few activities included in the learners' workbooks were developed by the educators in both schools (Table 5.4).

In school 1 the educators (Ms A and Ms B) approached teaching similarly. They explained the work to the learners and there was not much interaction between the educators and learners (section 5.4). As mentioned in section 6.2.2, only Ms A referred to systematics as part of her introduction to biodiversity, whereas Ms B made no reference to systematics. In school 2, Ms D followed her own teaching approach and was supported by Mr C if needed. Both used the question-and-answer method and maintained good interaction with their learners (section 5.4). Mr C helped Ms D with additional information for inclusion in handouts. From section 6.2.2 it was clear that these two educators used and referred to systematics during presentations to their learners. Ms D found it harder to gather content on the Diversity, Change and Continuity strand needed to ensure the learners had new work daily.

Fraser, Loubser and Van Rooy (1993:48) contend that the mastering of content is facilitated when meaning is given to the essentials (facts, concepts and principles) and that knowledge of the basic insights promotes comprehension of the whole. Thus, population dynamics and biodiversity could be presented in an incorporated way, that is in a manner in which the interrelatedness between these concepts becomes clear. This could make it easier for learners to understand where these concepts fit into the holistic view of Life Sciences. There was no evidence of this happening in the two schools. Each concept was taught on its own without a clear link between it or other facts and concepts in the Life Sciences. Fortunately, on some occasions a link was made to systematics.

The assumption that educators do not prepare in a manner that leads to effective teaching of population dynamics and biodiversity (section 1.3.3) seems to be valid. Life Sciences should rather be taught in a way which reveals the interrelatedness between the concepts. According to Khodor, Halme and Walker (2004:120), the concepts that learners need to learn can be organised into a hierarchy and if the learners are to grasp and remember these concepts, the educator needs to be explicit about what these concepts are, how they are connected to each other and how they fit into the larger picture of the course. However, because there was not one prescribed textbook, the educators should have taken the responsibility to develop more activities from other resources and add relevant content from additional textbooks to the activities. If this was the case in this study which was only conducted in Afrikaans medium former model C schools how much worse will it not be in under privileged schools? The question also arises whether the textbooks used in these schools are adequate. Although the research indicated that educators used some additional learning material, this was still too limited. The heads of department (Ms A and Mr C) should have fashioned a balance between mentoring the younger educators (Ms B and Ms D) and allowing them to follow their own methods of teaching. This would ensure more effective teaching of population dynamics and biodiversity.

The assumption that educators follow the guidelines of the NCS but do not use their own initiative (section 1.3.3) is contradicted by the evidence that educators follow the guidelines of the curriculum and work schedule, but they use their initiative to consult additional sources and devise activities to make the work more interesting for their learners (section 5.2.3). The educators need to pay more attention to the latter aspect. It should be noted that the curriculum does not provide extensive guidance and the educators do not have a choice but to develop their own activities. Maybe the curriculum should have guided educators to make the links between different parts of the work.

6.2.5 Links between substance of systematics, population dynamics and biodiversity

What are the links between content knowledge (substance) of systematics, population dynamics and biodiversity?

Symington and Tytler (2004:1403) noted that the key concern of advocates of scientific literacy is that the curriculum should prepare all students to engage with science in their adult lives. Ms X, one of the curriculum developers, explained that when the curriculum went out to the public, educators had mixed feelings about it – some educators were shocked that systematics was excluded while others were pleased because they deemed it to be irrelevant and "boring" to learners and that it is not easily grasped by them (section 5.3.2 and section 5.3.2.1).

The research found that certain concepts and processes must be understood by learners before they are able to apply them to problem-solving and scientific inquiry. The classroom observations revealed that knowledge and content of systematics could be incorporated as a point of departure for teaching about certain concepts. The concept of the development of primitive species to developed species could be used as an example (section 5.4.3). With knowledge of the main grouping of organisms (content of systematics), learners would understand the development of organisms better. Another concept that could be used as an example is the diversity of species within animal and plant groups (section 5.4.3). Knowledge of systematics would enable learners to understand where each species fits into the animal and plant groups. Anderson (in Carin, Bass and Contant, 2005:121) asserted that scientific concepts need to be explicitly introduced and taught to learners. Dr S, the systematics expert, explained that when conducting an inquiry on an environment, knowledge of systematics is needed. An ecological study can only be conducted successfully when one knows and understands the existing species of an area (section 5.3.3.1). However, Prof E, the ecology expert, maintained that prior knowledge of systematics was only important for the understanding of biodiversity (section 5.3.3.1). Consequently, learners should start off with systematics as foundation and proceed to the understanding of the other concepts and the interrelationship between them. Perrone (in Nagel, 1996:15) emphasised that students need to be able to use knowledge, and not only know about things. Understanding is about making connections among and between things, about deep and not surface knowledge and about greater complexity, not simplicity.

One must agree with the experts in systematics and ecology that biodiversity is dependent on systematics and that systematics should not be seen as an 'add on' to population studies or biodiversity, but that systematics must be seen as an entity (section 5.3.3.1). But it is important that the systematics entity be taught in a manner that helps learners understand the interrelatedness between systematics, biodiversity and population dynamics.

Systematics is still studied at tertiary level and a student without prior knowledge of systematics will struggle if he or she follows a course in Life Sciences at university level (Table 2.2 and section 5.3.3.1). Educators (Ms A, Ms B, Mr C and Ms D) agreed that tertiary study will be a revelation for learners because so little emphasis is placed on content knowledge in school. It was mentioned that if the university study is not for an application degree, learners will struggle to pass due to their lack of knowledge and inquiry expertise (section 5.3.1.4). Depending on the learners' field of study, they would need to do much self-study to acquire the necessary prior knowledge. Systematics and prior knowledge would certainly help learners in their tertiary studies because some of the concepts would be familiar to them and part of their thought processes. Carin, Bass and Contant (2005:70) explain that the construction of new knowledge is always guided and enabled by the learner's prior knowledge. The expert on systematics, Dr S, explained that the study of systematics is becoming increasingly unpopular at university and that the number of experts in the field of systematics and taxonomy is declining (section 5.3.3.1). Learners are no longer eager to study in an animal or plant sciences field because there is not enough content about these fields at school level. Evidence supporting this latter reason is obvious by its absence in the NCS Life Sciences curriculum (Department of Education, 2003:39). The assumption that systematics and content knowledge have implications for learners in understanding population dynamics, biodiversity, problem-solving, scientific inquiry and for possible future studies (section 1.3.3) is validated by the findings presented above.

6.2.6 Reasons for and implications of reintroduction of systematics

Why has systematics been reintroduced into the Life Sciences curriculum and what differences has the reintroduction caused?

Activity theory (section 3.7) considers an activity such as curriculum development to be a "horizon, the object is never fully reached or conquered" (Engeström, 1999:380). Scrutiny of the New Content Framework for Life Sciences (Department of Education, 2007a:11-12, 23-25, 34-35) clearly shows that systematics has been reintroduced into the curriculum and now forms a major part of it. The trend in the Diversity, Change and Continuity strand is away from population studies and social behaviour to a focus on knowledge of systematics, evolutionary trends, biodiversity, modifications of basic body plans and biogeography (Table 5.2 and section 5.2.2). Emphasis is also placed on the awareness of conservation and the value of plants and animals.

There is new content under the Diversity, Change and Continuity strand that was not included in the previous NATED 550 Biology curriculum and NCS Life Sciences curricula (Table 5.2). The new content falling under systematics includes the history of classification to indicate that as information increases classification changes; naming things in science using Latin; the three-domain classification system with kingdoms in each domain; interpreting a phylogenetic tree representing the evolutionary history of animals; and modifications of basic body plans (section 5.2.2).

Other new biodiversity-related concepts are components concerning the history of life on earth; key events in life's history for which there is evidence from southern Africa; the diversity of life and endemic species; distribution maps of species; the role of invertebrates in agriculture and ecosystems; sustainable use of animals in South Africa; modifications of basic body plans; and biogeography (Table 5.2 and section 5.2.2).

The inclusion of these concepts signify a modernised Life Sciences curriculum, especially because it is the first time that the three-domain classification system has been included in a Life Sciences curriculum. This curriculum also provides more detailed guidance for educators compared to that given in the previous NCS Life Sciences curriculum (Department of Education, 2003). The Department of Education (2007a:3) argues that

> "because the content in the subject Life Sciences as listed in the National Curriculum Statement (NCS) Grades 10 – 12 (General) was underspecified, it was deemed necessary to revise the subject with a view to supporting the implementation of the NCS Grades 10 – 12 (General)."

The population studies content has been moved to the grade 12 curriculum (Department of Education, 2007a:27, 28) under the strand Population and Community Ecology (Environmental Studies). This is an improvement on the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 because learners will be better informed when they are confronted with population and community ecology in grade 12. The knowledge platform is laid in grades 10 and 11 by providing learners with a holistic view of diversity and some evolutionary trends on which to build in greater detail in grade 12 in population and community ecology. This links to the 'spiral curriculum' discussed in section 3.4 and also leads to Bloom's levels of cognitive thinking because it exposes the learners to lower-and higher-order thinking (see section 3.5 and Table 3.1).

The information obtained from the interviews with the curriculum developers, Ms X and Dr Y, (section 5.3.2.2) align with my analysis of the curriculum. There was supposed to be a sequence in the development of the Diversity, Change and Continuity strand. The big picture of biodiversity was looked at and it was necessary to establish strong foundations on which to build the theory of evolution by natural selection. The emphasis in this strand is on a clearer understanding of the link between evolution, biodiversity and the reasons for classifying organisms in certain ways. Dr Y acknowledged that the exclusion of systematics from the previous NCS Life Sciences curriculum was not a good idea because systematics is one of the foundations of biology. A similar point of view is highlighted by Case (2008:472) as follows:

> "Taxonomy, the identification, naming, and classification of living things, is an indispensable unit in any biology curriculum and indeed, an integral part of biological science. Taxonomy catalogues life's diversity and is an essential tool for communications. Taxonomy is an especially dynamic field today."

Woodland's (2000:ix) contention that the role of contemporary systematics is unifying, accords with the above statements and with the following one from the New Content Framework for Life Sciences (Department of Education, 2007a: 5) about the necessity for students to be able to link related topics:

> "When teaching this Life Sciences framework, it is very important to emphasise the links that students need to make with related topics to help them to achieve a deep understanding of the nature and connectedness of life."

Three educators (Ms A, Mr C and Ms D) are positively inclined toward the reintroduction of systematics in the New Content Framework for Life Sciences (Department of Education, 2007a) implemented in 2009 (section 5.3.1.5), for example that the section on systematics is necessary for explaining biodiversity. Some (Mr C and Ms D) believe that population and genetic diversity will be better understood by learners (section 5.3.1.5), that they will be able to form a more complete picture of the development of organisms and that the explanation of the importance of biodiversity is assisted (section 5.3.1.5). Systematics fits the current content, the examples were more applicable and animal and plant systematics are linked to population studies and biodiversity (section 5.3.1.5). Educators at school 2 (Mr C and Ms D) felt that the understanding of most concepts in the curriculum was improved through the inclusion of systematics, with the exception of the physiology themes (section 5.3.1.5). An educator at school 1 (Ms A) holds that learners' understanding of the organisation of living organisms, which is included in the Life Processes in Plants and Animals strand, has improved (section 5.3.1.5).

Case (2008:472) has explained that modern classification systems are hypotheses about the genetic relationships among species and the evolution history of life. The curriculum developers, Ms X and Dr Y contend that the inclusion of systematics is successful because it leads to a better understanding of the similarities and differences in structure and function in different organisms as well as concepts such as evolution, biodiversity and body plans (section 5.3.2.2). Systematics was reintroduced in the context of evolution and understanding biodiversity and it should not be dealt with in the detailed way in which it was formerly covered. Dr Y mentioned that she had conducted workshops with educators who thought they are going back to the NATED 550 "old syllabus" (section 5.3.2.2). Two further reasons for the inclusion of systematics are, first that learners need to make sense of diversity and in order to do that, it is necessary to learn the basics of systematics, and second that systematics aligns to an evolutionary approach to biodiversity (section 5.3.2.2).

According to three educators (Ms A, Mr C and Ms D), learners gained a better approach to problem-solving and scientific inquiry (section 5.3.1.5). Gouws, Kruger and Burger (2000:124) have stated that knowledge makes it easier to solve a problem. One reason is that systematics had been included in the curriculum giving learners more insight (due to prior knowledge of systematics) regarding problem-solving and scientific inquiry. Another reason is that the learners were skilled in problem-solving. The New Content Framework for Life Sciences (Department of Education, 2007a:11-12, 23-25, 34-35) provided a number of suggestions for practical work.

According to Ms X, an understanding of systematics helped if scientific inquiry and problem-solving were conducted within the context of understanding diversity and change. The Life Sciences curriculum implemented in 2009 exposes learners to higher-order thinking. Dr Y concurs mentioning that the inclusion of systematics ensures that learners use higher-order thinking skills and that the Linnean system enables one to categorise objects, thus improving memory (see Table 3.1).

The assumption that systematics has been reintroduced into the Life Sciences curriculum because knowledge of systematics is a necessity for understanding biodiversity and population dynamics (section 1.3.3), is partially valid. The findings illustrate that the inclusion of systematics improves learners' understanding of biodiversity and even their problem-solving and scientific inquiry skills. There is no conclusive evidence that comprehension of population dynamics is advanced by the inclusion of systematics.

This section provided information in terms of the main curriculum elements and components of population dynamics and biodiversity, the integration of systematics in task planning or design and on integrating of science process skills and scientific inquiry related to systematics. Furthermore, information was given on selecting substance of systematics in population dynamics and biodiversity lesson preparation, on the links between substance of systematics, population dynamics and biodiversity and reasons for and implications of reintroduction of systematics. The next section reports on the major findings of the research.

6.3 Major findings

First, three different curricula have been implemented in schools since 1996. There was the NATED 550 Biology curriculum (Department of Education, n.d.) which included systematics, followed by the NCS Life Sciences curriculum (Department of Education, 2003) which excluded systematics as a separate unit and a New Content Framework for Life Sciences (Department of Education, 2007a) which reintroduced systematics as a single unit in 2009. Activity theory (section 3.7) acknowledges that dis-coordination is inevitably in the functioning of any system, "contradictions are present in every collective activity and indicate emergent opportunities for the activity development" (Foot, 2001:67). The contradictions inherent in the NCS Life Sciences curriculum implemented in 2006 provided the impetus for further curriculum development, leading to the New Content Framework for Life Sciences implemented in 2009.

Second, the curriculum development team involved in the development of the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 consisted of a number of knowledgeable individuals in the Life Sciences and the curriculum development fields. No expert on population dynamics was included in the curriculum development team. The curriculum team had to focus on outcomes due to the outcomes-based education system and not on content. Curricula from overseas countries were studied and the themes (strands) were determined from these curricula. Many books were used as resources for the development of the curricula. Opinions expressed by different stakeholders such as educators and the public were used as input to the development of the curriculum.

The strengths of the NCS Life Sciences curriculum (Department of Education, 2003) are the freedom the curriculum provides educators concerning content and pedagogy, and the inclusion of content like cloning, medicinal plants and conservation to name a few. This content can be linked to present-day topics. Another strength is the application of science in society (LO 3), for example ecotourism, sustainable development and legislation over pollution control. This makes learners aware of Life Sciences in everyday life and broadens their mind to the possibilities Life Sciences can provide – careerwise or in other fields like biotechnology, agriculture, medicine and sport.

On the other hand, weaknesses in the NCS Life Sciences curriculum (Department of Education, 2003) are the lack of guidance it provides to educators; uncertainty about the relevance of certain concepts to learners' ability to conceptualise (photosynthesis, respiration and gaseous exchange in grade 10); the fact that there is not one standard prescribed textbook; inexperienced or under qualified educators might find the different interpretations in various textbooks difficult to evaluate and interpret; and the exclusion of systematics as a separate unit from the curriculum. The latter weakness deserves further comment. Factors contributing to the exclusion of systematics as a separate unit were possibly that there was no expert on population dynamics in the curriculum development team and the point that emphasis was on outcomes and not content. Two other factors playing a role were the thinking of the curriculum team based on the new movement that science should be relevant to all learners and the effect of prior knowledge (academic background) of the members of the curriculum development team. According to the curriculum developers (section 5.3.2) systematics was excluded because most of the educators opined that it is difficult to teach owing to its uninteresting nature. They testified that learners also found it uninteresting. This latter reason for the exclusion of systematics from the curriculum is questionable because the educators had ulterior motives that do not accord with curriculum development principles. One might correctly but sadly conclude that the curriculum development team's decision to exclude systematics as a separate unit was led by their perceived boring nature of systematics.

Third, the exclusion of systematics as a separate unit from the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 affected learners' understanding of biodiversity and its application to problem-solving and scientific inquiry. Educators included only a few activities that were based on scientific inquiry. The feeling among these educators, curriculum developers and experts in ecology and systematics was that the exclusion of systematics influences the understanding of biodiversity and the exclusion caused a disadvantageous void. Regarding the effect of the exclusion of systematics on population dynamics, only half of the educators, one of the curriculum developers and one of the experts agreed that systematics is a necessity for understanding of population dynamics. Consequently, one concludes that systematics must be included in the curriculum, but the systematics content should be approached in a different and more interesting way. This underlines the importance of prior knowledge in understanding certain processes and concepts as well as the application of knowledge when completing practical skills like problem-solving and scientific inquiry.

The implementation of the New Content Framework for Life Sciences (Department of Education, 2007a) in 2009 saw the reintroduction of systematics as a single unit of study. The reason given for the inclusion of systematics was to ensure that learners understand biodiversity and evolution throughout natural selection. Both curriculum developers asserted that the inclusion was successful and one acknowledged that systematics should never have been excluded as a separate unit from the previous NCS Life Sciences curriculum (Department of Education, 2003). Systematics provides learners with a better foundation to understand biodiversity, evolution, similarities and differences in structure and function of different organisms and body plans. The inclusion of systematics also ensures that learners use higher-order thinking skills (see Chapter 3) when approaching problem-solving and scientific inquiry activities.

The educators agree with the curriculum developers that systematics is necessary to explain biodiversity. According to them concepts like population and genetic diversity and the organisation of living organisms could be better understood as a result of the inclusion of systematics. They concurred that it helps learners understand the complete picture of the development of organisms. They mentioned that systematics is also linked to population studies. The educators share the curriculum developers' opinion regarding learners' approach to problem-solving and scientific inquiry, namely that prior knowledge of systematics gives learners more insight into problem-solving and scientific inquiry.

The points of view of the ecology and systematics experts on the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 concur with the comments made by the educators and curriculum developers about the New Content Framework for Life Sciences (Department of Education, 2007a). Clearly, the experts felt that systematics is a necessary component of the Life Sciences curriculum. Knowledge of systematics helps learners to understand biodiversity and to a lesser degree, also population dynamics. Finally, systematics makes the interrelatedness of concepts in the Life Sciences clearer to learners.

Fourth, the educators who taught the NCS Life Sciences curriculum (Department of Education, 2003) to learners were guided by the work schedule, learning outcomes and prescribed textbooks. The lack of detailed descriptions of content and skills in the curriculum and work schedule mean that the curriculum and work schedule leave much room for educators to use their initiative. The onus is on educators to develop their own curriculum and activities accordingly. There was some evidence of additional content being included in the learners' workbooks, but the activities were mainly sourced from the prescribed textbooks. Most of the activities were problem-solving activities with few scientific inquiry activities. No portfolio work was done for the Diversity, Change and Continuity strand.

The educators did not expand much on content and focused on certain practical skills due to the lack of time. The time allocated to the Environmental Studies and Diversity, Change and Continuity strands was less than that devoted to the first two strands (Cells and Molecular studies and Structure, Control and Processes in Basic Life Systems). Another factor influencing the amount of content covered is probably that examination paper 2 primarily consists of application questions and the educators preferred to allow time for examination preparation (Department of Education, 2009). These educators did not teach for comprehension, but for examination preparation.

The latest version of the Life Sciences curriculum (Department of Education, 2007a) provides sufficient descriptions of content and practical skills to be included by the educators. The guidance given to the educators including inexperienced or under qualified educators ensures that they develop more activities relating to content and practical skills enabling learners to understand the content and apply it. Furthermore, comprehension of the interrelatedness of the concepts in Life Sciences is fostered.

Fifth, the less-experienced educators and the experienced educators place emphasis on different topics and use different approaches to teach population dynamics and biodiversity. The experienced educators used a lot more examples and made better use of different resources. The educators at school 2 used the question-and-answer method more effectively than the educators at school 1. When looking at the academic qualifications of the educators it was evident that the two experienced educators had strong academic groundings in animal and plant sciences. This, as well as the lesser experience of the two young educators, are the probable reasons for the aforementioned differences in teaching. Again it should be taken into account that this is the case in privileged schools, what is happening in underprivileged schools?

Some of the educators thought that the inclusion of systematics in the New Content Framework for Life Sciences (Department of Education, 2007a) meant that they were going back to the NATED 550 Biology curriculum (Department of Education, n.d.). Others were unaware that the content included was systematics. Comments made by educators that systematics is uninteresting and irrelevant therefore leading to its exclusion from the NCS Life Sciences curriculum (Department of Education, 2003) implemented in 2006 are insubstantial.

6.4 Recommendations

The following eleven recommendations are made concerning the Life Sciences curriculum in the light of the influence the exclusion of systematics as a separate unit from the curriculum has on the teaching of population studies and biodiversity:

- Systematics should be maintained in the curriculum to help learners to have a better understanding of biodiversity. Learners will also better understand why certain organisms are affected more by pollution or habitat destruction than other organisms.
- Experts from a variety of fields in the Life Sciences could be co-opted to work on the curriculum development team. This will help to ensure that the interrelatedness of certain concepts is taken into account to construct a holistic picture of Life Sciences. The members of the curriculum development team will have certain roles and responsibilities and as inferred from the CHAT model (section 3.7) this division of labour will influence the way that the activity is performed.
- Certain prerequisites for curriculum development should be followed when developing curricula. If these prerequisites are followed the inclusion or exclusion of certain content can be validated on academic grounds. The prerequisites could be the selection of knowledge and the criteria on which the selections are based, sequencing, organising and structuring of the curriculum.
- A curriculum development process should be followed by consulting with educators in the field, current and past students, academics, professional bodies

and individuals from the public and private sectors. Aspects relating to theoretical learning like child psychology, cognitive process, society-centered curricula and structural theories should be included. This latter recommendation and the abovementioned recommendations can be of value to curriculum developers, department officials, educators of Life Sciences and other stakeholders (public and private sectors).

- Greater attention might be paid to the relevance of prior knowledge (knowledge framework hierarchy) that is needed in order to master the work in each grade. In the New Content Framework for Life Sciences, the population studies content has been moved to the grade 12 curriculum under the strand Population and Community Ecology (Environmental Studies). This is an improvement on the NCS because learners will be better informed when they are confronted with population and community ecology in grade 12. The knowledge platform has been created in grade 11 by providing learners with a holistic view of diversity (inclusive of systematics) and some evolutionary trends on which to build in greater detail in grade 12 in population and community ecology.
- Focus on the application of knowledge during skills development – not only on problem-solving, but also on scientific inquiry, debating, data collection, case studies and research activities. Problem questions should challenge students to develop higher-order thinking skills, moving them beyond Bloom's lower cognitive levels of knowledge and comprehension to the higher Bloom levels, where they analyse, synthesise and evaluate.
- Content could be covered in such a way that it leads to the understanding of concepts and their application. Learners need to apply their knowledge to their daily lives and current issues like conservation, ecotourism and biotechnology.
- Other resources to enhance the content might be used more frequently by educators. Not only will this make the work more interesting to learners, but it will broaden educators' knowledge, enabling them to incorporate this newly found knowledge into the content being taught. This will broaden learners' knowledge and ensure that changes in the field of Life Sciences are continually reflected in the subject content.

- Educators should take the responsibility to create their own curricula based on the guidelines provided to them especially if the curriculum does not include reference to the essential prior knowledge needed for understanding to develop original activities relating to the lives of the learners in their classes.
- A revised training programme could be implemented for Life Sciences educators with an emphasis on the Environmental studies and Diversity, Change and Continuity strands. This would support educators in developing activities in these strands.
- More emphasis might be placed on mentoring less-experienced educators and on the evaluation of educators over a period of time. These measures should be implemented in relation to curriculum content changes for which educators are trained. The improvement of Life Sciences education in schools would be the inevitable result.

6.5 Topics for future research

A number of topics for future research emerge from this study, namely

- The practical application of theoretical knowledge in the Life Sciences;
- The development of a standardised training programme for Life Sciences educators concerning content (theory and practice) and the link between grade 10, 11 and 12 content;
- The use of technology (for example television programmes and videos) and other resources (different textbooks, articles, wall charts and models) in the teaching of Life Sciences;
- The effect of educators' academic background on the teaching of certain topics in the Life Sciences curriculum and the development of pedagogical content knowledge (PCK) in these topics;
- The continued existence and place of Life Sciences at school level in view of tertiary studies; and

- Life Sciences curriculum development with specific reference to current theory and practice in the field, the process of curriculum change and the identification and implementation of appropriate teaching methods.

6.6 Limitations of the study

The study provides a generalised conclusion, because of the limited number of participants the findings are actually very specific to the few individuals participating in this study and the results cannot be seen as representing a general (universal) view. The schools included in the study are Afrikaans medium former model C (privileged) schools, not representative of the majority of schools in the country. The convenience sampling method meant that personal bias and subjectivity of the researcher determined which elements were included in the sample. The fact that only the researcher observed in the classrooms makes the observations and findings one-sided. More than one observer's views would have been enlightening. However to limit personal bias and subjectivity, triangulation was applied to this study by means of gathering data from multiple sources and using this information to reach the findings. The interview schedules, learners' workbooks evaluation tool and classroom observation tool were approved by experts for applicability.

6.7 Conclusion

This research addressed the question *What influence do the changes in the curriculum that excluded systematics from the Life Sciences curriculum implemented in 2006 have on the way educators interpret the curriculum when teaching population studies and biodiversity?* The research concluded that systematics is essential for the understanding of biodiversity as well as for related problem-solving and scientific inquiry so that its exclusion is detrimental to comprehension and investigation. The effect of the absence of systematics on the understanding of population dynamics was indeterminable. It is clear that systematics plays an important role in understanding concepts such as evolution and the interrelatedness of concepts in the Life Sciences, thus the exclusion of systematics as a separate unit is disadvantageous. The reintroduction of systematics as a single unit in the Life Sciences curriculum implemented in 2009 could serve as further evidence that systematics forms an integral part of the Life Sciences and cannot be excluded from the curriculum.

REFERENCES

Andersson, I. & Franke-Wikberg, S. 1990. Review article – The formation of school subjects. *Educational Theory,* 40(4): 495-499.

Ausubel, D.P. 1968. *Educational psychology, a cognitive view.* New York. Holt, Rinehart and Winston, Inc.

Billet, S. 2003. Vocational Curriculum and Pedagogy: an activity theory perspective. *European Educational Research Journal,* 2(1): 6-21.

Black, P. & Atkin, J.M. 1996. *Changing the subject, innovations in science, mathematics and technology education.* London and New York. Routledge.

Bruner, J.S. 1960. *The process of education.* Cambridge, Massachusetts. Harvard University.

Capper, P. & Williams, B. 2004. Cultural-Historical Activity Theory. Enhancing evaluation using systems concepts. *American Evaluation Association.* Available at http://www.docstoc.com/docs/22726536/CULTURAL-HISTORICAL-ACTIVITY-THEORY-(CHAT). Accessed on 2010/07/14.

Carin, A.A., Bass J.E. & Contant, T.L. 2005. *Methods for teaching science as inquiry,* 9th Edition. Upper Saddle River, New Jersey. Pearson Education, Inc.

Case, E. 2008. Teaching taxonomy: How many kingdoms? *The American Biology Teacher*, 70(8): 472-477.

Chapman, J.L. & Reiss, M.J. 1995. *Ecology principles and applications.* Cambridge. Cambridge University Press.

Chrisen, W.L. & Murphy, T.J. 1991. *Increasing Comprehension by Activating Prior knowledge.* ERIC Digest. Available at http://www.ericdigests.org/pre-9219/prior.htm. Accessed on 2009/09/18.

Clitheroe, F., Doidge, M., Marsden, S., Van Aarde, I., Ashwell, A., Buckley, L. & Dilley, L. 2006. *Verken Lewenswetenskappe Graad 11.* Kaapstad. Maskew Miller Longman (Edms) Bpk.

Creswell, J.W. 1998. *Qualitative inquiry and research design, choosing among five traditions.* Thousand Oaks. SAGE Publications, International Educational and Professional Publisher.

Curzon, L.B. 1985. *Teaching in further education. An outline of principles and practice*, 3rd Edition. New York. Holt, Rinehart and Winston.

Del Barrio, C., Gutierrez, H., Hoyos, O., Barrios, A., Van der Meulen, K. & Smorti, A. 1999. *The use of semi-structured interviews and qualitative methods for the study of peer bullying*. TMR Network Project. Available at http://www.gold.ac.uk/tmr/reports/aim2_madrid1.html. Accessed on 2006/07/11.

Denzin, N.K. & Lincoln, Y.S. 2005. *The sage handbook of qualitative research*, 3rd Edition. Thousand Oaks, London and New Delhi. SAGE Publications.

Department of Education. n.d. *Interim core syllabus and provincialised guide for Biology grades 10 – 12 higher grade and standard grade.* Pretoria. Department of Education.

Department of Education. 2000. *Government Gazette, (415): 1-34.* Pretoria. Department of Education.

Department of Education. 2002. *Revised National Curriculum Statement for grades R-9 (Schools), Natural Sciences.* Pretoria. National Department of Education.

Department of Education. 2003. *National Curriculum Statement grades 10-12 (General) Life Sciences.* Pretoria. Department of Education.

Department of Education. 2005a. *National Curriculum Statement grades 10-12 (General) Orientation Participant's manual Life Sciences.* Johannesburg. University of the Witwatersrand.

Department of Education. 2005b. *National Curriculum Statement grades 10-12 (General) Learning Programme Guidelines Physical Sciences and Life Sciences.* Pretoria. Department of Education.

Department of Education. 2007a. *The New Content Framework for the subject Life Sciences as listed in the National Curriculum Statements grades 10-12 (General). Circular 67/2007.* Johannesburg. Department of Education.

Department of Education. 2007b. *National Curriculum Statement grades 10-12 (General) Learning Programme Guidelines Life Sciences.* Pretoria. Department of Education.

Department of Education. 2009. *Department of Education, Gauteng Provincial Government.* Available at http://www.education.gpg. gov.za. Accessed on 2009/11/20.

De Vos, A.S., Strydom, H., Fouché, C.B. & Delport, C.S.L. 2005. *Research at grass roots. For the social sciences and human service professions*, 3rd Edition. Paarl, South Africa. Van Schaik Publishers.

Doidge, M., Dempster, E., Crowe, A. & Naidoo, K. 2008. *The Life Science content framework: A story of curriculum change.* Johannesburg. South African Association of Science and Technolgy Educators (SAASTE).

Duch, B.J., Groh, S.E & Allen, D.E. 2001. *The power of problem-based learning: A practical "How to" for teaching undergraduate courses in any discipline.* LLC., USA. Stylus Publishing.

Ellis, V. 2004. *Learning and teaching in secondary schools. Achieving QTS.* United Kingdom. Learning Matters Ltd.

Engeström, Y. 1999. Innovative learning in work teams: Analysing cycles of knowledge creation in practice. In Engeström, Y., Miettinen, R. & Punamäki, R. (Eds.), *Perspectives on activity theory.* New York. Cambridge University Press.

Engeström, Y. & Miettinen, R. 1999. Introduction. In Engeström, Y., Miettinen, R. & Punamäki, R. (Eds.), *Perspectives on activity theory.* New York. Cambridge University Press.

Foot, K.A. 2001. Cultural-Historical Activity Theory as Practical Theory: Illuminating the Development of a Conflict Monitoring Network. *Communication Theory,* 11(1): 56-83.

Fraser, W.J., Howie, S. & Plomp T. 2003. Assessment of change in education. *Perspectives in Education*, 21(1): vii-x.

Fraser, W.J., Loubser C.P. & Van Rooy, M.P. 1993. *Didactics for the undergraduate student*, 2nd Edition. Durban. Butterworths Publishers (Pty) Ltd.

Gaston, K.J. & Spicer, J.I. 1998. *Biodiversity, an Introduction.* Oxford. Blackwell Science Ltd.

Glatthorn, A.A., Boschee, F. & Whitehead, B.M. 2006. *Curriculum leadership: development and implementation.* Thousand Oaks. SAGE Publications, Inc.

Golafshani, N. 2003. Understanding reliability and validity in qualitative research. *The Qualitative Report*, 8(4): 597-607. Available at http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf . Accessed on 2010/02/03.

Gouws, E., Kruger, N. & Burger, S. 2000. *The Adolescent,* 2nd Edition. Sandown. Heinemann Publishers (Pty) Ltd.

Grobler, J.M. n.d. *Lewenswetenskappe as prentjiesvak graad 11.* Teorie en werkboek, Nasionale kurrikulum verklaring. Rustenburg. Alpha Print.

Henning, E., Van Rensburg, W. & Smit, B. 2004. *Finding your way in qualitative research.* Pretoria. Van Schaik Publishers.

Hewson, P.W., Kahle, J., Scantlebury, K. & Davies, D. 2001. Equitable science education in urban middle schools: Do reform efforts make a difference? *Journal of Research in Science Teaching,* 38(10): 1130-1144.

Hittleman, D.R. & Simon, A.J. 2006. *Interpreting educational research. An Introduction for consumers of research*, 4th Edition. Upper Saddle River, New Jersey. Pearson Education Inc., Merrill Prentice Hall.

Hofmeyr, J.H.S. 2007. Seeking a common language of life. *Quest Magazine,* 4(1): 29-30.

Isaac, T., Chetty, S., Naidoo, S., Manganye, H.T., Mdhluli, B.N., Mpondwana, N.L. & White, L. 2006. *Verstaan Lewenswetenskappe graad 11 leerdersboek vir die NKS.* Durban. Pulse Education Services cc.

Jones, S.B & Luchsinger, A.E. 1986. *Plant systematics.* New York. McGraw-Hill.

Kaplan, E.H. 1976. *Problem solving in biology. A laboratory workbook for full-year courses*, 2nd Edition. New York. Macmillan Publishing Co., Inc.

Kearsley, G. (2009a). *The Theory Into Practice Database. Subsumption Theory-TIP theories.* Available at http://tip. psychology.org. Accessed on 2009/01/10.

Kearsley, G. (2009b). *The Theory Into Practice Database. Constructivist theory-TIP theories.* Available at http://tip. psychology.org. Accessed on 2009/01/10.

Khodor, J., Halme, D.G & Walker, G.C. 2004. A hierarchical biology concept framework: A tool for course design. *Cell Biology Education,* 3(2): 111-121.

Kuutti, K. 1996. Activity theory as a potential framework for human-computer interaction research. In Nardi, B.A. (Ed.), *Context and consciousness.* Cambridge, MA. MIT Press.

Lawson, A.E. 2002. *Science teaching and the development of thinking.* USA. Wadsworth Group, Thomson Learning Inc.

Leedy, P.D., Newby, T.J. & Ertmer, P.A. 1997. *Practical research: Planning and design*, 6th Edition. Upper Saddle River, New Jersey. Prentice-Hall, Inc. Simon & Schuster/ A Viacom Company.

Leedy, P.D. & Ormrod, J.E. 2001. *Practical research.* New Jersey. Merrill Prentice Hall.

Linek, W.M., Sampson, M.B., Gomez, K.A., Linder, P.E., Torti, C., Levingston, C & Palmer, J. 2009. Middle school alternatively certified science teachers: Resources, teacher choices, and student achievement. *The Journal of Educational Research,* 102(6): 403-412.

Mader, S.S. 1998. *Biology*, 6th Edition. USA. WCB McGraw-Hill Companies, Inc.

Mader, S.S. 2004. *Biology*, 8th Edition. USA. WCB McGraw-Hill Companies, Inc.

Maree, J.G. 2003. *Introduction to Quantitative Research. NME 732 Reader.* Pretoria. Faculty of Education, University of Pretoria.

Maree, K. & Ebersöhn, L. 2002. *Lifeskills and career counseling.* Sandown. Heinemann Publishers (Pty) Ltd.

Maree, K. & Van der Westhuizen, C. 2009. *Head start in designing research proposals in the Social Sciences.* Cape Town. JUTA & Company Ltd.

McEneaney, E.H. 2003. The worldwide cachet of scientific literacy. *Comparative Education Review,* 47(2): 217-237.

Merriam, S.B. & Associates. 2002. *Qualitative research in practice, examples for discussion and analysis.* USA. John Wiley and Sons, Inc.

Miller, G.T. 2007. *Essentials of ecology*, 4th Edition. USA. Brooks/Cole.

Miller, S.A. & Harley, J.B. 1999. *Zoology*, 4th Edition. USA. WCB McGraw-Hill.

Monteith, J.L. de K., Postma, F. & Scott, M. 1988. *Die opvoeding en ontwikkeling van die adolessent.* Pretoria. Academica.

Nagel, N.C. 1996. *Learning through real-world problem solving, the power of integrative teaching*. California. Corwin Press, Inc. A SAGE Publications Company.

Neill, J. 2006. *Analysis of professional literature class 6: Qualitative research.* Lecture notes. Available at http://www.wilderdom.com/OEcourses/PROFLIT/Class6Qualitative1.htm. Accessed on 2008/01/10.

O'Riordan, T. & Stoll-Kleemann, S. 2002. *Biodiversity, sustainability and human Communties, Protecting beyond the protected.* Cambridge. Cambridge University Press.

Pinar, W.F. 2003. *International handbook of curriculum research.* USA. Lawrence Erlbaum Associates.

Popkewitz, T.S. 1988. *The formation of school subjects: The struggle for creating an American institution.* New York, Philidelphia and London. The Falmer Press (Taylor and Francis Group).

Robertson, I. 2008. Sustainable e-learning, activity theory and professional development. *In Hello! Where are you in the landscape of educational technology? Proceedings ascilite Melbourne*. Available at http://www.ascilite.org.au/conferences/melbourne08/procs/robertson.pdf . Accessed on 2010/07/16.

Rogers, C.R. 1983. *Freedom to learn for the 80's.* USA. Merril Publishing Company.

Saunders, M.N.K., Lewis, P. & Thornhill, A. 2000. *Research methods for business students.* Edinburgh. Pearson Education.

Schulze, S. 2003. Views on the combination of quantitative and qualitative research approaches. *Progressio,* 25(2): 8-20.

Smit, B. 2001. *An introduction to the qualitative and quantitative research debate. NME 740 Reader.* Pretoria. Faculty of Education, University of Pretoria.

Smith, M.K. 2002. *Jerome Bruner and the process of education, the encyclopedia of informal education.* Available at http://www.infed.org/thinkers/bruner.htm. Accessed on 2008/01/10.

Stace, C.A. 1989. *Plant taxonomy and biosystematics*, 2nd Edition. London. Edward Arnold.

Stern, L. & Roseman, J. 2004. Can middle-school science textbooks help students learn important ideas? Findings from Project 2061's Curriculum Evaluation Study: Life Sciences. *Journal of Research in Science Teaching,* 26(6): 538-568.

Symington, D. & Tytler, R. 2004. Community leaders' views of the purposes of science in the compulsory years of schooling. *International Journal of Science Education,* 26(11): 1403-1418.

Tobin, K. 2005. Building enacted science curricula on the capital of learners. *International Journal of Science Education,* 89(4): 577-594.

University of Pretoria. 2009. *Faculty of Natural and Agricultural Science.* Yearbook. Pretoria. University of Pretoria.

University of Stellenbosch. 2009. *Faculty of Science, Calendar 2009, Part 5.* Stellenbosch. Stellenbosch University.

Verduin, J.R. 1996. *Helping students develop investigative, problem solving and thinking skills in a cooperative setting. A handbook for teachers, administrators and curriculum workers.* Springfield, Illinois, USA. Charles C Thomas Publisher.

Watkins, J.A. 2006. *Thesis/dissertations/research reports: A practical guide for students to the preparation of written presentations of academic research.* Gordon's Bay. J.A. Watkins.

Woese, C.R., Kandler, O. & Wheelis, M.L. 1990. Towards a natural system of organisms: Proposal for the domains Archaea, Bacteria and Eucarya. *Proceedings of the National Academy of Sciences USA,* 87(12): 4576–4579.

Wood, K.E. 2001. *Interdisciplinary instruction. A practical guide for elementary and middle school teachers,* 2nd Edition. Upper Saddle River, New Jersey. Merrill Prentice Hall Inc.

Woodland, D.D. 2000. *Contemporary plant systematics*, 3rd Edition. Michigan, USA. Andrews University Press.

Woods, P. 1999. *Successful writing for qualitative researchers.* United Kingdom. St. Edmundsbury Press Ltd.

Yamagata-Lynch, L.C. 2003. Using Activity Theory as an Analytic Lens for Examining Technology Professional Development in Schools. *Mind, Culture, and Activity,* 10(2): 100 - 119.

Appendix A

New Content Framework for Life Sciences implemented in 2009

The Diversity, Change and Continuity strand of the curriculum now included topics listed below. The information was taken from the New Content Framework for the subject Life Sciences as listed in the National Curriculum Statements Grades 10 – 12 (General), (Department of Education, 2007a:11, 23-25):

STRAND: Diversity, Change and Continuity

Grade 10: History of life and biodiversity

Underlying concept: Life exists in a huge array of forms and modes of life at present, which scientists organise according to a man-made classification system. Modern life has a long history, extending from the first cells around 3.5 billion years ago. South Africa has a rich fossil record of some key events in the history of life. Changes in life forms are related to climate changes and movements of continents and oceans over long periods of time.

Table 1: The Diversity, Change and Continuity strand as included in the New Content Framework for grade 10 Life Sciences

LO1 Investigating phenomena in the Life Sciences	**LO2 Constructing Life Sciences knowledge**	**LO3 Applying Life Sciences in society**
	Biodiversity and classification	
Demonstrate classification principles by grouping everyday objects on the basis of shared similarities and construct a simple nested hierarchy Classify organisms into groups based on evidence. [Links to use of keys and identification guides]	Enormous biodiversity on Earth at present emphasizing the extent of biodiversity and endemism in southern Africa Classification schemes as a way of organizing biodiversity. Main groupings of living organisms are bacteria, protists, fungi, plants and animals Bacteria: simple single-celled organisms with no nucleus Protists: Very diverse group including single-celled or	History of classification: Scientists attempt to classify organisms based on shared features. As information increases classification changes. Some examples of classification systems are: Two-kingdom system: plants and animals (no longer used) Five-kingdom system: Plantae, Animalia, Fungi, Protista and Monera (Bacteria) Three-domain system: Eubacteria, Archaea, Eukarya, with kingdoms in each domain e.g. Plantae, Animalia, Fungi, Protista in the Eukarya

	simple multicellular organisms, some obtain energy by photosynthesis (algae), some ingest other organisms, some absorb molecules through the cell membrane. Fungi: Single-celled (e.g. yeasts) to multicellular organisms; body composed of very fine threads; saprotrophic nutrition. Plants: Multicellular terrestrial organisms; cells have cell walls; obtain energy through photosynthesis Animals: Multicellular aquatic and terrestrial organisms; cells have no cell walls; feed on other organisms.	Naming things in science: why do we use Latin? Linnaeus and his role in classification systems

Grade 11: Diversity of animals and plants and biogeography

Underlying concepts: Plants and animals can be grouped according to similarities in their basic structure or body plan. Members of each group have modified versions of their basic body plan, depending on their mode of life. Biogeographic variation shows that different but similarly adapted species inhabit different continents and islands.

Table 2: The Diversity, Change and Continuity strand as included in the New Content Framework for grade 11 Life Sciences

LO1 Investigating phenomena in the Life Sciences	**LO2 Constructing Life Sciences knowledge**	**LO3 Applying Life Sciences in society**
Plant and animal diversity in South Africa		
Illustrate through diagrams, charts and graphs, the numbers of species of each major group represented in South Africa. Read and interpret distribution maps of species.	Enormous diversity of life in southern Africa, and the number of endemic species.	Threats to biodiversity in South Africa: Consider the impact of agriculture, industry, human population growth, cities and roads on biodiversity. Value of retaining biodiversity: tourism potential, aesthetic value of retaining biodiversity for its own sake.

Plant diversity		
Learners should be able to identify South African examples of each of these groups of plants. • Bryophytes (mosses and liverworts). • Pterophytes (ferns) • Gymnosperms (yellowwoods, cycads) • Angiosperms (flowering plants) Compare the morphology of a local monocotyledonous and a dicotyledonous plant, including the flowers.	Plants can be grouped according to the presence or absence of: • vascular tissue (xylem phloem) • true leaves and roots • seeds or spores • fruit, as well as the dependence on water for reproduction These groups include the: • Bryophytes: no vascular tissue, no true leaves and roots, spores, depend on water for fertilisation • Pterophytes: vascular tissue, true leaves and roots, spores, depend on water for fertilization. Gymnosperms and angiosperms: vascular tissue, true leaves and roots, seeds, fertilization independent of water. Gymnosperms produce cones which bear seeds with no protective covering. Angiosperms produce flowers, the seed is enclosed in a fruit.	Ancient and unique plant groups in southern Africa: cycads and Welwitschia. Ecotourism and theft of cycads, conservation efforts. Angiosperms include many agriculturally important plants, such as fruit trees, and crops such as maize, wheat, oats and sorghum. Forestry – economic importance and impact on ecosystems [Link to environmental issues.]
Animal diversity		
Interpret a phylogenetic tree representing the evolutionary history of animals. Identify Southern African representatives of each of the phyla listed below, through photographs, appropriate books, or during visits to museums or on field trips and by using field guides. • Porifera (sponges) • Cnidaria (jelly fish, blue bottles, corals, sea anemones) • Platyhelminthes (Planaria, flukes e.g. bilharzia worm, tapeworm) • Annelida (earthworm,	Concept of phylum as illustrated by a body plan. The Animal kingdom contains about 30 phyla, but we will focus on only six, i.e. Porifera, Cnidaria, Platyhelminthes, Annelida, Arthropoda, Chordata, with respect to the following body plans. • Symmetry (asymmetry, bilateral symmetry, radial symmetry) • Number of tissue layers developing from the embryo (two or three). • Absence or presence of a coelom (a cavity	Any ONE of the parasitic worms found in South Africa: distribution, prevalence, life cycle, effects on host, treatment, and ways of reducing the spread. (Select a local parasitic worm that is problematic for humans or other animals). Role of arthropods as ectoparasites and vectors of pathogens that cause disease e.g flies and cholera, ticks and tick bite fever, mosquitoes and malaria, tsetse flies and sleeping sickness. Role of invertebrates in

polychaetes, leeches) • Nematoda (roundworms, hookworms, threadworms) • Arthropoda (insects, arachnids, crustaceans, myriapods) • Mollusca (snails, oysters, limpets, octopus and squid) • Echinoderms (sea urchins, starfish) • Chordata (fish, amphibians, reptiles, birds, mammals). Choose ONE phylum or class from the list above and illustrate its biodiversity in South Africa on a poster. (Individuals or small groups each select a different animal group)	within the mesoderm). • Presence or absence of a through-gut Relate body plans to mode of life. • Phylum Porifera: asymmetrical, no tissues and no coelom; simple but highly specialized for filter-feeding • Phylum Cnidaria: radially symmetrical, two tissue layers, no coelom, single opening to the gastrointestinal cavity. Simple, but possess highly specialized nematocysts. • Phylum Platyhelminthes: bilaterally symmetrical, three tissue layers, no coelom, and a single opening to the gut. • Phylum Annelida: bilaterally symmetrical, three tissue layers, a coelom, a through-gut. • Phylum Arthropoda: bilaterally symmetrical, three tissue layers, coelom, through-gut, an exoskeleton made of chitin • Phylum Chordata: bilaterally symmetrical, three tissue layers, coelom, through-gut. Internal skeleton made of cartilage and bone. A very brief comparative analysis of the body plans of the different phyla is required. It should be explained in the context of evolution.	agriculture and ecosystems (e.g. pollinators, decomposition, aerating the soil). Sustainable use of animals in South Africa e.g. perlemoen/ fishing / game farming: economic and employment opportunities. Problems with poaching.

Modifications of basic body plans		
Select ONE of the following for investigation [Link to LO 2]: Identify the limb bones of vertebrates from diagrams, and make notes of how the bones are modified to suit each function. OR Identify feeding or locomotory appendages of insects. OR Identify modified flowers.	Select ONE of the following for further study: Mammal forelimb: basic plan modified for digging (mole), flying (bat), fast running (horse), swimming (seal) and climbing trees (monkey). OR Modification of feeding or locomotory appendages of insects for eating different foods OR Modification of flowers such as orchids (or any other suitable group) for specific pollinators.	Nature of science: Looking for explanations for modifications of body plans: Charles Darwin proposed that modification of basic body plans indicates common descent from a single ancestor. [Relate to examples in LO 2]
Biogeography		
Draw a map of the world and put pictures of ostrich, emu, rhea and moa where they occur.	Diversity exists within continents, but is even more striking on different landmasses and islands. Worldwide distribution of large flightless birds: ostrich in Africa, emu in Australia, rhea in South America, and moa (recently extinct) in New Zealand. These flightless birds resemble each other, and have similar modes of life in each landmass, but they are distinctly different species.	Nature of science: Darwin's explanation for the biogeographic distribution of species.

Grade 12: Evolution

Underlying concepts: Evolution by natural selection explains evidence provided by the fossil record, similarities within groups and differences between groups, biogeography and many other kinds of evidence. Evolution by natural selection results in adaptation to an environment, or, speciation, if it coincides with geographic isolation of a small population. Genetics aids our understanding of evolution at a molecular level.

Table 3: The Diversity, Change and Continuity strand as included in the New Content Framework for grade 12 Life Sciences

LO1 Investigating phenomena in the Life Sciences	**LO2 Constructing Life Sciences knowledge**	**LO3 Applying Life Sciences in society**
	Origin of an idea about origins	
	The theory of evolution emerges from different lines of evidence e.g. fossil record (grade 10), modification by descent, and the evidence from biogeography (grade 11), genetics (grade 12) as other forms of evidence. Evolution as a scientific theory and not just a hypothesis. The difference between hypothesis and theory.	The role of Erasmus Darwin, Lamarck, Charles Darwin and Alfred Wallace in the development of the theory of evolution. Beginning of conflict between religion and science with respect to evolution.
	Evolution by natural selection	
Demonstration of principles of natural selection through camouflage and avoidance of predation, using e.g. games, models.	**Darwin's theory of evolution by natural selection** Life forms have evolved from previous life forms by natural selection (link to Genetics). Most species are unable to survive in a new environment, and become extinct, but a few species may successfully adapt to a new environment. Natural selection only operates on variation in inherited characteristics (link with Genetics). Artificial selection mimics natural selection. Artificial selection as illustrated by at least one domesticated animal species and one crop species.	

	Formation of new species	
	Biological species concept: a group of organisms that can interbreed and produce viable offspring. Speciation as a mechanism for producing new species. Geographic speciation due to isolation. Select ONE example e.g. cichlid fishes in Lake Malawi, Galapagos finches, mammals on different land masses. Mechanisms of reproductive isolation: - breeding at different times of the year - species-specific courtship behaviour (animals) - adaptation to different pollinators (plants) - infertile offspring (e.g. mules)	
	Human evolution	
Map out the sequence of human evolution from ape-like ancestor around 5 mya to modern *Homo sapiens*. Emphasize the fossils found in Africa, and the simultaneous existence of several species at various times in the past.	Evidence for common ancestors for living primates including humans. Out of Africa hypothesis and evidence for African origins of all modern humans. All modern humans are genetically very closely related.	African fossils have made a huge contribution to understanding human evolution e.g. Cradle of Humankind at Sterkfontein; Great Rift Valley.
	Evolution in present times	
	Examples that evolution is still occurring, e.g. the development of resistance to insecticides in insects; resistance to antibiotics in various bacteria.	Use of DDT and consequent resistance to DDT in insects can be explained in terms of natural selection. Development of resistant strains of TB – MDR and, more recently, XDR strains of tuberculosis-causing bacteria.

Alternative explanations		
Investigate and discuss cultural and religious explanations for the origin and development of life on earth.		<u>Alternatives to Darwin's explanation</u> People have different ways of understanding the history of life and the place of humans in life. Science has limits: it can explain physical structures and events, but not spiritual or faith-based matters. Both are important to humans, but in different ways.

Appendix B

Semi-structured interviews 1: Based on the National Curriculum Statement for Life Sciences implemented in 2006

Questions asked in the semi-structured interviews to the grade 11 Life Sciences educators

1. Describe your academic background.
2. How do you prepare for teaching population dynamics and biodiversity?
3. Is the time and resources adequate for the teaching of population dynamics and biodiversity?
4. Do you adhere to the prescribed curriculum or do you use your own initiative when teaching population dynamics and biodiversity?
5. What is your opinion on the following statement? Scientific inquiry and problem-solving relating to science process skills is minimised in the teaching of population dynamics and biodiversity.
6. Is there enough relevant content knowledge included in the teaching of population dynamics and biodiversity?
7. Do you refer to systematics when teaching population dynamics and biodiversity? Explain.
8. If the learner does not have knowledge of systematics, does it affect the understanding of population dynamics/biodiversity or even problem-solving?
9. If the learner has inadequate content knowledge, does it affect the understanding of population dynamics and biodiversity or scientific inquiry?
10. How will the understanding of content and knowledge of systematics influence tertiary studies in a similar field?

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Questions asked in the semi-structured interviews to the curriculum developers

1. Tell me about your academic background with specific emphasis relating to Life Sciences and curriculum development.

2. Are you acquainted with the members who were involved in the drafting of the NCS with specific reference to the Life Sciences?

3. How many members were involved in the developing of the new grade 11 Life Sciences Curriculum?

4. On what basis were the members selected to be part of this process?

    4.1 Was one/some of the members a specialist on population dynamics and biodiversity? If yes, can you provide me with names.

5. Are/Were you familiar with the procedures involved in the development of the grade 11 Life Sciences curriculum?

    5.1 What procedures were followed to develop the grade 11 Life Sciences curriculum?

6. What were the reasons for these procedures?

7. Why was the Diversity, Change and Continuity strand developed in such a way (population studies, social behaviour and diversity)?

    7.1 Explain how and where the content of the Diversity, Change and Continuity strand is interlinked with the other strands in the curriculum.

8. Why were Botany and Zoology systematics excluded from the grade 11 Life Sciences Curriculum? What is your opinion regarding the exclusion of systematics from the curriculum?

9. Do you believe if Botany and Zoology systematics had been included, the learners would have been able to understand the concepts in population studies and biodiversity better?

   9.1 Is problem-solving and inquiry therefore dependent on a better understanding of animal and plant systematics?

10. Do you think problem-solving and scientific inquiry skills are adequately addressed in the Diversity, Change and Continuity (especially in population dynamics and biodiversity) strand in relation to the other strands? Give reasons for your answer.

11. Please comment on the following statement: "The grade 11 Life Sciences curriculum leaves room for interpretation from the educator, which influences the use of content knowledge when teaching population dynamics." Do you feel the educators and the learners would benefit from more detailed guidance in terms of the curriculum content?

12. Some of the educators I have interviewed, argue that just the main concepts receive attention in the Diversity, Change and Continuity strand due to the amount of time allocated to the strand. How was time allocated to the strands?

13. Some of the educators also have the opinion that due to the difference in content of exam paper 1 (strands: structure and control of processes in basic life systems & tissues, cells and molecular studies) and 2, the content in the Diversity, Change and Continuity strand is rushed in even a shorter amount of time to revise the

learning material of the strands included in exam paper 1. What is your opinion of this?

14. What should the main elements and components of population dynamics be in terms of substance and syntax in the grade 11 Life Sciences curriculum?

15. What are the links between content knowledge (substance), scientific inquiry and problem-solving in the teaching of grade 11 Population Dynamics?

16. Would systematics have had a more prominent influence (on population dynamics and biodiversity) had it been part of the grade 11 Life Sciences curriculum?

Questions asked in the semi-structured interviews to the ecology and systematics experts

1. What is the link between systematics, population dynamics and biodiversity?

2. Is prior knowledge of systematics necessary for the successful teaching of population dynamics and biodiversity?

3. What is your opinion on the exclusion of systematics from the school curriculum?

4. What will the effect of the exclusion of systematics from the school curriculum be on tertiary studies in Life Sciences?

5. Can you supply me with examples that will highlight the dependability of population dynamics and biodiversity on the prior knowledge of systematics? If yes, give examples.

6. Are problem-solving and scientific inquiry in population dynamics and biodiversity dependent on the understanding of animal and plant systematics?

7. Which components according to you, are the main components (theory and practical) in population dynamics and biodiversity?

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Semi-structured interviews 2: Based on the New Content Framework for Life Sciences implemented in 2009

Questions asked in the semi-structured interviews to the grade 11 Life Sciences educators

1. Is your approach, concerning the Diversity, Change and Continuity strand, different since the reintroduction of systematics?

2. How will you use systematics to make the basic principles of Diversity, Change and Continuity strand more understandable?

3. What influence does the inclusion of systematics have on problem-solving and scientific research, if any?
   Concerning:
   - Advantages
   - Disadvantages
   - The effect on activities
   - The learners' approach to problem-solving and scientific research.

4. What is your opinion about the inclusion of systematics in the curriculum implemented in 2009?

5. What other concepts in the curriculum are improved through the inclusion of systematics in the Diversity, Change and Continuity strand, if any?

Questions asked in the semi-structured interviews to the curriculum developers

1. Would there be an improved link between problem-solving, scientific inquiry and a better understanding of animal and plant systematics? (In other words, to what extent, if any, has the inclusion of systematics improved addressing problem-solving and scientific inquiry skills?)

2. Is there suppose to be a sequence in the development of the Diversity, Change and Continuity strand? If yes, how?

3. Why were plant and animal systematics included/re-introduced into the Life Sciences Curriculum (implemented into grade 10 in 2009)?

4. What is your opinion regarding the inclusion of systematics in this curriculum?

5. With the inclusion of systematics, which concepts, if any, would be better understood?

6. What was the effect of the inclusion of systematics on the Diversity, Change and Continuity strand?

7. In retrospect – was the exclusion of animal and plant systematics in the National Curriculum Statement (previous curriculum) not a good idea?

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Appendix C

Document analysis

Example of workbook evaluation tool

Date: _______________

Number of periods: _____________

Theme:____

Topic: ____

Activity: ____

____

Type and aim of activity (such as worksheet, experiment, research project, simulation):

____

____

____

Groupwork or individual work:

____

Practical (models, experiments) or theoretical (written work) activity:

____

Evidence of content and knowledge of systematics:

Evidence of scientific inquiry and problem-solving:

Other comments:

Appendix D

Classroom observations

Example of the classroom observation tool

Date: _______________

Number of periods: _____________

Theme:____

Topic: ____

Activity: ____

Method of teaching (how information was taught):

____

____

Resources used (such as transparencies, textbooks or models):

____

____

On which concepts and content did the educator emphasise

____

____

Learners' involvement in activities (such as completing worksheets, group work, experiments):

Evidence of content and knowledge of systematics during teaching:

Evidence of scientific inquiry and problem-solving during teaching:

Other comments:

Appendix E

Consent letters

Consent letter submitted to schools

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Aansoek om navorsing te doen:

Hiermee wil ek, mnr E.M. Morrison, toestemming vra om navorsing te doen met die hulp van sekere graad 11 Lewenswetenskaponderwysers. Hierdie navorsing sal gebruik word vir die voltooïng van my MEd: Kurrikulum en Instruksionele ontwerp en ontwikkeling onder die tema "Integrating content and systematic knowledge during scientific inquiry and problem solving in the teaching of Population Dynamics to Grade 11 Life Science learners".

Voorkennis is 'n belangrike komponent in the bemeestering van Biologiese kennis, prosesvaardighede en probleemoplossing. In die verlede was Plant en Diersistematiek belangrike komponente van die Biologie kurrikulum en 'n noodsaaklike voorvereiste vir die bemeestering van Biologiese prosesse. Baie van hierdie prosesse was belangrik vir die verduideliking van sekere ekologiese en populasie interaksies. Plant en Diersistematiek is huidiglik nie ingesluit as aparte komponente in die Lewenswetenskap kurrikulum nie, dus, is dit moontlik dat sekere interaksies en integrasies van Populasie Dinamika nie effektief verduidelik kan word nie.

Daar word toestemming gevra om twee onderhoude met 'n minimum van 2 graad 11 Lewenswetenskaponderwysers in u skool te voer, die duur van die onderhoude sal 30 minute tot 'n uur wees op tye wat die onderwyser pas. Die onderhoude word gevoer om te bepaal hoe die onderwyser die inhoud selekteer in die aanbieding van Populasie

Dinamika en watter komponente (teoreties en prakties) die onderwyser as belangrik identifiseer in Populasie Dinamika. Die onderhoude sal opgeneem, getranskribeer en geanaliseer word. Verder word daar ook toestemming gevra om sekere graad 11 Lewenswetenskaplesse te observeer op tye wanneer Populasie Dinamika lesse aangebied word en om die vakmateriaal van die onderwysers te bestudeer as 'n bron van addisionele inligting.

Kwalitatiewe navorsing sal ook gedoen word deur die VOO beleidsdokument en die graad 11 Lewenswetenskap kurrikulum van die Gauteng Departement van Onderwys te analiseer en te evalueer. Verder word daar ook toestemming gevra om 10 leerders se werkboeke en portefueljelêers te bestudeer. Die werkboeke en portefeuljeleêrs sal die van helfte dogters en helfte seuns wees, dit sal ook wissel van leerders wat sukkel tot by toppresteerders in graad 11 Lewenswetenskap. Die leerders sal met behulp van die onderwysers geïdentifiseer word. Toestemmingsbriewe sowel as inligtingsbriewe sal aan onderwysers asook die leerders en hul ouers/voogde verskaf word. Die werkboeke en portefeuljeleêrs van die leerders word nie geassesseer nie en sal slegs gebruik word om te bepaal watter tipe aktiwiteite die onderwyser ontwikkel en gebruik.

Die navorsing handel oor die aktiwiteite van die onderwysers en die inligting in die leerders se werkboeke en portefueljelêers, nie die onderwysers en leerders nie. Ek wil slegs bepaal hoe en indien wel inhoud en Plant en Diersistematiek kennis gebruik word deur die onderwyser tydens die aanbieding van Populasie Dinamika. Verder om verskillende metodes (soos probleemoplossing en wetenskaplike navorsing) van aanbieding te identifiseer waarvan gebruik gemaak word in Populasie Dinamika aan leerders.

Alle inligting sal streng vertroulik hanteer word en geen name sal gebruik word nie. Dus, sal bronne anoniem bly en op geen manier identifiseerbaar wees nie. Die deelname van die onderwysers en leerders is vrywillig en beide kan onttrek uit die studie op enige stadium.

Met dank.

Morrison

Mnr E.M. Morrison

Consent letter to educators

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Geagte onderwyser/es,

Hiermee wil ek vir u graag uitnooi om deel te wees van my studie. As u instem, sal ek met u onderhoude voer. Dit is noodsaaklik aangesien u 'n graad 11 Lewenswetenskap onderwyser is. Ek sal twee keer met u onderhoude voer, die duur van die onderhoude sal wissel tussen 30 minute en 'n uur op tye wat gerieflik vir u sal wees. Die onderhoude word gevoer om te bepaal hoe u die inhoud selekteer in die aanbieding van Populasie Dinamika en watter komponente (teoreties en prakties) u as belangrik identifiseer in Populasie Dinamika. Die onderhoude sal opgeneem, getranskribeer en geanaliseer word.

Verder word daar ook toestemming gevra om sekere graad 11 Lewenswetenskaplesse te observeer op tye wanneer Populasie Dinamika lesse aangebied word en om u vakmateriaal te bestudeer as 'n bron van addisionele inligting. Ek wil slegs bepaal hoe en indien wel u inhoud en Plant en Diersistematiek kennis tydens die aanbieding van Populasie Dinamika gebruik. Verder om verskillende metodes (soos probleemoplossing en wetenskaplike navorsing) van aanbieding te identifiseer waarvan u gebruik maak in Populasie Dinamika aan leerders.

Hierdie navorsing sal gebruik word vir die voltooïng van my MEd: Kurrikulum en Instruksionele Ontwerp en Ontwikkeling, "Integrating content and systematic knowledge during scientific inquiry and problem solving in the teaching of Population Dynamics to Grade 11 Life Science learners".

Die hoofdoel van hierdie studie is om te bepaal hoe onderwysers inhoud en kennis van sistematiek tydens wetenskaplike ondersoek en probleemoplossing integreer in die aanbieding van Populasie Dinamika vir graad 11 Lewenswetenskap leerders.

Die Departement van Onderwys (2005:2) vereis dat leerders blootgestel moet word aan verskillende en hoër vaardigheidsvlakke en kennis as dié van die vorige Suid Afrikaanse kurrikulum. Daaroor, het die Suid Afrikaanse regering in 1995 die proses begin om 'n nuwe Kurrikulum vir die skoolsisteem te ontwikkel. Die nuwe Lewenswetenskapkurrikulum (vroeër bekend as Biologie) het ook merkwaardige veranderinge vir implementering in 2006 ondergaan.

Voorkennis is 'n belangrike komponent in the bemeestering van Biologiese kennis, prosesvaardighede en probleemoplossing. In die verlede was Plant en Diersistematiek belangrike komponente van die Biologie kurrikulum en 'n noodsaaklike voorvereiste vir die bemeestering van Biologiese prosesse. Baie van hierdie prosesse was belangrik vir die verduideliking van sekere ekologiese en populasie interaksies. Plant en Diersistematiek is huidiglik nie ingesluit as aparte komponente in die Lewenswetenskap kurrikulum nie, dus is dit moontlik dat sekere interaksies en integrasies van Populasie Dinamika nie effektief verduidelik kan word nie.

Kwalitatiewe navorsing sal ook gedoen word deur die VOO beleidsdokument en die graad 11 Lewenswetenskap kurrikulum van die Gauteng Departement van Onderwys te analiseer en te evalueer. Ek gaan ook met een persoon wat betrokke was by die ontwikkeling van die nuwe Lewenswetenskap kurrikulum 'n onderhoud voer.

Ek wil ook graag 10 leerders se werkboeke en portefueljelêers bestudeer. Die werkboeke en portefeuljeleêrs sal die van helfte dogters en helfte seuns wees, dit sal ook wissel van leerders wat sukkel tot by toppresteerders in graad 11 Lewenswetenskap. Die leerders gaan met u hulp geïdentifiseer word. Toestemmingsbriewe sowel as inligtingsbriewe sal aan dié leerders asook hul ouers/voogde verskaf word. Die werkboeke en portefeuljeleêrs van die leerders word nie geassesseer nie en sal slegs gebruik word om te bepaal watter tipe aktiwiteite deur u as onderwyser ontwikkel en gebruik is en om te bepaal of u inhoud sowel as kennis van sistematiek as voorkennis ingesluit het vir die leerders om sekere Populasie Dinamika konsepte te bemeester of nie.

Die navorsing handel oor die aktiwiteite van die onderwysers en die inligting in die leerders se werkboeke en portefueljelêers, nie die onderwysers en leerders nie.

Die doel van hierdie brief is om u vroegtydig in kennis te stel van die aard van die navorsing en om u die opsie te gee om vrywillig deel te wees van dit of nie. Verder, het u die reg om in enige stadium uit die navorsing te onttrek, aangesien deelname vrywillig en vertroulik is. Alle inligting sal streng vertroulik hanteer word en geen name sal gebruik word nie. Dus, sal bronne anoniem bly en op geen manier identifiseerbaar wees nie. As u besluit om nie deel te neem in die navorsing nie, sal u nie gepenaliseer word nie.

Ek sal seker maak dat ek duidelikheid het op elke antwoord van u en indien nie sal ek vir u vra om u antwoord aan my te verduidelik, dit sal daar toe lei dat die data wat versamel word objektief is. Bevindinge sal gerapporteer word op 'n eerlike en opregte manier, sonder misinterpretasies van wat ek gedoen het of om enige iemand te mislei. Ek sal ook onder geen omstandighede data fabriseer om by sekere gevolgtrekkings uit te kom nie. As u terugvoer nodig het, sal dit slegs aan u gegee word aangaande u persoonlike inligting of wanneer die thesis voltooi is.

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As u enige vrae het, voel asseblief vry om my te kontak.

Dankie vir u deelname en ondersteuning.

22/08/2008

______________________ ____________________

EM Morrison
Navorser

Datum

Naam:______________________________________

Posisie: _____________________________________

Departement: ________________________________

Ek stem hiermee vrywillig in om deel te neem in E.M. Morrison se navorsing.

__________________________ ___________________

Deelnemer

Datum

Consent letters to learners

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Geagte graad 11-leerder

Ek is tans besig met my Meestersgraad (Kurrikulum en Instruksionele Ontwikkeling en Ontwerp) aan die Universiteit van Pretoria. Dit gaan oor hoe ‘n kurrikulum ontwikkel word en hoe onderwysers teoretiese en praktiese lesse aanbied. ‘n Deel van my studies vereis dat ek navorsing doen oor hoe die onderwysers Populasie Dinamika vir julle as graad 11 Lewenswetenskap leerders aanbied.

Die rede vir my navorsing is dat daar in die verlede Plant en Diersistematiek (inligting oor waarom plante en diere in sekere groepe verdeel word, soos byvoorbeeld alge, varings, soogdiere en visse) in die Biologie kurrikulum voorgekom het. Baie van hierdie inligting was belangrik vir die verduideliking van sekere ekologiese en populasie verhoudings. Plant en Diersistematiek is nou nie meer ingesluit as ‘n aparte afdeling in die Lewenswetenskap kurrikulum nie. Daarom dink ek dat sekere inligting van Populasie Dinamika nie maklik verstaanbaar sal wees nie.

Om my navorsing te doen, is daar sekere take wat ek moet verrig. Hiervoor het ek egter julle hulp nodig. Dié take sluit in dat ek in die klaskamer gaan wees tydens sekere Populasie Dinamika lesperiodes. Tydens hierdie lesperiodes sal ek slegs in die klaskamer wees om te observeer (kyk) hoe lesse aangebied word deur die onderwyser. Dus, het die observasie net te doen met die onderwyser en nie julle (as leerders) nie.

Ek wil slegs bepaal hoe en indien wel inhoud en Plant en Diersistematiek kennis gebruik word deur die onderwysers wanneer hulle vir julle Populasie Dinamika aanbied. Verder om verskillende metodes (soos probleemoplossing en wetenskaplike navorsing) van aanbieding te identifiseer (uit te ken) waarvan die onderwysers gebruik maak om Populasie Dinamika aan julle te verduidelik.

Alle inligting sal streng vertroulik hanteer word en geen name sal gebruik word nie. Julle en die onderwysers sal anoniem bly en op geen manier identifiseerbaar wees nie. Die deelname van die onderwysers en julle is vrywillig en enige iemand kan onttrek uit die studie op enige stadium.

Indien jy enige beswaar hieroor mag hê, dui dit asseblief aan in die gegewe spasie te vinde onderaan die brief.

Baie dankie vir jou hulp.

Eddie Morrison

Kommentaar

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Geagte graad 11-leerder

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Die rede vir my navorsing is dat daar in die verlede Plant en Diersistematiek (inligting oor waarom plante en diere in sekere groepe verdeel word, soos byvoorbeeld alge, varings, soogdiere en visse) in die Biologie kurrikulum voorgekom het. Baie van hierdie inligting was belangrik vir die verduideliking van sekere ekologiese en populasie verhoudings. Plant en Diersistematiek is nou nie meer ingesluit as aparte dele in die Lewenswetenskap kurrikulum nie, Daarom dink ek dat sekere inligting van Populasie Dinamika nie goed vir julle verduidelik kan word nie.

Om my navorsing te doen, is daar sekere take wat ek moet verrig. Hiervoor het ek egter julle hulp nodig. Dié take sluit in die ondersoek van julle werkboeke en portefeuljewerk.

Hiermee vra ek dus toestemming om jou werkboek en portefeuljewerk te bestudeer om die nodige inligting te versamel. Die navorsing handel oor die aktiwiteite van die onderwysers en die inligting in jou werkboek en portefueljelêer, nie oor die onderwysers en jou nie. Jou werkboek en portefeuljeleêr word nie geassesseer nie, ek dit wil slegs gebruik word om te bepaal watter tipe aktiwiteite die onderwyser opgestel en gebruik het.

Jou en die onderwysers se name sal nie genoem word nie en alle inligting sal streng vertroulik behandel word. Dus, sal jy anoniem bly en op geen manier identifiseerbaar wees nie. Die deelname van julle en die onderwysers is vrywillig en enige iemand kan onttrek uit die studie op enige stadium.

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Indien jy nie instem dat ek, jou werkboek en portefeuljewerk mag gebruik nie, sal jy nie gepenaliseer word nie. Ek ondersoek die onderwysers se aktiwiteite in die navorsing en nie jou werk nie.

Indien jy sal instem om my te help moet jy asseblief die toestemmingstrokie onderaan die brief invul.

Baie dankie vir jou tyd en hulp.

Eddie Morrison

Hiermee gee ek ____

(Naam en van) ‘n graad 11-leerling aan die Hoërskool ________________________

toestemming aan Eddie Morrison om my werkboek en portefeuljewerk te ondersoek

en te gebruik as deel van sy navorsing.

______________________________ ________________________

Handtekening Datum

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Consent letters to parents/guardians

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Geagte graad 11-ouer/voog

Ek is tans besig met my MEd in Kurrikulum en Instruksionele Ontwikkeling en Ontwerp aan die Universiteit van Pretoria. Ek ondersoek die integrasie van inhoud en kennis van sistematiek tydens wetenskaplike ondersoek en probleemoplossing in die studie van populasie dinamika in die graad 11 Lewenswetenskapkurrikulum.

Voorkennis is ‘n belangrike komponent in the bemeestering van Biologiese kennis, prosesvaardighede en probleemoplossing. In die verlede was Plant en Diersistematiek belangrike komponente van die Biologie kurrikulum en ‘n noodsaaklike voorvereiste vir die bemeestering van Biologiese prosesse. Baie van hierdie prosesse was belangrik vir die verduideliking van sekere ekologiese en populasie interaksies. Plant en Diersistematiek is huidiglik nie ingesluit as aparte komponente in die Lewenswetenskap kurrikulum nie, dus, is dit moontlik dat sekere interaksies en integrasies van Populasie Dinamika nie effektief verduidelik kan word nie.

Dus, beteken dit dat ‘n deel van my studies vereis dat ek navorsing doen ten opsigte van die graad 11 Lewenswetenskapkurrikulum. Om my navorsing te doen, is daar sekere take wat ek moet verrig. Dié take sluit in die klaskamerobservasie op tye wanneer Populasie Dinamika lesse aangebied word. Tydens die betrokke lesperiodes sal ek slegs in die klaskamer wees om te observeer hoe lesse aangebied word deur die onderwyser. Dus, het die observasie bloot te doen met die onderwyser en nie die leerders nie.

Ek wil slegs bepaal hoe en indien wel inhoud en Plant en Diersistematiek kennis gebruik word deur die onderwyser tydens die aanbieding van Populasie Dinamika. Verder om verskillende metodes (probleemoplossing en wetenskaplike navorsing) van aanbieding te identifiseer waarvan gebruik gemaak word in Populasie Dinamika aan leerders.

Alle inligting sal streng vertroulik hanteer word en geen name sal gebruik word nie. Dus, sal bronne anoniem bly en op geen manier identifiseerbaar wees nie. Die deelname van die onderwysers en leerders is vrywillig en beide kan onttrek uit die studie op enige stadium.

Indien u enige beswaar hieroor mag hê, dui dit asseblief aan in die gegewe spasie te vinde onderaan die brief.

Baie dankie vir u begrip.

Eddie Morrison

Kommentaar

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Geagte graad 11-ouer/voog

Ek is tans besig met my MEd in Kurrikulum en Instruksionele Ontwikkeling en Ontwerp aan die Universiteit van Pretoria. Ek ondersoek die integrasie van inhoud en kennis van sistematiek tydens wetenskaplike ondersoek en probleemoplossing in die studie van populasie dinamika in die graad 11 Lewenswetenskapkurrikulum.

Voorkennis is ‘n belangrike komponent in the bemeestering van Biologiese kennis, prosesvaardighede en probleemoplossing. In die verlede was Plant en Diersistematiek belangrike komponente van die Biologie kurrikulum en ‘n noodsaaklike voorvereiste vir die bemeestering van Biologiese prosesse. Baie van hierdie prosesse was belangrik vir die verduideliking van sekere ekologiese en populasie interaksies. Plant en Diersistematiek is huidiglik nie ingesluit as aparte komponente in die Lewenswetenskap kurrikulum nie, dus, is dit moontlik dat sekere interaksies en integrasies van Populasie Dinamika nie effektief verduidelik kan word nie.

Dus, beteken dit dat ‘n deel van my studies vereis dat ek navorsing doen ten opsigte van die graad 11 Lewenswetenskapkurrikulum. Hiermee het ek u hulp nodig. Om my navorsing te doen, is daar sekere take wat ek moet verrig. Dié take sluit in die ondersoek van leerders se werkboeke en portefeuljewerk.

Hiermee vra ek dus toestemming om u kind se werkboek en portefeuljewerk te bestudeer om die nodige bewyse te versamel. Die navorsing handel oor die aktiwiteite van die onderwysers en die inligting in die leerders se werkboeke en portefueljelêers, nie die onderwysers en leerders nie. Die werkboeke en portefeuljeleêrs van die leerders word nie geassesseer nie, ek dit wil slegs gebruik word om te bepaal watter tipe aktiwiteite die onderwyser ontwikkel en gebruik.

Die bronne van my versamelde bewyse sal streng vertroulik behandel word, aangesien geen leerdername oorgedra sal word nie. Dus, sal bronne anoniem bly en op geen manier identifiseerbaar wees nie. Die deelname van die onderwysers en leerders is vrywillig en beide kan onttrek uit die studie op enige stadium.

Indien u nie instem dat u kind se werkboek en portefeuljewerk gebruik mag word nie, sal u kind nie gepenaliseer word nie.

Indien u sal instem om my te help moet u asseblief die toestemmingstrokie onderaan die brief invul.

Baie dankie vir u tyd en hulp.

Eddie Morrison

Hiermee gee ek ____ (Naam en

van) ouer/voog van ___________________________________ (leerdernaam en van)

'n graad 11-leerling aan die Hoërskool ___________ toestemming aan Eddie Morrison

om my kind se werkboeke en portefeulje - werk te ondersoek en te gebruik as deel van sy

navorsing.

______________________________ ______________________

Handtekening Datum

Consent letter to curriculum developers

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Dear participant

This study is conducted to complete my MEd in Curriculum and Instructional Design and Development at the University of Pretoria, "Integrating content and systematic knowledge during scientific inquiry and problem solving in the teaching of Population Dynamics to Grade 11 Life Science learners".

The main purpose of this study is to determine how educators integrate content and systematic knowledge during scientific inquiry and problem solving in the teaching of Population Dynamics to Grade 11 Life Science learners.

I would like to invite you to take part in my study. If you agree to take part, you will be interviewed by me. This is necessary because you were involved in the compiling of the new Life Sciences Curriculum. You will only be interviewed once, the duration of the interview will be between 30 minutes to an hour on a time suitable to yourself. I am interviewing you to determine why Botany and Zoology systematics are currently not included as separate components of the Life Sciences Curricula. I would also like to determine what the thought was behind the design and development of the new grade 11 Life Sciences Curriculum with reference to the content, practical skills and teachers. The data will be tape-recorded, transcribed and analysed.

The Department of Education (2005:2) require learners to be exposed to different and higher level skills and knowledge than those required by the previous South African Curricula. Therefore, in 1995 the South African government began the process of developing a new Curriculum for the school system. The new Life Sciences Curriculum (previously Biology) also underwent some significant changes for implementation in 2006.

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Prior knowledge is an important component in the mastery of biological knowledge, process skills and problem-solving skills. In the past Botany and Zoology systematics were prominant components of the Biology curriculum and an important prerequisite for the mastering of Biological processes. Many of these processes were important for the explanation of certain ecological and population interactions. Botany and Zoology systematics are currently not included as separate components of the Life Sciences Curricula. Consequently, it is possible that certain interactions and integrations of Population Dynamics cannot be effectively explained.

Teachers who teach Life Sciences to the grade eleven (11) learners at different Secondary schools will be interviewed twice, the duration of each interview will be from 30 minutes to an hour on a time suitable to their requirements. I will also study the work and the portfolio files of 10 learners in the grade eleven (11) Life Sciences Curriculum. I will conduct classroom observations on times when the relevant lessons (population dynamics) are taught in class.

Qualitative research will also be conducted by analysing and evaluating the FET policy document as well as the grade 11 Life Sciences Curriculum, provided by the Gauteng Department of Education.

The purpose of this letter is to inform you in advance about the nature of the study to be conducted, and to give you the choice of either participating or not participating. Furthermore, you have the right to withdraw from the study at any time, as participation in a study should be strictly voluntary and confidential. If you decide not to participate in the study you will not be penalised.

I will also ensure that when I am not totally clear on an answer from you, to ask you to explain what you meant, this will ensure that the data being collected is objective. Findings will be reported in a complete and honest fashion, without misrepresenting what I have done or intentionally misleading others as to the nature of the findings. I will under no circumstances fabricate data to support a particular conclusion, no matter how seemingly "noble" that conclusion may be.

If feedback is required, it will only be given on your personal information or when the final written report is completed.

Thank you for your participation.

EM Morrison
Researcher

22/08/2008
Date

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Name: ____________________________________

Position: __________________________________

Department: _______________________________

I hereby agree to participate in the study conducted by E.M. Morrison.

_________________________ ____________________

Participant Date

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Consent letter to experts in ecology and systematics

My naam is Eddie Morrison, ek is tans besig met 'n MEd verhandeling by die Universiteit van Pretoria, oor die onderwerp: "Integrating content and systematic knowledge during scientific inquiry and problem solving in the teaching of Population Dynamics to Grade 11 Life Science learners".

My basiese argument is dat die uitsluiting van sistematiek in die huidige skool kurrikulum die onderrig van die temas van populasiedinamika en biodiversiteit bemoeilik.

Sou dit moontlik wees dat u my kan help met antwoorde op die volgende vrae? As u bereid sou wees om my te help kan ons dit gedurende 'n kort onderhoud bespreek, of u kan dit vir my skriftelik stuur in antwoord op hierdie E-pos.

Ek sou graag u opinie oor die volgende aspekte wou hê:

1. Wat is die verband tussen sistematiek, populasiedinamika en biodiversiteit?

2. Hoeveel voorkennis van sistematiek dink u is nodig vir die suksesvolle onderrig van populasiedinamika en biodiversiteit?

3. Wat is u opinie oor die uitsluiting van sistematiek uit die skool kurrikulum?

4. Wat sal die gevolge wees vir studente wat later tersiêre studies in die lewenswetenskappe wil volg?

5. Kan u vir my van voorbeelde voorsien wat sal uitlig hoe populasiedinamika en biodiversiteit steun op 'n voorkennis van sistematiek?

Ek wil u verseker dat u bydra volgens die voorskrifte van die Etiese kommittee anoniem en konfidensieel sal bly. In enige publikasie sal daar slegs na u verwys word as 'n kenner op die gebied van sistematiek. Die inligting sal slegs aan my en my studieleier beskikbaar wees en sal op geen ander manier gebruik word as vir die doeleindes van hierdie studie nie.

By voorbaat dank

Eddie Morrison

084 679 5189

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FACULTY OF EDUCATION

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	**CLEARANCE NUMBER :** CS08/06/01
DEGREE AND PROJECT	MEd: Curriculum Studies Integration of knowledge of systematics in the teaching of population studies and biodiversity to grade 11 life sciences learners
INVESTIGATOR(S)	EM Morrison
DEPARTMENT	Science, Mathematics and Technology Education
DATE CONSIDERED	23 March 2010
DECISION OF THE COMMITTEE	APPROVED

Please note:

For Masters applications, ethical clearance is valid for 2 years

For PhD applications, ethical clearnace is valid for 3 years.

CHAIRPERSON OF ETHICS COMMITTEE	Prof L Ebersohn
DATE	23 March 2010
CC	Dr A.L Abrie Ms Jeannie Beukes

This ethical clearance certificate is issued subject to the following conditions:

1. A signed personal declaration of responsibility
2. If the research question changes significantly so as to alter the nature of the study, a new application for ethical clearance must be submitted
3. It remains the students' responsibility to ensure that all the necessary forms for informed consent are kept for future queries.

Please quote the clearance number in all enquiries.