Exploring the recontextualisation of biology in the South African life sciences curriculum, 1996-2009

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> If recontextualization totally severs any relation [between the parent knowledge structure and the recontextualized school subject], then how are specialised knowledges ever reproduced?
>
> (Muller, 2007, p.80)

Abstract

A school subject is not the same as its parent discipline. According to Bernstein's pedagogic device, knowledge is recontextualised from its disciplinary form, through the official curriculum, to its reproduction in schools. Curricula need to reflect their parent discipline to a reasonable degree, if the reproduction of specialised knowledges is not to be undermined.

We explored the recontextualisation of biology in the school curriculum in general, and in three versions of the post-apartheid South African life sciences curriculum in particular. We constructed a hierarchy of core concepts in biology, and a set of objectives for a school science education. We then utilised these findings in a comparative analysis of the South African curricula, and mapped the curricular content to determine the degree of conceptual progression.

The specialised knowledge of the discipline was recontextualised most faithfully in the New Content Framework of 2007. We consider the implications of our study in a context of ongoing curriculum revision.

Introduction

Bernstein's notion of the pedagogic device describes how knowledge moves and is transformed in educational settings (Bernstein, 1990, 1996). According to this concept, knowledge undergoes several recontextualisations as it passes from its origins as an academic discipline, to its form in the school curriculum, to the classroom where it is taught and assessed.

In recent years there has been a growing sense of the need to examine more closely the relationship between pedagogic structures and their parent knowledge structures. Maton and Muller (2007) argued that a school subject must resemble its parent discipline to a reasonable degree, if the role of schooling as a relay of specialised knowledges is not to be undermined. This is held to be most important in school subjects derived from what Bernstein (1996) termed hierarchical knowledge structures, in particular the natural sciences. The argument is that if this continuum is disrupted too markedly, students, especially those from disadvantaged backgrounds, will not successfully be inducted into the realms of the formal knowledge structure (Taylor, 2001; Muller, 2007). This issue is of particular relevance in post-apartheid South Africa, where the pursuit of social justice by transforming the education system has resulted in extensive and repeated curriculum revision since 1994 (Christie, 2008), particularly in the case of the subject biology/life sciences (Doidge, Dempster, Crowe and Naidoo, 2008).

This study represents an exploration of the recontextualisation of biology as an academic discipline to biology as a school subject, in general, and in three revisions of the biology/life sciences curriculum implemented in South Africa after 1994, in particular – the Interim Core Syllabus (ICS) (KwaZulu-Natal Department of Education and Culture, n.d.), the National Curriculum Statement (NCS) (Department of Education, 2003), and the New Content Framework (NCF) (Department of Education, 2007). Our findings at the general level served to supply criteria for a comparative analysis of the South African curricula, aimed at assessing whether there has been an improvement in the way biological knowledge has been recontextualised in the successive versions.

Since the conclusion of this study, the life sciences curriculum has been revised yet again as the Curriculum and Assessment Policy Statement (CAPS) (2010). An analysis of the CAPS life sciences curriculum is the subject of a separate study. We conclude by considering, firstly, the implications of our study in the context of ongoing curriculum revision in this country, and secondly, the usefulness of Bernstein's concepts in studies of this nature.

Conceptual framework

The broad conceptual framework for our study was constructed from two aspects of Bernstein's sociology of education – the *recontextualisation of* *knowledge in the pedagogic device*, and the *structure of knowledges*. In applying Bernsteinian concepts to the curricula under scrutiny, we utilised Schmidt, Wang and McKnight's (2005) notion of *curricular coherence*. These three concepts will be outlined here.

1. The pedagogic device and the recontextualisation of knowledge

Bernstein's 'pedagogic device' refers to the principles, or the collection of rules and procedures, whereby knowledge is converted into pedagogic communication. An elegant explication of this concept was provided by Singh (2002), while Maton and Muller (2007) provided a useful summary in the form of a table (Table 1).

Table 1: A simplified representation of Bernstein's conceptualisation of the pedagogic device (adapted from Maton and Muller, 2007, p.18 and Bertram, 2009, p.48)

Field of practice	**Production**	**Recontextualisation: official recontextualising field (ORF) and pedagogic recontextualising field (PRF)**	**Reproduction**
Form of regulation	Distributive rules	Recontextualising rules	Evaluative rules
Kinds of symbolic structure	Knowledge structures (hierarchical and horizontal)	Curriculum	Pedagogy and evaluation
Typical agents	Academics	ORF: curriculum writers PRF: teacher trainers, textbook writers	Teachers, learners
Typical sites	Research papers, conferences, laboratories	ORF: curriculum policy PRF: textbooks, learning aids	Classrooms, examinations, assessment tasks

According to this concept, knowledge is generated in the field of production by specialists in the various disciplines, typically researchers and academics at universities. Within this intellectual arena, distributive rules govern the distribution of different forms of knowledge. These give rise to recontextualising rules which regulate the formation of pedagogic discourse within the recontextualising field. The recontextualising rules in turn give rise to evaluative rules, which constitute pedagogic transmission and acquisition in the field of reproduction, the schools.

Recontextualisation, then, involves the movement of knowledge from the primary context of the intellectual arena where knowledge is produced, to the secondary context of the educational arena, where knowledge is reproduced (Bernstein, 1990). Bernstein distinguished between an "*official recontextualising field* (ORF)", created and dominated by the state and its selected agents and ministries" – which includes the agents of curriculum construction – and a "*pedagogic recontextualising field* (PRF)" (Bernstein, 1996, p.48). In Bernstein's definition, the PRF "consists of pedagogues in schools and colleges, and departments of education, specialised journals, private research foundations" (Bernstein, 1996, p.48), while Bertram (2009) interpreted this to mean those who "take the official curriculum and recontextualise it as they train teachers, write textbooks or conduct research" (p.52).

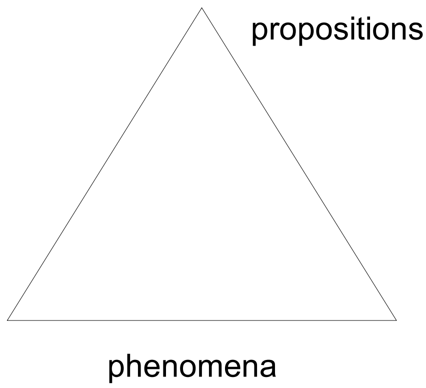
2. The structure of knowledges

In educational sociology the distinction is frequently made between 'everyday' and 'school' knowledge, a dichotomy originating in Emile Durkheim's (1915 [1976]) famous distinction between the 'profane' and the 'sacred'. Bernstein (1996) reformulated this as 'horizontal discourse' and 'vertical discourse'. Horizontal discourse (everyday or profane knowledge) is typically transmitted orally and is localised, context-specific and context-dependent. Vertical discourse (school or sacred knowledge), by contrast, usually has a written form, and is concerned with context-independent meaning within an integrated knowledge system. This is the knowledge which society considers worth transmitting to future generations, in formal educational settings such as schools and universities.

Within vertical discourse Bernstein (1999) distinguished between 'horizontal' and 'hierarchical' knowledge structures. Horizontal knowledge structures, exemplified by the social sciences and humanities, "take the form of a series of specialised languages with specialised modes of interrogation and specialised criteria for the production and circulation of texts" (Bernstein, 1999, p.159). Hierarchical knowledge structures, on the other hand, are "coherent, explicit and systematically principled" as well as being "hierarchically organised" (p.159).

Bernstein elaborated on this further by writing that hierarchical knowledge structures "[attempt] to create very general propositions and theories, which integrate knowledge at lower levels, and in this way [show] underlying uniformities across an expanding range of apparently different phenomena" (Bernstein, 1999, p.162). He represented hierarchical knowledge structures by means of a triangle, its pinnacle representing the general theories or propositions, and its base the phenomena which are integrated by these propositions (Figure 1; Bernstein, 1996).

Figure 1: Bernstein's depiction of an hierarchical knowledge structure (redrawn from Bernstein, 1996)



In Bernstein's view, hierarchical knowledge structures are exemplified by the natural sciences, including biology (1996; 1999). Other authors have endorsed and elaborated on this concept to varying degrees in relation to the natural sciences (e.g. Schmidt, Wang and McKnight, 2005; Donnelly, 2006; Martin, 2007; Muller, 2007; O'Halloran, 2007).

3. Curricular coherence

Schmidt, Wang and McKnight (2005) contend that if the inherent hierarchical structure of the parent discipline is to be made visible to students, the curriculum must be *coherent*. Indeed, these authors regard coherence as one of the most critical defining elements of a high quality curriculum, and essential for promoting a deep understanding of the subject matter.

In simple terms, curricular coherence can be taken to mean "sensible connections and co-ordination between the topics that students study in each subject within a grade and as they advance through the grades" (Newman *et al.*, 2001, as cited in Schmidt *et al.*, 2005). Thus a curriculum is coherent if the subject matter shows progression, both within and across grades, from particulars to the deeper structures which connect those particulars, or from descriptive to more theoretical and explanatory aspects. In a coherent curriculum new topics are not introduced before the prerequisite knowledge has been covered, nor is material simply repeated from grade to grade.

Summary

This section has served to introduce the various theoretical concepts which helped to provide a language of description for the study. We have outlined Bernstein's notion of types of knowledge structures, in particular hierarchical knowledge structures, of which biology is an example. Knowledge in an hierarchical knowledge structure builds upwards from the concrete and particular to ever more integrating and general propositions. When an hierarchical knowledge structure is transformed into a school subject, this knowledge is recontextualised during a series of processes, the first being the construction of the school curriculum. This is a selective process involving human agents with particular agendas, and the resulting curriculum will thus differ from its parent discipline. It has been argued the curriculum must nevertheless reflect the structure of the parent discipline to a reasonable degree, if the cause of social justice is to be upheld.

Schmidt *et al.*'s (2005) concept of curricular coherence – the need for the material in a curriculum derived from an hierarchical knowledge structure to reflect the logical structure of the corresponding discipline – suggested criteria for measuring the coherence of the curricula in question.

The study

Our study was concerned with the broad question *How is biological knowledge recontextualised in the school curriculum?* We addressed this at three levels: biology as an academic discipline, biology as a school subject, and biology in the South African school curriculum post-1994. A detailed account of our research methodology and findings is provided elsewhere (Johnson, 2009). Here we summarise our approach and key findings, before considering the implications of our study for constructing and assessing future life sciences curricula in South Africa.

1. Biology as an academic discipline

If biology represents an hierarchical knowledge structure *sensu* Bernstein, it should be possible to delimit the general, integrating propositions, or core concepts, within the discipline. The starting point of our study, then, was an attempt to answer the question, *What are some of the core concepts of biology, and how can they be conceptualised as a hierarchy?* This was obviously an ambitious project; our aim was simply to generate one possible set of concepts and a means of organising them, which could facilitate a comparative analysis of the curricula under scrutiny.

Answers were sought from the following sources: a selection of the writings of biologist Ernst Mayr, representing the field of knowledge production (Mayr, 1982, 1988, 1991, 1997, 2005); two tertiary level biology textbooks (Starr and Taggart, 2001; Campbell and Reece, 2005), and interviews with two practising academic biologists, namely Professors George Branch (University of Cape Town), and Lawrence Harder (University of Calgary).[1]

Findings with regard to biology as an academic discipline

There was considerable overlap in the core concepts suggested by the various sources, with each one highlighting the following seven: *the cell, inheritance, evolution, interactions*, *regulation, energy flow* and *diversity*. In terms of how these could be organised, we followed Mayr's (1997) assertion that biology is structured according to 'what', 'how' and 'why' questions, which equate broadly to issues of biodiversity, structure in relation to functioning, and evolution, respectively. We used these findings to generate Figure 2 below, which depicts a possible hierarchical arrangement of biology's core concepts.

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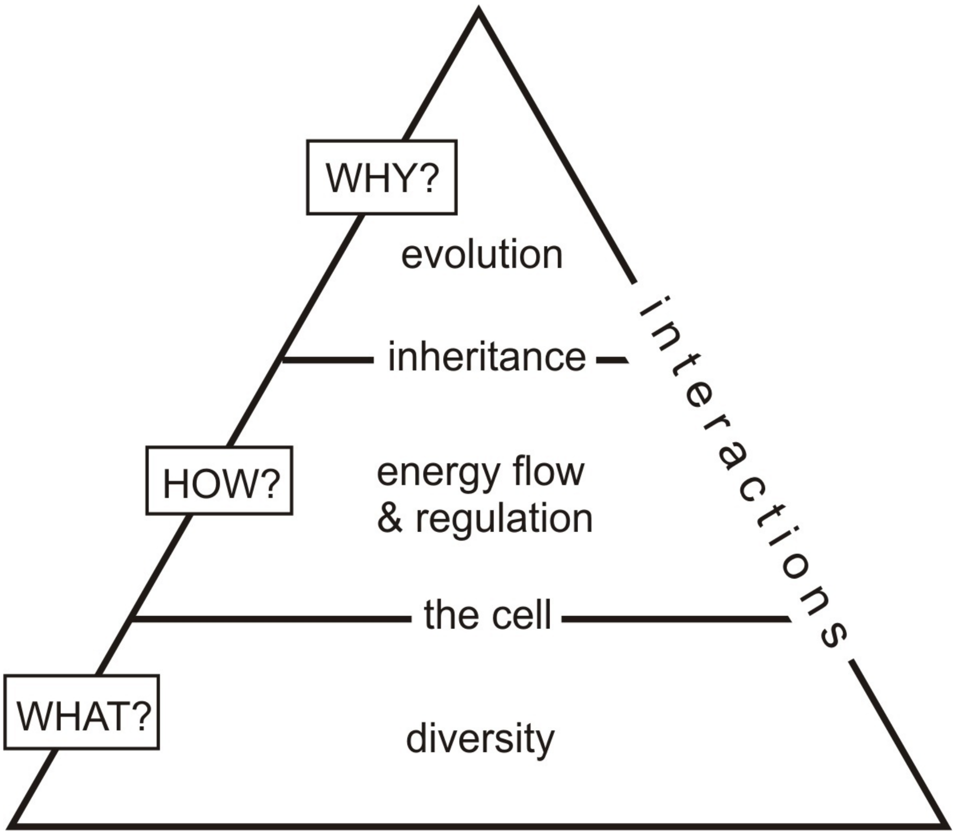
1 Since biology is a very broad subject, a limited number of sources were interrogated to establish a consensus list of core foundational concepts. Ernst Mayr is regarded as one of the world's leading evolutionary biologists, historians and philosophers of biology, and has published extensively in this field (see references in Johnson, 2009). The two textbooks were selected as they are widely prescribed in national and international tertiary institutions, and hence can be regarded as authoritative sources of the fundamental concepts of the subject (see Kuhn, 1970 in Deng, 2001). The two professors were interviewed because they are known to the first author (K. Johnson), and both are highly respected practitioners in their fields, each with a strong publication record based on more than three decades' experience in biology teaching and research.

Figure 2: Schematic representation of a possible hierarchical arrangement of seven core concepts in biology



In this scheme we represented the academic discipline of biology as a triangle in which all the canonical knowledge builds upwards towards biology's highest ordering principle. We used Mayr's categories of 'what', 'how' and 'why' to divide the triangle horizontally, and placed the seven core concepts within or alongside the triangle.

'What' questions form the base of the knowledge triangle, as they generate the concrete, particular, descriptive knowledge forming the foundation of all other studies in biology. These are represented by the concept of *diversity* – the variability that characterises all living organisms, past and present. 'How' questions, the realm of functional biology, occupy the centre of the triangle; these go beyond descriptions of organisms and structures to the explication of processes in living systems. *Regulation*, which characterises metabolism and serves as a unifying concept in physiology, is placed here; as metabolism requires energy, the study of *energy flow* is also included. The concept of *the* *cell*, the basic unit of life, straddles categories 'what' and 'how' as the topic can be studied in relation to the diversity of cells as well as their structure and functioning.

'Why' questions, which search for the historical and evolutionary causes of phenomena, form the apex of the knowledge triangle. Biologists regard *evolution* as the principle which draws together all sub-disciplines of biology and demonstrates the historical development of life. This is because all living organisms are part of the same genealogy and share a common mechanism of inheritance, which is dictated by the principle of natural selection. Hence evolution occupies this position on our scheme. The concept of *inheritance* (genetics) straddles the 'how' and 'why' levels, as certain aspects are essentially physiological while others relate to issues of evolutionary significance. Finally, because *interactions* occur at all levels of biology, as well as between living organisms and the non-living environment, we placed this concept along the side of the triangle.

2. Biology as a school subject

Much has been written about the development of biology (typically subsumed within the field of science education) as a school subject in the western anglophone world (see for example Goodson, 1983; Rosenthal and Bybee, 1987; Goodson and Dowbiggin, 1993; Atkin and Black, 2003). The second question of our study was *What are the goals of a school biology curriculum?*, as it is these that would be expected to inform the selection and prioritising of content material, and thus direct how the subject is recontextualised. We used an inductive approach to answer the question, reviewing relevant literature in the field of science education and curriculum of the past fifty years (see references in Johnson, 2009).

Findings with regard to Biology as a school subject

We found that the question of what science – or *whose* science – children ought to be taught in school forms a frequent refrain (e.g. MacDonald, 2003; Zembylas, 2005; Aikenhead, 2006). The answers are largely determined by the perceived goals of a science education, but such goals are by no means cast in stone and have been debated almost continuously since the inception of science as a school subject in the late nineteenth century (Bybee, 1977; Aikenhead, 2006). In considering the question "What counts as science education?", Roberts (1988) concluded that "the answer is a defensible decision, rather than a theoretically determined solution" (p.30), because the goals for a school science education are determined by numerous factors, including the historical, political, economic and sociological context, the agents responsible for drawing up the curriculum, and any stakeholders or interest groups – none of which is static.

There have been many attempts over the years to summarise and categorise these goals (or 'emphases' – see Roberts, 1982) (e.g. Bybee, 1977; Ogden and Jackson, 1978; Roberts, 1982, 1988; Rosenthal and Bybee, 1987; Fensham, 1997 in Fensham, 2000; DeBoer, 2000; BouJaoude, 2002). We suggest that they can generally be assigned to one of the following five broad categories: *knowledge*, *skills*, *applications, attitudes and values*, and *science as a human enterprise*. Table 2 lists the kinds of topics which each category incorporates.

Table 2: Elaboration of the general goals of a western school science education

Goal	Elaboration
Knowledge	scientific facts, concepts, generalisations, principles, hypotheses, theories and laws, answering the question 'What do scientists know?'; preparation for future studies and careers in the sciences.
Skills	includes those skills, abilities, methods, techniques and processes specifically concerned with the study of science, answering the question, 'What do scientists do?', for example skills associated with doing scientific investigations, such as observation, hypothesis formation, data collection and processing, laboratory procedures, and the communication of scientific findings; developing the capacity to do research; as well as generic skills such as critical thinking and problem solving, communication and co-operation.
Applications	understanding and solving problems regarding the scientific or technological aspects of daily life; science as a means for solving problems in society and the environment, as well as the limits of science in solving problems, and the potential for the applications of science and technology to harm the individual and the environment.
Attitudes and values	incorporates what are considered to be 'scientific' attitudes and values such as objectivity, respect for evidence, critical thinking, openness, honesty and so forth, but also the fostering of positive attitudes towards the subject, aesthetic appeal, satisfying curiosity, promoting appreciation and respect for nature; ethics.
Science as a human enterprise	the nature of science; how science functions as an intellectual enterprise; science as a means of generating knowledge about the world; the nature of evidence and the relationship between evidence and theory; the tentative, changing and self-correcting nature of science; the history of science and scientific discoveries; science as a product of human endeavour, a part of our intellectual heritage; the dichotomy between 'western modern science' and 'indigenous knowledge'; different worldviews; social, political and religious influences on science; multiculturalism; different interpretations of phenomena by different cultural and religious groups, including the creation-evolution debate; biases.

The relative prominence of each category of goals has varied over time. Several authors have noted how this can be represented in broad terms as a pendulum swing between the extremes of 'pure' and 'applied' science, a dichotomy of approaches which has also been expressed as a 'science of life' versus a 'science of living' (Rosenthal and Bybee, 1987; Le Grange, 2008), and more recently, a traditional versus a 'humanistic' approach (Aikenhead, 2006).

In a traditional science curriculum, the goals of *knowledge* and *skills* (i.e. those specifically associated with science) are prioritised, and the others excluded or downplayed. By contrast, a humanistic approach is far more concerned with *relevance* to the lives of students as individuals and in society, with nurturing a critical, 'outsider's' view of science and technology, and with considering other forms of science, especially indigenous knowledge. In a humanistic curriculum the goals of *applications, attitudes and values* and *science as a human enterprise* are regarded as more important, or at least of equal importance as those of knowledge and skills.

3. Biology in successive versions of the South African life sciences curriculum documents implemented between 1996 and 2009

Historical background

Historical accounts of the revision of the South African biology/life sciences curriculum post-apartheid have been provided elsewhere (Jansen, 1999; Doidge, Dempster, Crowe and Naidoo, 2008; Le Grange, 2008; Johnson, 2009), and this will be touched on only briefly here.

Essentially, the first revision, known as the Interim Core Syllabus (ICS) (implemented in 1996, KwaZulu-Natal Department of Education and Culture, n.d.), was little more than a slight modification of the apartheid-era House of Assembly [white] education department biology curriculum (Jansen, 1999). Divided into Higher and Standard Grades, it followed a highly academic approach, yet, underpinned as it was by the conservative ideology of Christian National Education, excluded any mention of evolution.

In the wake of the radical restructuring of education according to the outcomes-based principles of Curriculum 2005 (Department of Education, 1997), the ICS was replaced by the National Curriculum Statement (NCS) (Department of Education, 2003) in 2006. This curriculum document was completely different from the ICS in structure and emphasis. Higher and Standard grades were done away with, and the subject was organised into four Knowledge Areas (Tissues, cells and molecular studies; Structure and control of processes in basic life systems; Environmental studies, and Diversity, change and continuity), the last of which introduced the topic of evolution. Within each knowledge area, the material was divided into three Learning Outcomes (LOs), which focused on the development of skills (LO1), the construction of knowledge (LO2), and the nature of science and its interrelationships with technology, indigenous knowledge, the environment and society (LO3).

Dissatisfaction with the extreme underspecification of the content material of the NCS led to its rewriting just three years later as the New Content Framework (NCF) (Department of Education, 2007). This version retained the Knowledge Areas and Learning Outcomes (with slight modifications), but substantially altered the structure and focus of the content material, and provided far more detail.

Since the completion of this study, a fourth phase of curriculum review took place in which it was recommended that the numerous curriculum documents associated with the NCS should be consolidated into just one document per subject (DoE, 2009). The resulting documents were called the Curriculum and Assessment Policy Statements (CAPS), which were released for public comment in October 2010, and will be implemented in 2012. An analysis of CAPS for life sciences will form the subject matter of a subsequent paper.

Questions

These three versions (the ICS, the NCS and the NCF) were the focus of the third question of our study, which asked *Was there an improvement in the way biology was recontextualised in successive versions of the South African school curriculum implemented between 1996 and 2009*? This was approached by means of the following three sub-questions:

(a) What was the balance of canonical versus humanistic biology in each curriculum?

(b) Which of biology's core concepts were included, and in what proportions?

(c) Was there clear conceptual progression towards these core concepts, and have relevant connections been drawn between them?

Methods

The actual documents analysed were as follows:

1. The ICS: KwaZulu-Natal Department of Education and Culture (n.d.). *Interim Core Syllabus and Provincialised Guide for Biology Grades 10–12 Higher Grade and Standard Grade.*

2. The NCS: Department of Education. 2003. *National Curriculum Statement Grades 10–12 (General): Life Sciences.* Pretoria: Department of Education.

3. The NCF: Department of Education. 2007. *A new content framework for the Subject Life Sciences as listed in the National Curriculum Statements Grades 10–12 (GENERAL).* Circular 67/2007, 25 September. Johannesburg: Department of Education.

Questions (a) and (b) were addressed by means of document analysis (Fraenkel, 1993). We divided the knowledge content specifications of each curriculum into 'statements', which were then assigned to predetermined categories. A 'statement' was defined as one or more sentences, phrases or words that clearly dealt with just one topic. In the case of the ICS, only the Higher Grade text was analysed, as the Standard Grade specifications were essentially a subset of this. In the case of the NCS and the NCF, where the material is divided into Learning Outcomes, the divisions between Learning Outcomes were removed and all the text included.

For question (a) (canonical versus humanistic biology), every statement within the content specifications of each document was assigned to either 'canonical biology' or 'humanistic biology'. Canonical biology statements were those which were regarded as relating to canonical biological knowledge (which can be defined as "the generally accepted facts, ideas, concepts, and theories shared within the scientific community" (National Centre for Education Statistics, 2006, p.7)), or the development of specifically scientific skills. Statements were regarded as pertaining to humanistic biology if they dealt with more generic skills, applications, attitudes and values, or science as a human enterprise (see Table 2).

For question (b) (inclusion of biology's core concepts), only the canonical biology statements were analysed. Seven broad themes, based on the core concepts of biology derived previously but modified to be more applicable to the curricula in question, were delimited. These were (with the related 'core concepts' in parenthesis) *Life at the molecular and cellular level* (the cell), *Inheritance* (inheritance), *Evolution* (evolution), *Diversity* (diversity) *[in school curricula, this typically takes the form of descriptions of the characteristics of different taxonomic groups]*, *Plant structure and functioning, Animal structure and functioning* (both incorporate aspects of diversity, the cell, and regulation), and *Ecology* (incorporates interactions, energy flow and regulation, and diversity). The weighting of each theme in each curriculum was determined by calculating the number of statements related to each theme as a percentage of the total number of canonical biology codings.

Question (c) was addressed by mapping the content specifications of each document grade by grade (after the draft concept maps of Project 2061's *Atlas of Science Literacy,* 2006). In the case of the ICS, where there are no divisions into either Learning Outcomes or Knowledge Areas, all the content material was included in abbreviated form. In the case of the NCS and NCF, only the material from LO2 was included,[2] with the four Knowledge Areas forming columns on the maps. Major topics were placed into individual boxes which were joined by broken lines if, according to our judgment, the topics are connected. If this connection was explicitly stated in the curriculum, we joined the boxes with solid lines.

Findings with regard to conceptions of biology in successive South African curricula

a) Balance of canonical and humanistic biology

Table 3 shows the results of the analysis of the documents into canonical or humanistic biology.

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[2] The reason for including only the material from LO2 in the NCS and NCF was that the purpose of the maps was to reveal the conceptual progression of the canonical content material towards the core concepts of biology, and canonical content within these two curricula was largely confined to LO2 (the construction of knowledge). LO1 focused on the development of skills, and LO3 on the nature of science and its interrelationships with technology, indigenous knowledge, the environment and society, emphases which conform more to our definition of 'humanistic knowledge'. In the case of the ICS, almost all (96%) of the total content was 'canonical'.

Table 3: Balance of canonical and humanistic biology statements in three versions of the South African life sciences curriculum, 1996–2009 (n = total number of statements coded)

	Interim Core Syllabus (n = 276)	National Curriculum Statement (n = 144)	New Content Framework (n = 512)
Canonical biology	96%	36.1%	60.5%
Humanistic biology	4%	63.9%	39.5%

b) Inclusion of biology's core concepts

The results are shown in Table 4.

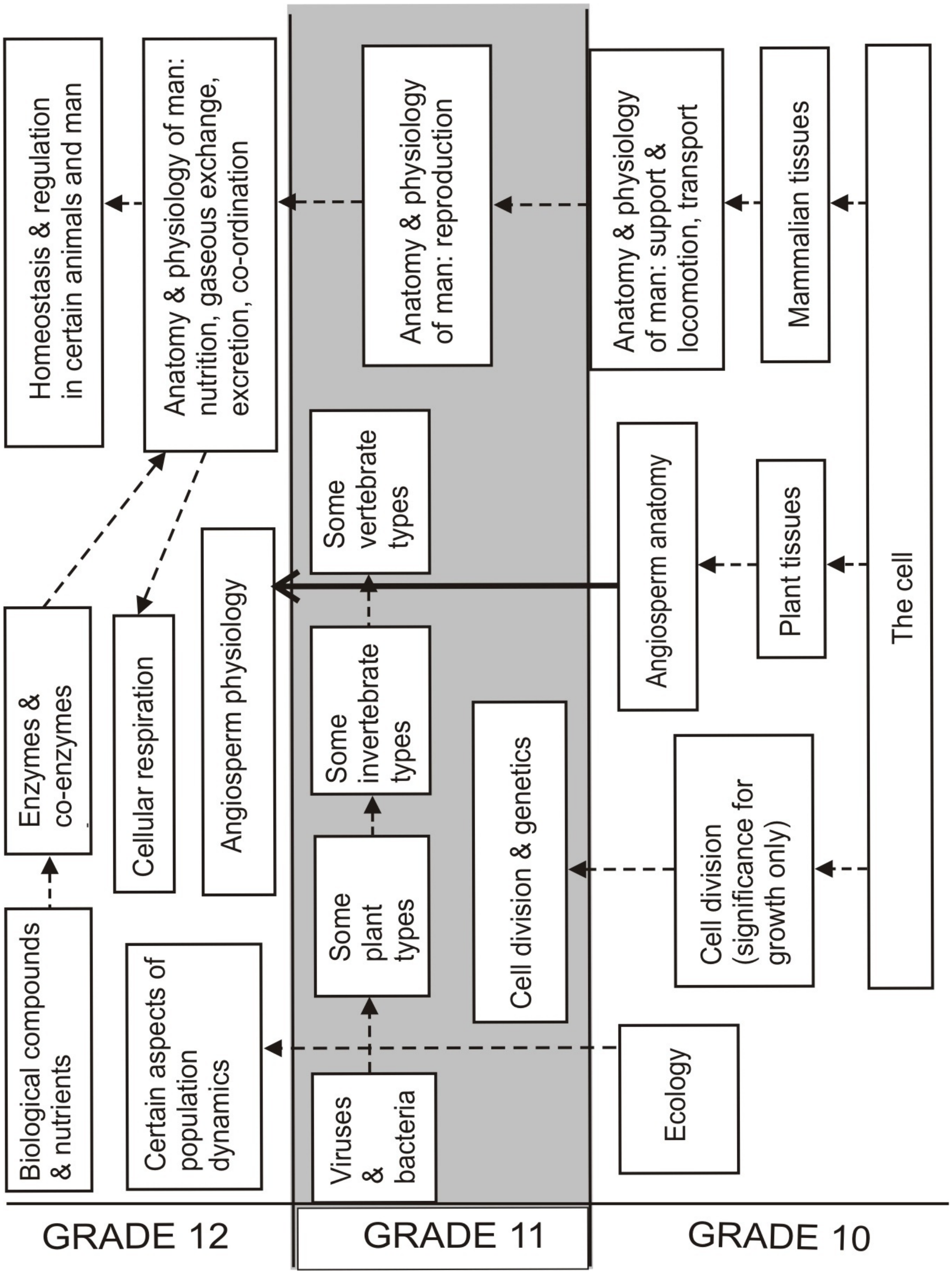
Table 4: Weighting of canonical biology themes in three versions of the South African life sciences curriculum, 1996–2009 (n = number of canonical biology statements)

Theme	Interim Core Syllabus (n = 265)	National Curriculum Statement (n = 52)	New Content Framework (n = 310)
Life at the molecular and cellular level	13%	13.3%	16.2%
Inheritance	7.6%	6.7%	7.2%
Evolution	0%	20%	9.6%
Diversity	29.8%	4.4%	13.4%
Plant structure and functioning	5.9%	6.7%	10.3%
Animal structure and functioning	34.9%	20%	33.3%
Ecology	8.8%	28.9%	10%

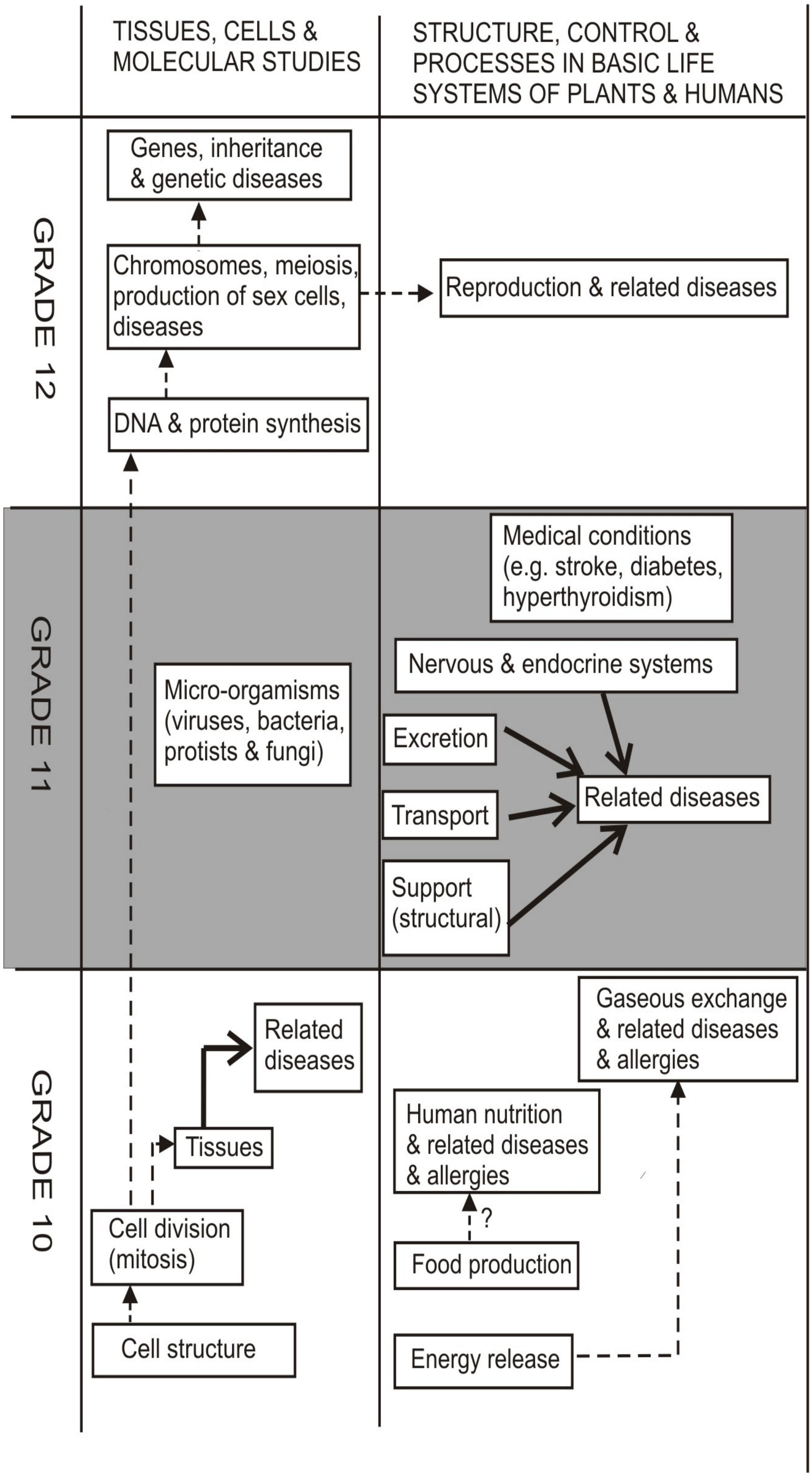
c) Is there clear conceptual progression towards these core concepts, and have relevant connections been drawn between them?

The conceptual progression maps for the three curricula are shown in Figure 3 a) – c) below.

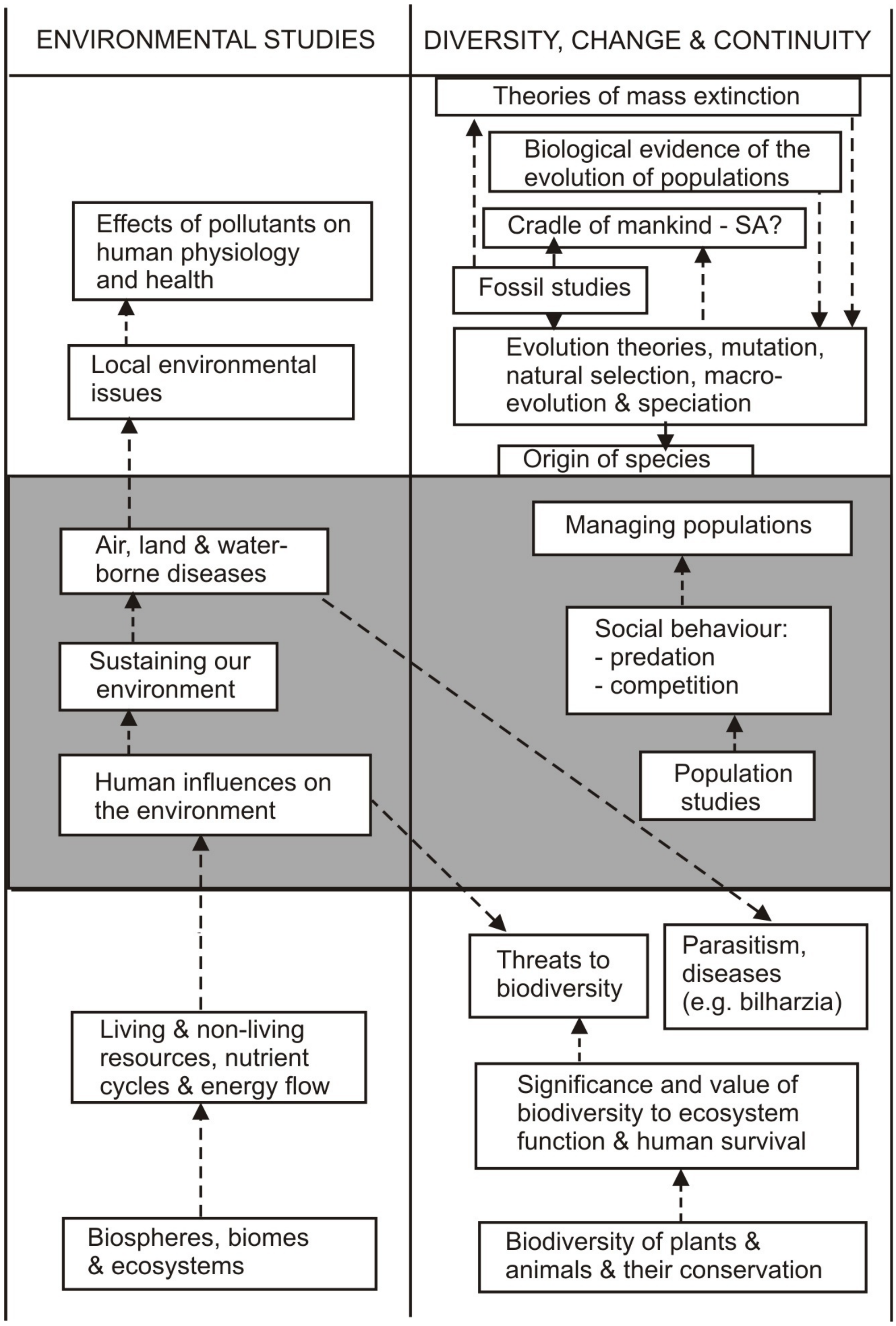
Figure 3: Conceptual progression maps of the knowledge content of three versions of the South African life sciences curriculum, 1996–2009.



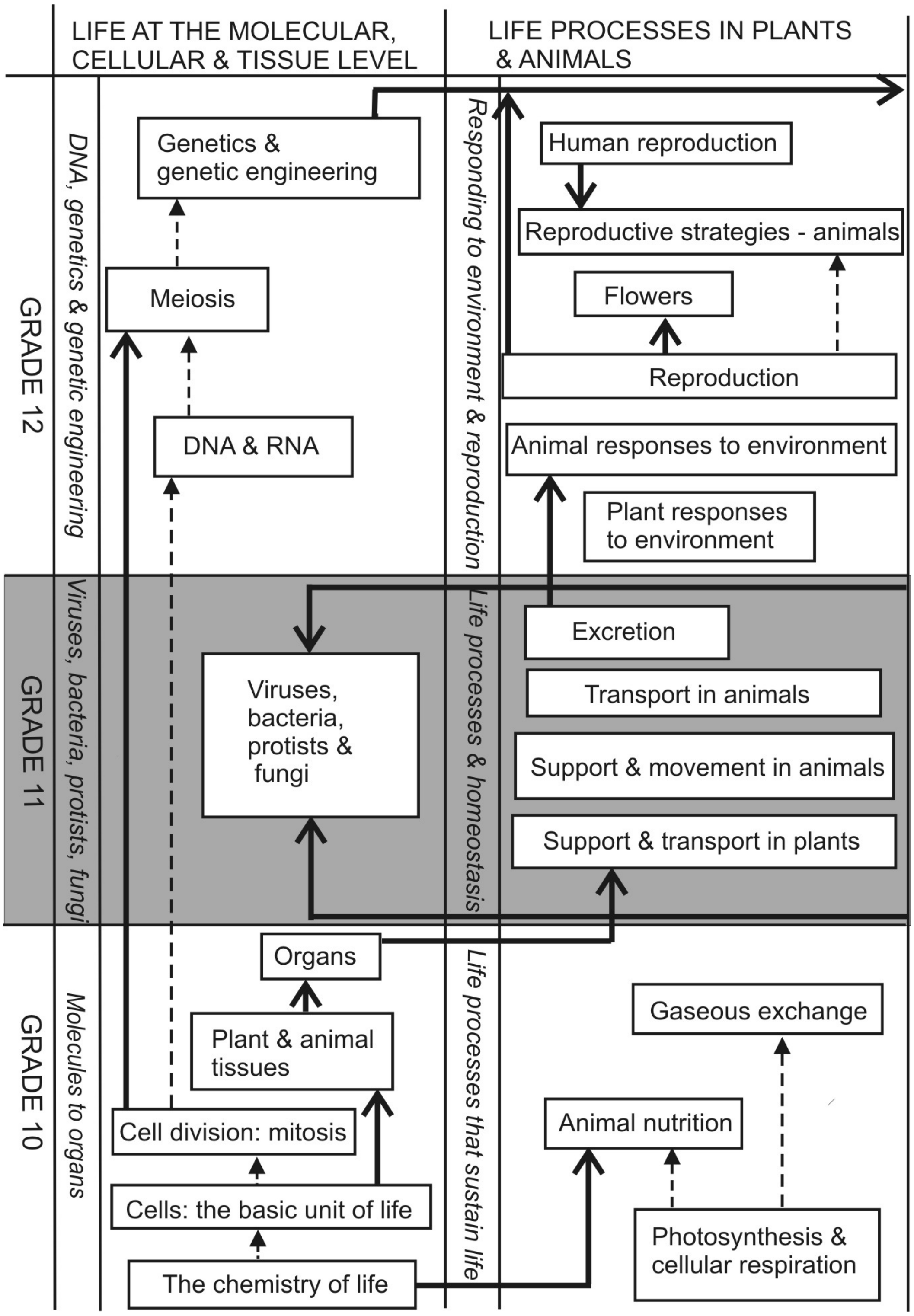
(a) The Interim Core Syllabus



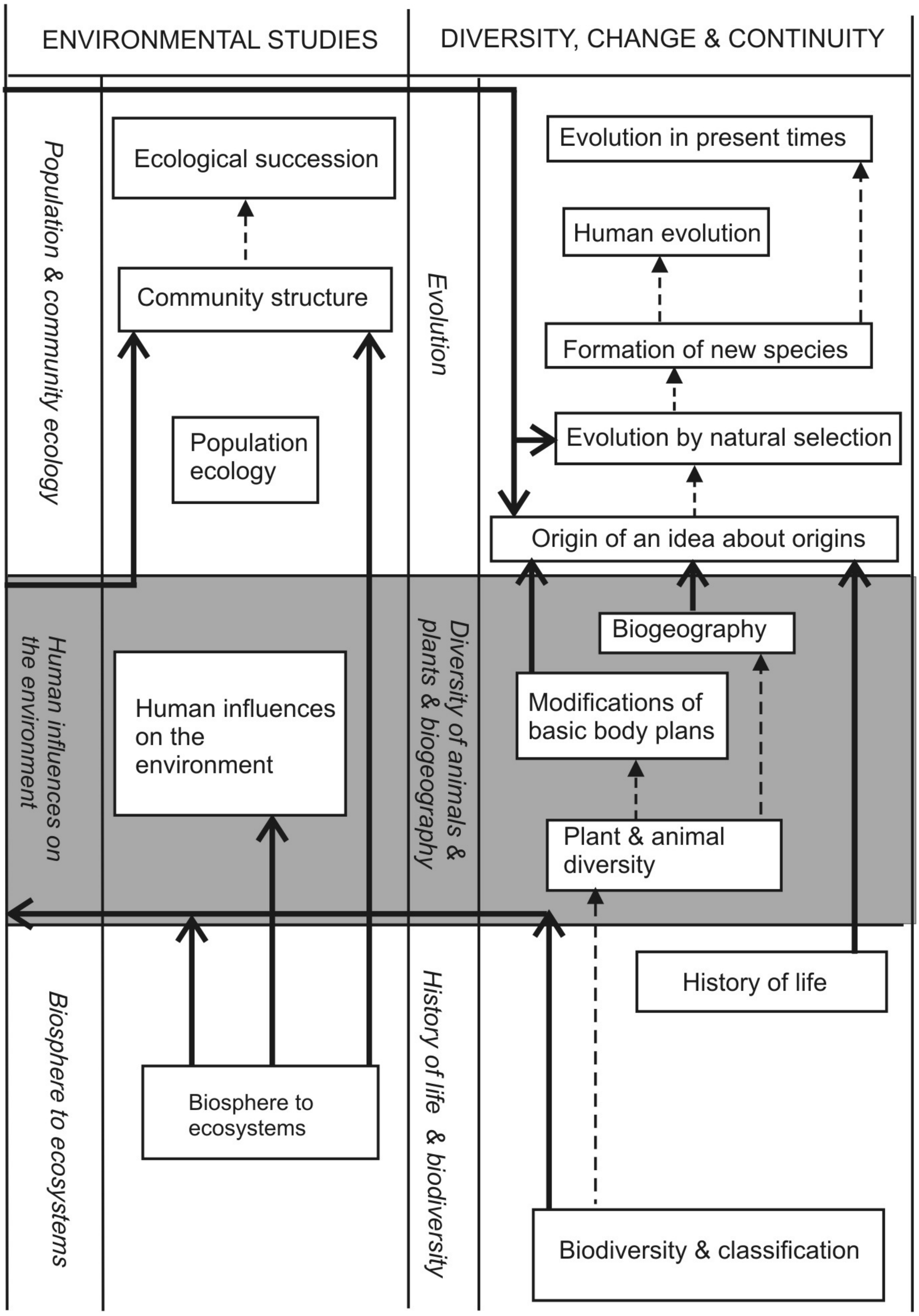
(b) The National Curriculum Statement



(b) The National Curriculum Statement (continued)



(c) The New Content Framework



(c) The New Content Framework (continued)

Discussion

In apartheid South Africa, the educational philosophy of 'fundamental pedagogics' (see Reagan, 1990) resulted in a highly traditional approach to science curricula, which prioritised canonical knowledge above application to everyday life. This approach persisted in the ICS, but was radically changed with the introduction of outcomes-based education as embodied in Curriculum 2005 and later in the NCS, as noted in comparative studies of the ICS and NCS for physical science (Green and Naidoo, 2006) and biology (Le Grange, 2008). While the purveyors of OBE obviously supported this shift, another school of researchers warned of the unintended negative consequences for disadvantaged learners of curricula which promote everyday experience above the careful conceptual development of the disciplinary content of subjects (e.g. Taylor, 2001; Muller, 2004; Dempster and Hugo, 2006). Our comparative analysis of the first three life sciences curricula implemented after 1994 aimed to determine whether there was an improvement in the way canonical biological knowledge had been recontextualised in the successive versions, and hence to assess which of the three had the greatest potential to induct South African learners into the specialised knowledge of the discipline of biology.

When we analysed the curriculum statements according to the categories 'canonical' and 'humanistic', we found quantitative support for Le Grange's (2008) observation that the highly traditional or 'science of life' approach of the ICS (96% canonical content) was replaced by a more humanistic or 'science of living' approach in the NCS (36.1% canonical content). The NCF, which was constructed after Le Grange's study, reverted to a more traditional approach, comprising 60.5% canonical statements (Table 3).

In analysing just the canonical content, we used our scheme of biology's core concepts, translating these into themes which were more applicable to all the curricula, and then measuring the proportional content of each. Mayr's 'big questions' served to reveal strengths and weaknesses in the balance of these themes in the different curricula. The ICS, in making no mention of evolution, clearly omitted any consideration of the 'why' aspects of biology, while the NCS was deficient in the 'what' of biology (diversity). The NCF, by contrast, incorporated the 'what' and the 'why' in more balanced proportions (Table 4).

Finally, we considered the coherence of the three curricula (Schmidt *et al.*, 2005) by mapping their canonical content, in order to reveal the degree of conceptual progression and connectedness of the material (Figure 3). While an initial reading of the ICS document suggested little or no sequencing, the map instead revealed a certain logicality in the structure of the syllabus, in that there is conceptual progression both within and between grades, and connections are either implied or stated directly.

The NCS appeared to have more structure in that the material was divided into Knowledge Areas. Mapping the content material revealed the opposite, however, in that conceptual hierarchies were hard to find, foundational concepts were seldom laid down, and nowhere were connections between topics explicitly drawn. This was particularly evident in the handling of evolution, biology's highest ordering concept, in that no foundational material was provided before Grade 12, nor was there any logical sequence to the list of topics specified. A further feature of the NCS was a tendency towards repetition rather than knowledge progression, particularly between the Knowledge Areas 'Environmental studies' and 'Diversity, change and continuity'.

The map of the NCF revealed that it showed the greatest coherence of the three curricula. Conceptual progression was the best developed; this is demonstrated most clearly in the theme 'Diversity, change and continuity'. As in the NCS, evolution was covered in Grade 12, but in this case the foundations were laid from Grade 10 – the fossil record (Grade 10), diversity (Grade 11), biogeography (Grade 11), descent with modification (Grade 11), and genetics (Grade 12) – and drawn together in Grade 12 as lines of evidence for the theory. The repetition evident in the NCS between the themes of 'Diversity, change and continuity' and 'Environmental studies' was avoided, and explicit connections between topics were frequently made throughout the syllabus, both within and between Knowledge Areas and grades.

The study reported here represents a response to the challenge implicit in Maton and Muller's (2007) statement that "Relations between knowledge structures and their corresponding curriculum structures is, in short, a key area for future exploration" (p.28). In Bernstein's conceptualisation of the pedagogic device, the school curriculum, representing the 'official recontextualising field', lies between the parent knowledge structure and the form in which it is reproduced in schools. Much has been written on the 'gap' or 'slippage' between curriculum policy and its realisation in schools (e.g. MacDonald, 2003; Morais, Neves and Pires, 2004). Studies on the relationship between academic knowledge and knowledge in the school curriculum are in relatively short supply, however (but see Deng, 2001; Bertram, 2008, and Luckett, 2009).

Such studies are important for a number of reasons. The argument that a school subject must reflect its parent discipline to a reasonable degree, if the role of schooling as a relay of specialised knowledges is to be upheld and if children are to be successfully inducted into the specialised knowledge of the discipline, has already been mentioned. Beyond that, Bernstein also emphasised that "every time a discourse moves, there is space for ideology to play" (Bernstein, 1996, p.24; see also Neves and Morais, 2001). Differences between a knowledge structure and its curricular version can reveal the ideologies being played out in the recontextualising process.

Yet while Bernstein provided both a language of description, and reasons for studying this relationship, he did not supply a methodology. Researchers are faced with the problems of firstly, how to present the particular knowledge structure, and secondly, how to hold up its curricular equivalent for comparison in a meaningful way. We suggest that the type of knowledge structure under consideration – horizontal or hierarchical – will inform the ways in which this is accomplished.

Regarding biology as an hierarchical knowledge structure generates at least three implications for the construction of a school biology curriculum: that the core concepts of the discipline should be incorporated, that there should clear progression towards those concepts, and that relevant connections should be drawn between concepts. We therefore initiated our study by attempting to delimit the core concepts of biology and their conceptual organisation (Figure 2).

In order to explore the 'space' between biology as a knowledge structure and as a curriculum structure, we then researched the goals of a western school science education as expressed in the literature. While we were able to elicit five broad categories of goals (see Table 2), the most heuristic terminology we found to describe the extremes of emphasis was Aikenhead's (2006) 'traditional [canonical]' versus 'humanistic' approaches. Over the years, the ideologies of various governments, agents of curriculum construction and stakeholders in the process have determined whether the resultant curricula have tended towards either one or the other approach. Aikenhead is of the opinion that a more humanistic approach has greater potential to promote student self-identity, achievement and even empowerment, particularly in those students whose cultures differ from that of western science, and thus serves the social equity imperative more faithfully. Aikenhead's views are not universally supported, however. Donnelly (2006), in particular, sounds a warning that a humanistic approach to science is typically an *ad hoc* approach which could, in fact, represent a crude instrumentalism, whereby science education serves the agendas of those in control of the curriculum rather than the needs of the learner as a growing human being.

Conclusion

Here we have presented the first study in which South African school biology curricula have been held up for comparison not only with each other, but also with the parent discipline of biology. Our study thus represents a test of the applicability of Bernstein's theoretical notion of knowledge recontextualisation to this particular context, and, in turn, of the methods we devised to perform such a test.

Beginning with the premise that there ought to be a reasonably close resemblance between parent discipline and curricular equivalent, we devised a schematic depiction of core contents and conceptual organisation in biology against which the curricula in question could be compared. We examined the space between the discipline and the curriculum from the viewpoint of the changing goals of school science, and found that characterising a curriculum as either more traditional or more humanistic gave an indication of the dominant prevailing ideology of the sociopolitical context, as well as the belief systems of the agents of and stakeholders in curriculum construction. Finally, by mapping the curricular content we were able to trace the development of key biological concepts, detect repetition of material, and note the degree of connectedness of topics. We believe that these techniques could prove useful in assessing future versions of the biology curricula, whether in South Africa or elsewhere.

On the basis of the results presented here, we believe our findings have provided evidence that there was indeed an improvement in the recontextualisation of biology as an hierarchical knowledge structure in the biology/life sciences curricula implemented in South Africa between 1996 and 2009. The NCF was the most faithful to the hierarchical structure of its parent discipline biology in terms of its inclusion and balance of biology's core concepts, conceptual progression and drawing conceptual connections between concepts, and achieved the most satisfactory balance of canonical and humanistic biology.

We believe therefore that it is regrettable that the NCF has since been revised to form the CAPS, before its implementation in South African schools has had a chance to be adequately studied. A preliminary reading of the CAPS for life sciences has revealed that, while much of the NCF was retained, some key topics have been excised, thus compromising the overall integrity of the document. In a subsequent study (in prep.), we use the same techniques to analyse CAPS for life sciences.

References

Aikenhead, G.S. 2006. *Science education for everyday life: evidence-based practice.* New York: Teachers College Press.

Atkin, J.M. and Black, P. 2003. *Inside science education reform. A history of curricular and policy change.* Buckingham, UK: Open University Press.

Bernstein, B. 1990. *The structuring of pedagogic discourse Volume IV: class, codes and control.* London and New York: Routledge.

Bernstein, B. 1996. *Pedagogy, symbolic control, and identity: theory, research, critique.* London: Taylor & Francis.

Bernstein, B. 1999. Vertical and horizontal discourse: an essay. *British Journal of Sociology of Education,* 20(2): pp.158–173.

Bertram, C. 2008. *Curriculum recontextualisation: a case study of the South African high school History curriculum.* PhD thesis. Pietermaritzburg: University of KwaZulu-Natal.

Bertram, C. 2009. Procedural and substantive knowledge: some implications of an outcomes-based history curriculum in South Africa. *Southern African Review of Education,* 15(1): pp.45–62.

BouJaoude, S. 2002. Balance of scientific literacy themes in science curricula: the case of Lebanon. *International Journal of Science Education,* 24(2): pp.139–156.

Branch, G. 2008. Interviewed by K. Johnson. University of Cape Town, 18 September.

Bybee, R.W. 1977. The new transformation of science education. *Science Education,* 61(1): pp.85–97.

Campbell, N.A. and Reece, J.B. 2005. *Biology*. 7th edition. San Francisco: Pearson Education Inc. (Benjamin Cummings).

Christie, P. 2008. *Opening the doors of learning.* Johannesburg: Heinemann.

Curriculum and Assessment Policy Statement. 2010. Government Gazette, 543(33528), 3 September. Pretoria: Government Printers.

DeBoer, G.E. 2000. Scientific literacy: another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching,* 37(6): pp.582–601.

Dempster, E.R., and Hugo, W. 2006. Introducing the concept of evolution into South African schools. *South African Journal of Science,* 102, pp.106–112.

Deng, Z. 2001. The distinction between key ideas in teaching school physics and key ideas in the discipline of physics. *Science Education,* 85, pp.263–278.

Department of Education. 1997. *Curriculum 2005: learning for the 21st century.* Pretoria: Government Printers.

Department of Education. 2003. *National Curriculum Statement Grades 10–12 (General): Life Sciences.* Pretoria: Department of Education.

Department of Education. 2007. *A new content framework for the Subject Life Sciences as listed in the National Curriculum Statements Grades 10–12 (GENERAL).* Circular 67/2007, 25 September. Johannesburg: Department of Education.

Doidge, M., Dempster, E., Crowe, A., and Naidoo, K. 2008. The *Life Sciences* content framework: a story of curriculum change. *Proceedings of the 4th Biennial Conference of the South African Association of Science and Technology Educators*, pp.14–19.

Donnelly, J. 2006. The intellectual positioning of science in the curriculum, and its relationship to reform. *Journal of Curriculum Studies,* 38(6): pp.623–640.

Durkheim, E. 1915 [1976]. *The elementary forms of the religious life.* London: George Allen & Unwin.

Fensham, P. 2000. Providing suitable content in the 'science for all' curriculum. In Millar, R., Leach, J. and Osborne, J. (Eds), *Improving science education: the contributions of research.* Buckingham: Open University Press. pp.147–164.

Fraenkel, J.R. 1993. *How to design and evaluate research in education.* 2nd edition. New York: McGraw-Hill.

Goodson, I. 1983. *School subjects and curriculum change: case studies in curriculum history.* London: Croom Helm.

Goodson, I. and Dowbiggin, I. 1993. Curriculum history, professionalisation and the social organization of knowledge: an extended paradigm for the history of education. In Taylor, N. (Ed.), *Inventing knowledge: contests in curriculum construction.* Cape Town: Maskew Millar Longman, pp.143–158.

Green, W. and Naidoo, D. 2006. Knowledge contents reflected in post-apartheid South African Physical Science curriculum documents. *African Journal of Research in SMT Education,* 10(1): pp.71–80.

Harder, L. 2009. Interviewed by K. Johnson. Email correspondence, 18 March. Transcript held by K. Johnson.

Jansen, J. 1999. The school curriculum since apartheid: intersections of politics and policy in the South African transition. *Journal of Curriculum Studies,* 31(1): pp.57–67.

Johnson, K. 2009. Biology and its recontextualisation in the school curriculum: a comparative analysis of post-apartheid South African life sciences curricula. MEd thesis. Pietermaritzburg: University of KwaZulu-Natal.

KwaZulu-Natal Department of Education and Culture (n.d.). *Interim Core Syllabus and Provincialised Guide for Biology Grades 10–12 Higher Grade and Standard Grade.*

Le Grange, L. 2008. The history of biology as a school subject and developments in the subject in contemporary South Africa. *Southern African Review of Education,* 14(3): pp.89–105.

Luckett, K. 2009. The relationship between knowledge structure and curriculum: a case study in sociology. *Studies in Higher Education*, 34(4): pp.441–453.

MacDonald, D. 2003. Curriculum change and the post-modern world: is the school curriculum-reform movement an anachronism? *Journal of Curriculum Studies,* 35(2): pp.139–149.

Martin, J.R. 2007. Construing knowledge: a functional linguistic perspective. In Christie, F. and Martin, J.R. (Eds). *Language, knowledge and pedagogy: functional linguistic and sociological perspectives.* London: Continuum. pp.34–64.

Maton, K. and Muller, J. 2007. A sociology for the transmission of knowledges. In Christie, F. and Martin, J.R. (Eds), *Language, knowledge and pedagogy: functional linguistic and sociological perspectives.* London: Continuum, pp.14–33.

Mayr, E. 1982. *The growth of biological thought: diversity, evolution and inheritance.* Cambridge: Belknap Press.

Mayr, E. 1988. *Towards a new philosophy of biology: observations of an evolutionist.* Cambridge: Harvard University Press.

Mayr, E. 1991. *One long argument: Charles Darwin and the genesis of modern evolutionary thought.* Cambridge: Harvard University Press.

Mayr, E. 1997. *This is biology: the science of the living world.* Cambridge: The Belknap Press of Harvard University Press.

Mayr, E. 2005. Walter Arndt Lecture: *The Autonomy of Biology*. <www.biologie.uni-hamburg.de/b-online/e01_2/ autonomy.htm>. 13 January.

Morais, A., Neves, I. and Pires, D. 2004. The *what* and the *how* of teaching and learning: going deeper into sociological analysis and intervention. In Muller, J., Davies, B. and Morais, A. (Eds), *Reading Bernstein, researching Bernstein.* London: RoutledgeFalmer. pp.75–90.

Muller, J. 2004. Differentiation and progression in the FETC. Mimeo.

Muller, J. 2007. On splitting hairs: hierarchy, knowledge and the school curriculum. In Christie, F. and Martin, J.R. (Eds), *Language, knowledge and pedagogy: functional linguistic and sociological perspectives.* London: Continuum, pp.65–86.

National Centre for Education Statistics (NCES). 2006. *Highlights from the TIMSS 1999 video study of eighth-grade science teaching.* U.S. Department of Education: Institute of Education Sciences.

Neves, I. and Morais, A. 2001. Knowledge and values in science syllabuses: a sociological study of educational reforms. *British Journal of Sociology of Education,* 22(4): pp.531–556.

O'Halloran, K. 2007. Mathematical and scientific forms of knowledge: a systemic functional multimodal grammatical approach. In Christie, F. and Martin, J.R. (Eds), *Language, knowledge and pedagogy: functional linguistic and sociological perspectives.* London: Continuum, pp.205–236.

Ogden, W.R. and Jackson, J.J. 1978. Secondary school Biology teaching, 1918–1972: objectives as stated in periodical literature. *Science Education,* 62(3): pp.291–302.

Project 2061. 2006. <http:// www.project2061.org> 5 September.

Reagan, T. 1990. Philosophy of education in the service of apartheid: the role of 'Fundamental Pedagogics' in South African Education. *Educational Foundations*, 4(2): pp.59–71.

Roberts, D.A. 1982. Developing the concept of 'curriculum emphases' in science education. *Science Education,* 66(2): pp.243–260.

Roberts, D.A. 1988. What counts as science education? In Fensham, P.J. (Ed.), *Developments and dilemmas in science education.* London: The Falmer Press, pp.27–54.

Rosenthal, D.B., and Bybee, R.W. 1987. Emergence of the biology curriculum: a science of life or a science of living? In Popkewitz, T.S. (Ed.), *The formation of school subjects. The struggle for creating an American institution.* New York: The Falmer Press, pp.123–144.

Schmidt, W.H., Wang, H.C. and McKnight, C.C. 2005. Curriculum coherence: an examination of US mathematics and science content standards from an international perspective. *Journal of Curriculum Studies,* 37(5): pp.525–559.

Singh, P. 2002. Pedagogising knowledge: Bernstein’s theory of the pedagogic device. *British Journal of the Sociology of Education,* 23(4): pp.571–582.

Starr, C. and Taggart, R. 2001. *Biology: the unity and diversity of life.* 9th edition. Pacific Grove: Thomson Learning, Inc. (Brooks/Cole).

Taylor, N. 2001. *‘Anything but knowledge’: the case of the undisciplined curriculum.* Paper presented at the Curriculum Dialogue Seminar: What counts as worthwhile knowledge for the 21st century South African citizen? GICD, Johannesburg. 14 February.

Zembylas, M. 2005. Science education: for citizenship and/or for social justice? *Journal of Curriculum Studies,* 37(6): pp.709–722.

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