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# Differences in Curriculum Structure between High School and University Biology: The Implications for Epistemological Access

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Despite doing well in biology at high school, some students struggle with the same subject at university level. This can have implications for epistemological access - access to knowledge that allows students to remain at university. Therefore, it is important to identify factors that may be causing this problem. We propose that one such factor may be differences in the structure of knowledge between the two levels. Therefore, this paper will assess some of the differences in the structuring of knowledge that exist between a high school and a university biology curriculum. To do this, a section of a high school and a university textbook which cover the same topic will be analysed using one aspect of Legitimation Code Theory called Semantics. Our findings suggest that there is a mismatch between the semantic range students are expected to navigate at university and that demanded by high school biology, and that this may pose a stumbling block to students gaining epistemological access to first-year study at university. If this is indeed the case, then pedagogic interventions which explicitly address this may contribute to improving undergraduate student retention and throughput rates at university.

Keywords: *Biology; Legitimation Code Theory; Epistemological access; Semantics; Education*

Biology is a basic science which focuses on the study of living things. In South Africa, as in many countries, it is taught at both high school (Life Sciences) and university level. From a university perspective, students should learn biology at high school in a way that benefits them in further studies in biology. However, despite being top students in their biology class at high school, many first-year biology students, especially those from

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previously disadvantaged backgrounds, struggle with the demands of first-year university biology. Based on their top marks in matric [a term for the final year of high school]: these students are given ‘formal access’ to the university but not necessarily ‘epistemological access’- access to knowledge (Morrow 2009). This access to knowledge is critical to success at University and without it students are likely to be excluded. This has implications for student retention, graduation rates and throughput. This fact is highlighted by data published by Scott, Yeld, and Hendry (2007); of the first-time students who entered South African Universities in 2000, only 38% of them graduated within 5 years. At the end of this 5-year period, only 17% were still registered and 45% left without graduating. The figures are even worse when focused on students from previously disadvantaged backgrounds. It is important to properly diagnose this problem in order to effectively intervene in mediating the transition from high school to university biology.

Several factors have been implicated in this lack of epistemological access, for example, language, academic literacy, quantitative literacy (numeracy) and learning/study skills. Despite interventions in these areas, there are still many students who are obtaining formal access but not epistemological access. Several programmes which focus on increasing the success of students from previously disadvantaged backgrounds at university have already been introduced at universities throughout South Africa (Alexander, Badenhorst, and Gibbs 2005, 66–70; Downs 2005, 666–683; Van Schalkwyk 2007, 954–968). Such programmes and indeed many mainstream programmes have incorporated interventions that address not just generic skills, but what Fang and Coatoam (2013) refer to as disciplinary literacy. Examples of these in the biological sciences would include; interventions in quantitative literacy/numeracy (Speth et al. 2010; Frith 2012) and academic literacy (Monroe 2006; Humphrey and Hao 2013; Clarke 2015; Kelly-Laubscher and Van der Merwe 2015). Although these types of interventions are of great importance, Muller (2012, 7) warns that a focus on academic practices ‘all too easily “black boxes” the knowledge of which the practices are an expression’. Therefore, it may be that the emphasis of these interventions on the social practices entailed in knowing (which is of course important) ignores interrogation of the organising principles of the knowledge form. Biology students often comment that some of the topics they do in first year are the same as they did in high school, and so they switch off. Although some of the topics are indeed the same, We would suggest that the organising principles of the knowledge within the topics is not the same, and that an inability to identify and navigate these differences may pose a serious stumbling block for some students. Therefore, this paper will describe a language of description that can be used to assess the structure of knowledge in biology curricula. It will also present an example of how this language of description can be used to compare the knowledge structure of two curricula. To do this, a comparable section of a high school and a university textbook which cover the same topic will be analysed using Maton’s concepts of semantic gravity (SG) and semantic density (SD) (Maton 2011, 62–84).

## Theoretical Background

Maton’s concepts of SG and SD form part of his Legitimation Code Theory (LCT). LCT builds on the work of Pierre Bordieu and Basil Bernstein and through doing so provides a range of concepts and tools for analysing the constitutive principles that underpin knowledge structures/practices (Maton 2013b). Of particular interest for us is the manner in which this theory extends and integrates Bernstein's (1990) concepts of hierarchical and horizontal knowledge structures. In Bernstein's terms, a horizontal knowledge structure 'takes the form of a series of specialised languages with specialised modes of interrogation, specialised criteria for the production and circulation of texts', e.g. Humanities or Social Sciences (Bernstein 1999, 161). In this type of knowledge structure, there is little integration, but rather a series of 'languages' or theories which run alongside each other as competing segments; for example, in sociology, these languages could be Marxism, poststructuralism, postmodernism, etc. By contrast, Bernstein describes hierarchical knowledge structures as being 'coherent, explicit and systematically principled structures', for e.g. physics or biology. Hierarchical knowledge structures are organised with successive integration of lower levels of knowledge into overarching theories. According to Bernstein (1999), 'Hierarchical knowledge structures appear by their users to be motivated towards greater and greater integrating propositions, operating at more and more abstract levels'. (161)

Biology, as a discipline, at both high school and university level, has a hierarchical knowledge structure. Although Bernstein's conceptualisation of knowledge structures allows differentiation of hierarchical and horizontal knowledge structures, it does not allow for differentiation within hierarchical knowledge structures. By providing a set of conceptual tools to uncover the underlying principles of knowledge structures, Maton's LCT provides a topology of knowledge structure rather than a dichotomy/typology such as horizontal and hierarchical structures. This study will focus on curriculum structure using one dimension of LCT called Semantics. LCT Semantics addresses the 'context dependence and condensation of meaning' (Maton 2015, 4) and its main concepts, SD and SG, can be used to describe the structure of knowledge in terms of its organisation of meanings and their relations to contexts, respectively. SD is defined as 'the degree to which meaning is condensed within symbols (a term, concept, phrase, expression, gesture, etc.), where semantic density is stronger (SD+), the symbol has more meaning condensed within it; where the semantic density is weaker (SD−), the symbol condenses less meaning'.(Maton 2011, 66). SG is defined as 'the degree to which meaning is dependent on its context. SG may be relatively stronger (+) or weaker (−). When SG is stronger (SG+) meaning is more closely related to its context; when weaker, meaning is less dependent on its context'. (Maton 2011, 65).

All knowledge structures are composed of both SG and SD and they may strengthen and weaken independently of each other to produce semantic codes (SG+/−, SD+/−). These codes may be present in different combinations producing four possible modalities; rhizomatic codes (SG−, SD+), prosaic codes (SG+, SD−), worldly codes (SG+, SD+) and rarefied codes (SG−, SD−). These modalities represent what is valued as legitimate practice. For example, if a biology curriculum had a rhizomatic code this would entail that context-independent abstract ideas were valued, whereas if it had a prosaic code then more context-dependent knowledge with simpler meanings would be valued, a rarefied code would entail that knowledge with relatively context-independent, but also relatively simple meanings was valued, and worldly codes would demonstrate that context-dependent knowledge that condenses manifold meanings was valued. These modalities and their relationship to SD and SG can be seen in Figure 1 (Maton 2015).

By analysing the SG and SD of a text or practice over time, a 'semantic profile' can be determined (Maton 2013b, 8–22). These semantic profiles can take different forms. In a situation where knowledge is consistently embedded in its context and symbols condense little meaning (SG+, SD−), the profile is likely to be a low SG flat line. If there is a successive strengthening and weakening of SG and SD, the profile may take the form of a semantic wave. These semantic waves can have different ranges (distance from top to bottom) and patterns.

### *The Field of Recontextualisation*

The mechanisms by which society distributes, pedagogises and acquires knowledge can be described by a conceptual device called the pedagogic device (Bernstein 1999). It deals with three fields of practice; the field of production, where knowledge is created (e.g. laboratories); the field of recontextualisation, where knowledge from the field of production is recontextualised to form a pedagogic discourse (e.g. curriculum); and the field of reproduction, where the knowledge is taught and learnt (e.g. pedagogic practice). Since this study focuses on curriculum, we will focus here on the field of recontextualisation.

### *How Might the Semantic Structure of the Curriculum Affect Learning?*

Maton (2013a) described two types of learning; 'segmental learning', where 'students learn a series of ideas or skills that are strongly tied to their contexts of acquisition, problematizing transfer and knowledge building', and 'cumulative learning', where 'new knowledge builds on and integrates past knowledge …' (Maton 2013a, 106–124).

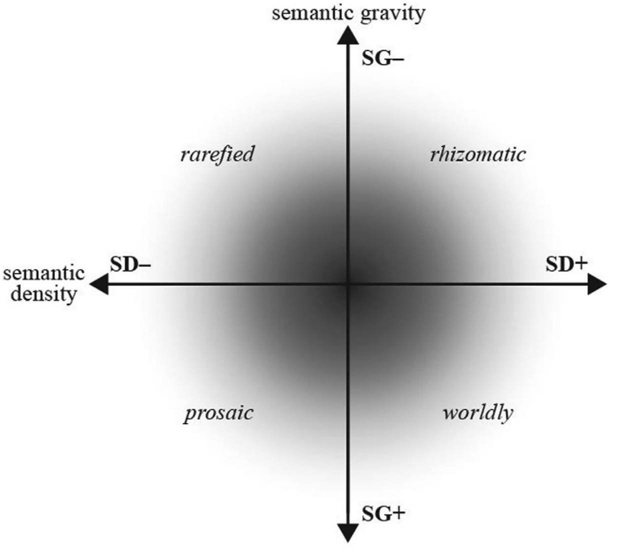


Figure 1. The semantic plane
Source: Reproduced with permission from Maton (2015, Figure 1.3).

According to Maton (2013a), cumulative learning requires not only being able to deal with abstracted symbolic forms (low semantic gravity, SG−), but also being able to apply these forms to many different contexts (SG++). Cumulative learning tends to develop where students can work with a large 'semantic range' and thus form conceptual relations between theory and empirical data (Maton 2013b, 8–22). However, students do not all have the same 'semantic range'. For some, they understand topics within the pedagogic context but cannot transfer theory to situations beyond this context. This is characteristic of 'segmental learning' and a SG flatline.

Maton (2013b, 20) tells us that 'not everyone is equally capable of enacting the semantic shifts required for achievement'. He suggests that students' backgrounds may affect their ability to recognise and navigate such semantic waves within teaching and their own writings. Drawing on the work of Bordieu and Bernstein, Maton suggests that 'orientations to meaning that weaken and enable greater semantic range of SG are more associated with the socialisation practices of cultural middle-class families than those of working class families' (Maton 2013a). Thus, if semantic waves are in fact a key to cumulative learning (Maton 2013b, 8–22), then students from disadvantaged backgrounds may struggle to recognise the type of semantic waves valued within biology curricula and thus battle to succeed. Although the focus of this paper is the curriculum (the field of recontextualisation) and not teaching or student learning (the field of reproduction), we think that delineation of the differences in the structure of biology knowledge in the curriculum at high school and university level might form a stepping stone towards the development of explicit teaching interventions which would facilitate cumulative learning.

### *The Semantic Structure of Knowledge in Biology*

Part of the 'Disciplinary, Knowledge, and schooling' (DISKs) project, which focused on analysis of semantic structure in pedagogic practice at a high school level, investigated the semantic structure of biology knowledge in the field of reproduction. Within this project, Macnaught et al. (2013) examined the semantic structure of biology knowledge in student texts. They found that the text that scored higher marks had a greater semantic range. In another paper based on this project, Maton (2013b) found that even when a large semantic range is modelled in pedagogic practice, not all students are capable of navigating the semantic profiles required for success. Although these studies shed light on the semantic structure of biology at a high school level, they focus on the structure of knowledge in the field of reproduction. The current paper will focus not only on the structure of biology knowledge in the field of recontextualisation, but also on the differences in the structure of the curricula at high school and university.

### *Development of an External Language of Description*

An external language of description (L2) is a tool for relating an internal language of description (such as theory) to the empirical world (Bernstein 1996, 131–141). For this paper, the L2 was be developed to relate Maton's concepts of SG and SD (Maton 2011, 62–84) to the empirical world, which in this case was two curriculum texts. According to

Moore and Muller (2002, 627–637) '… every investigation requires the construction of an external language of description that consists of empirical categories that can unambiguously be translated into the conceptual categories of the internal language'. Before we could describe those 'empirical categories', we first needed to describe the general context of biology and the general knowledge relations within biology. From these descriptions, we devised 'empirical categories' that could be used to categorise the data and relate it to the conceptual tools–SG and SD, respectively.

SG refers to the extent to which meaning relates to context. Biology is no longer simply referred to as biology at many levels. It is made up of many subdisciplines, each with their own knowledge, values and cultures, e.g. Physiology, Zoology, Botany, Microbiology, etc. There are overarching principles that are common to all, but the context for students from each of these subdisciplines can be very diverse. However, there is one context that is common across all of them and that is the research experiment, whether it is carried out in a lab, in the field or at the bottom of the sea. Therefore, for the purposes of this analysis, stronger semantic gravity (SG+) is conceptualised as something embedded in the context of a specific experiment. Weakening of the semantic gravity (SG↓) would happen via the extraction of more theoretical/abstract principles demonstrated by the results of the experiment, so that the knowledge can now be applied to other similar situations. Further weakening of semantic gravity (SG↓↓) would be via the integration of this knowledge with existing knowledge from similar situations to form a generalisation of the principle for more general use, i.e. the knowledge is now applicable to a wide range of contexts. Finally, the integration of the new theory with other existing theories from other contexts will form a unifying theory which will be applicable in any context. The L2 for SG that will be used in this study is presented in Table 1.

SD relates to the condensation of knowledge. Figure 2 shows how we perceive the condensation of knowledge within biology. Generally, there will be a level of structures, location, etc. These ideas can interact at a basic level to produce general effects. These basic interactions can be further explained in terms of how they interact. Finally each process can interact with other processes to form more integrated effects. Each of these steps integrates the knowledge acquired in the previous step, thus strengthening SD, e.g. the structure and location of the mitochondria, how the parts of the mitochondria interact with each other to carry out cellular metabolism, how the process of cellular metabolism is regulated through the integration of many processes, how this function relates to other parts of the cell.

The L2 for SD that was used in this study is presented in Table 2. Using the above described L2 for SG and SD, we analysed the semantic structure of a comparable section of a high school and university biology textbook.

## Methods of Analysis

Since this type of analysis is quite novel in biology, we decided to focus on sections from two textbooks only, in the hopes that if the analysis was successful, it could be used on a wider scale by other biologists. Two curriculum texts, a section of a high school biology textbook (Preethlall et al., 2010) and a section of a first-year Bachelor of Science biology textbook (Reece 2011), were selected for analysis. These texts were selected

Table 1. External language of description for analysing the semantic gravity of knowledge in biology

| External language of description for analysing types of knowledge in biology textbooks: semantic gravity | | |
|---|---|---|
| Strengths of semantic gravity | Description | Example |
| SG−− | Unifying principles: principles that unite 2 or more theories | 'Sex linked genes exhibit a unique pattern of inheritance.' This incorporates the knowledge below but also principles regarding normal patterns of inheritance |
| SG− | Generalising principles | Males have different sex chromosomes to females |
| SG+ | Context embedded | An experiment and its results are presented in the text OR specific examples context specific examples are given |
| SG++ | Deeply context embedded | Student is asked to carry out an experiment themselves that produces results |

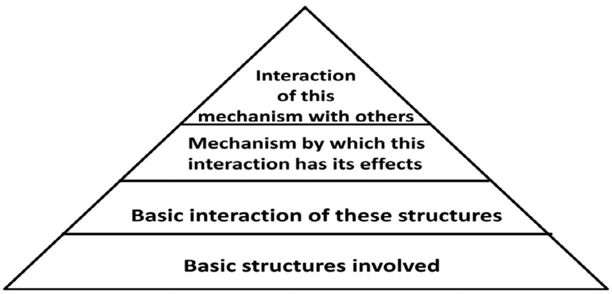


Figure 2. Condensation of knowledge in biology

based on their wide usage; the University textbook is currently in its 10th edition and is used worldwide while the high school textbook is one of the most popular Grade 12 textbooks for the South African syllabus and was in its second edition at the time of the paper. The sections analysed in these textbooks cover comparable content, more specifically they focus on sex determination and sex-linked genes. These topics were chosen specifically because of the overlap of content within these textbooks. Using these texts as samples of the high school and university curricula, respectively, their semantic profiles were determined/analysed by applying the L2 as described above.

Only text was analysed, i.e. figures, activities, etc. were excluded from the analysis. While we feel that the analysis of figures and activities is important, we felt that a different L2 may have been more appropriate for their analysis. Therefore, the current paper focuses on the analysis of text only. Each paragraph was coded separately according to its SG and SD. Many studies using semantic profiles use a 'semantic scale' that combines SG and SD. However, in the current study, this would not have revealed the true profile of each of the components. Thus, the SG and SD profiles were analysed separately.

Table 2. External language of description for analysing the semantic density of knowledge in biology

| External language of description for analysing the semantic profile of knowledge in biology textbooks: semantic density | | |
|---|---|---|
| Strengths of semantic density | Description | Example |
| SD++ | Interaction of this mechanism with others | This mechanism by itself would not determine the sex of a person. Other mechanisms and structures are required to make the protein encoded by the DNA at SRY |
| SD+ | Mechanism by which this interaction has its effects | How this interaction causes a child to be male or female, i.e. the presence of the sex determining region of Y (SRY) causes the development of testes and other male characteristics. The absence of the protein that SRY codes for causes the child to be female |
| SD− | Basic interaction of these structures | Interaction of sex chromosomes from each parent to form either a male or female genotype |
| SD−− | Basic structures involved | Sex chromosomes |

The relative strength SD and gravity depend on the semantic structure within which they are situated. It also depends on the point of view from which you view the text, for e.g. an idea that has relatively weak SD for a novice or outsider to the semantic structure (biology in this case) may have relatively strong SD for a full-fledged biologist. For a student reading the title, ‘The chromosomal basis of sex’, (Reece 2011) they may think that what is written in the text following it is all there is to know about the role of chromosomes in sex determination; however, for an experienced scientist, the title would be much more semantically dense because they would know what is contained in the text and bring to bear on the meanings everything else they have ever learnt about the role of chromosomes in sex determination. Therefore, in this study, we assumed that learners who would be exposed to both curricula do not have a background in the subject. Therefore, if a semantically dense symbol is not elaborated on within the text, it will not be coded semantically dense for these students, as the meaning is not developed. This meant that paragraphs that included knowledge with stronger semantic density (SD+) always tended to include knowledge with weaker semantic density (SD−), but not vice versa. Therefore, each paragraph was scored according to the strongest SD.

## Results

### *High School Textbook: Study & Master (Preethlall et al. 2010, 51, 71–73)*

In a unit focused on Chromosomes, Meiosis and Associated Diseases, the preceding paragraphs in this chapter of the high school textbook outline Mendelian inheritance. The first paragraph analysed focused on sex-linked alleles and begins with the statement of the general principle, i.e. ‘Sex linked inheritance is determined by genes located on sex chromosomes’. Therefore, the paragraph begins with a relatively low semantic gravity (SG−) and high semantic density (SD+). From there, it elaborates on this principle with regard

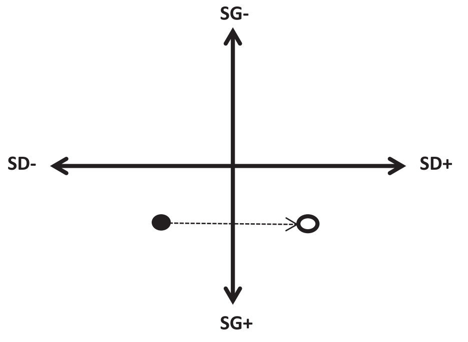


Figure 3. Average semantic gravity and semantic density plotted on a Cartesian plane
Notes: This picture shows the average semantic gravity and semantic density for the high school textbook (●, SG+, SD−) and the university textbook (○,SG+, SD+) plotted on a Cartesian plane.

to humans specifically. The second and third paragraphs (SG+) are continuations of this. The next paragraphs with content corresponding to the University textbook were located in a unit focused on Genetics and Genetic screening. These paragraphs (Paragraphs 4, 5, and 6) provide specific examples of traits controlled by X-linked alleles and therefore have a relatively strong semantic gravity (SG+). The gap in the data (Figure 4) for the high school textbook highlights the fact that the section on sex determination was not in the same chapter as the section on sex-linked genes.

Overall, in the high school textbook, the average SG was found to be relatively strong, while the average semantic density was relatively weak (SG+, SD−). The semantic code for the high school curriculum can be seen plotted on a Cartesian plane (Figure 3) and represents a prosaic modality. The semantic profile of the high school textbook (Figure 4) demonstrates a relatively weak semantic flatline for SG with a further weakening of SG at the end of the section. It also demonstrates a large range of SD; however, this range is exhibited only once in the profile.

### *University Textbook (Reece 2011, 334–337)*

Following on from a chapter on the Mendelian principles of genetics, the section under investigation formed part of a chapter focused on the chromosomal basis of inheritance. After linking Mendelian inheritance with chromosomal behaviour, the section begins with a description of an experiment using fruit flies to investigate inheritance of genetic traits. This experiment was carried out in the early twentieth century by Thomas Hunt Morgan. The experiment and its results demonstrate the principles of sex-linked recessive traits as applied to fruit fly eye colour (Reece 2011).

In the first paragraph analysed, Morgan's experimental protocol and results are outlined. This would be an example of relatively strong semantic gravity (SG++), since it describes a specific experiment that occurred at a specific time. However, in the description of the investigators reasoning for coming to the conclusion that he did based on the results–there is a weakening of semantic gravity (SG↑).

The human X-Y system is provided as an example of a system of sex determination. One line alludes to the fact that the X-Y system is not the only system of sex determination. ‘Note that the mammalian X-Y system is not the only chromosomal system for determining sex’. (Reece 2011)

This is an example of relatively strong semantic gravity (SG+) because the principles are only expressed in context. The general principle that sex is usually determined by chromosomes (there are exceptions) is only ever stated in the title of this section. The title would be an example of weaker SG and stronger SD in this text (SG−/SD+).

The explanation of the pattern of inheritance throughout this text is described in the context of the human X-Y system (Reece 2011). Using the human context to describe these concepts, without abstracting the underlying principles means that much of what is written would not be directly applicable to all cases. One may make the jump and assume that the ZW system of sex determination, found in chickens and some other birds, works similarly to the human X-Y system. However, there are many major differences at both the basic interactional level and the interaction with other processes within the organism.

Overall in the university text, the average SG was found to be relatively strong and the SD was relatively strong (SG+, SD+), with only two generalising statements being explicitly stated (see Table 1). The semantic code for the university curriculum can be seen plotted on a Cartesian plane (Figure 3) and represents a worldly modality. The semantic profile of the university textbook (Figure 5) demonstrates a relatively large semantic range for SG followed by a semantic flatline similar to that seen in the high school textbook. It also demonstrates a large range of SD which is repeated throughout the profile.

## Discussion

The major differences found between the university and high school curriculum knowledge structures were a stronger SD and a greater semantic range for SG in the university curriculum compared to the high school curriculum. The analysis shows that the semantic code of the high school textbook and the university textbook are located in different quadrants (Figure 3) with the high school curriculum exhibiting a more prosaic modality and the university curriculum exhibiting a more worldly modality. This suggests that the type of knowledge valued within these two curricula is different in terms of the degree of condensation of knowledge valued (Figure 3). However, the averaging of the SG in the semantic plane does not convey the greater semantic range in the university textbook compared to the high school textbook for SG (Figures 4 and 5). Focusing on the profile of the SG for the university textbook (Figure 5), it can be seen that the SG is most dynamic and has a greater range at the beginning of the text and this corresponds to a section describing a specific experiment. This type of section occurs at the beginning of most chapters of this university textbook and represents historical accounts of pivotal experiments in the history of biology. When we look at the high school textbook, it can be seen that this is absent from the section analysed, possibly due to the fact that at a high school level, demonstration of procedural and methodological knowledge specific to science is considered less important than knowledge that can be applied to everyday life.

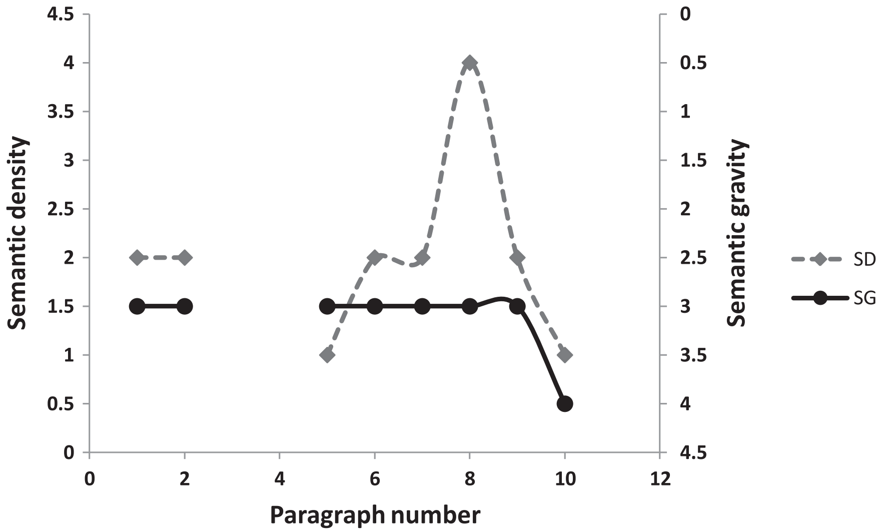


Figure 4. Semantic profile for the high school textbook
Notes: Semantic density (grey) strengthens progressively and then weakens again. This happens only once. Semantic gravity (black) remains constant throughout most of the text.

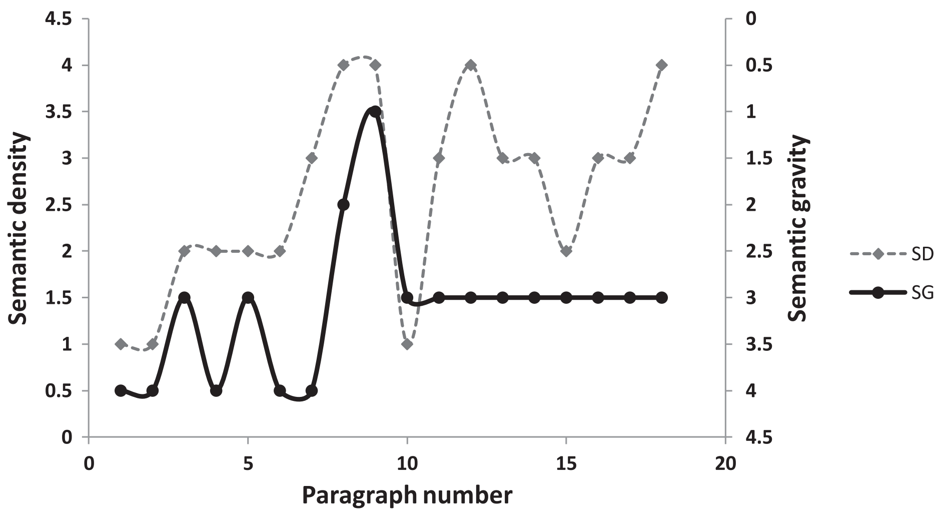


Figure 5. Semantic profile of the university textbook
Notes: Semantic density (grey) strengthens and weakens throughout the text. Semantic gravity (black) changes during the first half of the text but from paragraph 10 remains constant.

This greater semantic range may suggest that for this section of the curriculum, the semantic range which students have to navigate at university is different to that which they may be exposed to in high school. The semantic range for SD is similar for both textbooks, however, in the high school textbook this range is only seen once, whereas in the University textbook it is repeated three times (Figures 4 and 5), which may reflect a greater appreciation in the university course for the application of generalising principles in different contexts. It may also be reflective of the larger volumes of information that students are expected to learn at university level.The implications of these preliminary findings for curriculum design that facilitates epistemological access is taken up in the discussion which follows.

Although what is contained in curriculum texts is not exactly what is taught by teachers and learnt by students, the knowledge taught must bear some resemblance to its 'parent knowledge' or education would fail in '… its role as a relay of specialised knowledge'. (Maton and Muller 2007, 28), i.e. fail to provide epistemological access. Therefore, one could speculate on the possible effects of the differences in these curriculum structures for learning. The increase in SD and range of SG in this university curriculum compared to the high school curriculum may pose problems for the students who were never exposed to this degree of semantic range at high school. Finding ways of increasing access to a greater semantic range for all students at high school may increase their potential for cumulative learning (Maton 2013b, 8–22). We would suggest that one way of increasing the semantic range could be by modelling it in pedagogy–i.e. in the case of the differences in curriculum structure identified for these courses, by explicitly building relations between abstract or general theory (SG−) and empirical experiments and examples (SG++). The SG flatline in the high school curriculum suggests that this is not facilitated through the high school curriculum text. Thus, in order to access a wide range of semantic relations, students would either need to be exposed to this at home (cultural capital (Bourdieu and Wacquant 1992)) or through their own reading or through excellent pedagogic practice that goes beyond the textbook and models a greater semantic range. One could suggest that the SG flatline of the high school curriculum (in the absence of additional factors that may mediate a greater semantic range) is unlikely on its own to develop learners potential for cumulative learning. In the example analysed in this study, the knowledge in the high school curriculum remains locked into its context and thus does not adequately prepare learners for the same topic at university-level undergraduate biology where the knowledge structure is legitimated by a greater range of SG. One may also speculate that the modelling of a greater semantic range for SG within the university textbook may assist students in developing the ability to establish semantic relations between empirical data and scientific theory and thus the potential for cumulative learning. Similarly, since in the university textbook, the modelling of relationships between concepts with relatively strong SD and data with relatively weak SD is more frequent than in the high school textbook, students are more likely to develop stronger relational conceptual thinking. However, since the intentions of a curriculum are not always realised in student learning at the level of pedagogy (Maton 2009, 43–57), this analysis at a curriculum text level needs to be investigated further by looking at texts produced by students who are using the two texts analysed here.

### *Limitations of the Study*

This study focused on the analysis of two texts, both dealing with one of the many common topics dealt with in the university and high school biology curricula. The unit of analysis within the selected texts was a paragraph (changes in semantic profile within paragraphs were not included). Furthermore, the analysis focused on the text and ignored figures, activities and questions. Therefore, it is possible that these findings are not representative of the overall curriculum. In each case, a more detailed analysis of a larger and more inclusive sample of each text would increase the reliability of the findings.

This analysis of curriculum knowledge structures does not account for the multitude of pedagogic practices that mediate curriculum knowledge. These are dependent upon a range of variables, the most important being the teachers/lecturers' pedagogic skills and content knowledge. One could confirm the findings, using the same L2 presented here, by extending the study to include a comparative analysis of pedagogic practice and student products in both settings.

Finally, this study analysed the SG and SD of the curriculum knowledge. There may be other differences in the knowledge structures of the two curricula that were not picked up by these analytical tools. Luckett suggests that '… any analysis of curriculum knowledge needs to take into account its knowledge structure, its knower structure and the social and cultural structures of its recontextualising context' (Luckett 2009, 441–453). The current study has analysed only the internal relations of the knowledge structure of the two curriculum texts using LCT semantics. The analysis would be strengthened by including an analysis of the specialisation codes using LCT specialisation (Maton 2010, 35–59) as well as an analysis of the relevant curriculum policy documents to ascertain the social and cultural reasons for the differences in curriculum.

## Conclusion

This study provides a glimpse into the differences in semantic profiles between a high school Grade 12 biology text and Bachelor of Science first-year biology text. The methodology used in this paper has the potential to assess the semantic profiles of biology curricula and pedagogic practice across a wide range of contexts. Although the current paper only analyses a small sample of two curricula, the findings suggest that for this topic there may be a mismatch between the semantic range students are expected to navigate at university and that demanded by high school biology, and that this may pose a stumbling block to students gaining epistemological access to first-year study at university. Further application of the language of description described in this paper to the broader biology curriculum at both levels may lead to pedagogic interventions which explicitly address differences in curriculum structures that first-year undergraduate students need to navigate. Such interventions may contribute to improving undergraduate student retention and throughput rates at university.

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## Appendix 1.

**Table 1. Summary of contents and coding of semantic gravity and semantic density for each paragraph of the university biology curriculum**

| | University textbook (Reece 2011)<br>Summary of paragraph | SD | SG |
|---|---|---|---|
| Paragraph 1 | Outlines Thomas Morgans background and views and the significance of his early experiments | SD− | SG++ |
| Paragraph 2 | Outlines the organism used by Morgan for his studies and the significance of using the right organism in scientific research | SD− | SG++ |
| Paragraph 3 | Outlines the basic role of chromosomes in sex determination in the fruit fly | SD− | SG+ |
| Paragraph 4 | Outlines some of the procedures that Morgan undertook and the difficulties he faced. This paragraph also outlines some basic genetic terminology | SD− | SG++ |
| Paragraph 5 | This paragraph starts by describing the system that Morgan's group created for naming alleles in Drosophila but the system is never elaborated on. It is simply stated that there are similar systems for other organisms. Finally, the paragraph briefly describes such a system in humans | SD− | SG+ |
| Paragraph 6 | Outlines Morgans experimental results and the conclusions he drew from them | SD− | SG++ |
| Paragraph 7 | Morgan's results are integrated with knowledge that existed at the time, so that the logic of Morgan's conclusions can be seen | SD+ | SG++ |
| Paragraph 8 | This paragraph describes how Morgan's results support the results of others for the chromosome theory of inheritance and again highlighted the results of Morgans work | SD++ | SG− |

(*Continued*)

Appendix 1. (*Continued*).

| | University textbook (Reece 2011)<br>Summary of paragraph | SD | SG |
|---|---|---|---|
| Paragraph 9 | The heading of this paragraph is a generalising statement which foreshadows the rest of this section. In this paragraph Morgan's results are again integrated with knowledge that existed at the time, so that the logic of Morgan's conclusions can be seen | SD++ | SG− |
| Paragraph 10 | This section describes the basic structures of sex chromosomes and their basic interaction to form a male or female in humans | SD− | SG+ |
| Paragraph 11 | This section goes into slightly more detail about the basic interaction of male and female sex chromosomes to form males or females. It mentions at the end that the X-Y system is not the only system for determining sex | SD+ | SG+ |
| Paragraph 12 | This paragraph explains how, having a Y chromosome causes a person to be male. It also mentions the importance of the interaction of this mechanism with other mechanisms in the development of a human male | SD++ | SG+ |
| Paragraph 13 | This paragraph outlines the basic structure and purpose of the Y chromosome and its potential role in passing on disease | SD+ | SG+ |
| Paragraph 14 | This paragraph starts by outlining the structure of the X chromosome and finishes by outlining the general principle that X linked genes produce a pattern of inheritance different to that produced by other chromosomes. Even this generalising principle is also focused only on the X-Y system of sex determination | SD++ | SG+ |
| Paragraph 15 | Basic interactions between X linked genes and inheritance in Humans are described | SD− | SG+ |
| Paragraph 16 | The mechanism by which X linked genes produce alternative inheritance patterns in Humans is explained | SD+ | SG+ |
| Paragraph 17 | Outlines the role of X-linked genes in Duchenne Muscular Dystrophy | SD+ | SG+ |
| Paragraph 18 | Outlines the role of X-linked genes in Haemophilia, using the specific example of Queen Victoria of England's family tree | SD++ | SG+ |
| Average | | SD+ | SG+ |

## Appendix 2.

**Table 2. Summary of the contents and coding for semantic density and semantic gravity for each paragraph of the high school textbook**

| | High school textbook (Preethlall et al. 2010)<br>Summary of paragraph | SD | SG |
|---|---|---|---|
| *Section on sex determination* | | | |
| Paragraph 1 | Outlines key basic terminology in sex determination and outlines sex determination in humans | SD− | SG+ |
| Paragraph 2 | This short paragraph outlines what an X inked gene is. Again it refers to the human X-Y system | SD− | SG+ |
| *Section on sex linked genes* | | | |
| Paragraph 1 | This paragraph begins by stating a generalising principle; however this principle is not explicitly elaborated or explained. The paragraph goes on to explain what is meant by sex chromosomes in humans | SD− | SG+ |
| Paragraph 2 | This short paragraph describes the basic interaction of sex chromosomes to form a female in humans | SD− | SG+ |
| Paragraph 3 | This short paragraph describes the basic interaction of sex chromosomes to form a male in humans | SD− | SG+ |
| Paragraph 4 | Lists some commonly known traits controlled by sex chromosomes. Also, explains the interaction of chromosome to cause colour blindness. This description links genetics to other processes within the body | SD++ | SG+ |
| Paragraph 5 | Outlines the basic interaction of genes in inheritance of haemophilia. This is a contextualised example which does not relate back to the underlying principles. It also outlines the role of another process in the disease however; it does not relate the genetic patterns to the disease process | SD− | SG+ |
| Paragraph 6 | Provides the specific example of Royal families in Europe as an example of sex linked inheritance | SD− | SG++ |
| Average | | SD− | SG+ |