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Semantics from Legitimation Code Theory: How context-dependence and complexity shape academic discourse

Karl Maton

1. Introduction[1]

Almost everyone in education shares a desire for powerful knowledge that builds over time. Researchers typically aim to generate ideas that have value beyond the specificities of their originating contexts. Teachers wish their pedagogic practice to have effects beyond the initial conditions of learning and so enable students to build on previous understandings and transfer what they learn into future contexts. Policymakers proclaim that education must prepare students for living and working in fast-changing societies by providing knowledge that can build throughout their lives. In short, cumulative knowledge-building in research, teaching and learning are at the heart of education. Conversely, research and policy debates are full of concern about segmentalism, when knowledge is so strongly tied to its context that it is only meaningful within that context. Segmentalism can be seen in research whose findings remain locked into a specific object of study and in teaching that results in students learning highly segmented knowledges or skills. However, the question of how to achieve cumulative knowledge-building and avoid segmentalism is less clear.

As discussed in Chapter 1 of this volume, this problem forms the starting point for a series of transdisciplinary research projects involving Legitimation Code Theory (LCT) and systemic functional linguistics (SFL). In this chapter I introduce some of the ideas from LCT enacted in these projects and, in particular, results from the DISKS Project into 'Disciplinarity, Knowledge and Schooling'.[2] The chapter begins by introducing concepts from the Semantics dimension of LCT. These concepts are being adopted by a growing number of studies into a range of institutions, disciplines and artefacts, from schools to universities, physics to jazz, and theoretical frameworks to classroom practice. This chapter offers some introductory insights into why these ideas are being rapidly taken up by illustrating a conjecture that studies are giving rise to. In short, research suggests that knowledge-building involves *semantic waves* (recurrent shifts in context-dependence and complexity) that *weave* together different forms of knowledge. In contrast to much existing debate in which different types of knowledge are alternately valorized and criticized, this research proposes that powerful knowledge is not one kind of knowledge but rather mastery of how different kinds of knowledges are brought together and changed through semantic waving and weaving.

The chapter begins by defining the central concepts of *semantic gravity* (exploring context-dependence) and *semantic density* (exploring complexity), and how they combine to conceptualize organizing principles of practices as *semantic codes*. Second, I summarize how these LCT concepts extend the sociological framework inherited from Basil Bernstein and discuss how they overcome a problem in educational thinking more generally. Third, I describe how research is using the analytic method of *semantic profiling* to trace changes in semantic codes over time. I illustrate their value with examples from studies of student assessments and teaching practice. In particular, I draw on the PEAK Project to highlight how teaching often involves (to put it simply) a repeated pattern of unpacking abstract and

[1] This is a revised version of ideas first published in Maton (2013) and elaborated in Maton (2014a).
[2] DISKS was funded as an Australian Research Council Discovery Project (DP0988123).

complex educational knowledge into context-dependent and simpler meanings. This raises the question of how this context-dependent and simple knowledge can be transformed to become the relatively decontextualized and complex knowledge students must demonstrate in educational assessments to show their mastery of academic discourse. Using brief examples from History and Biology lessons I illustrate how *semantic waves* offer a potential means of traversing this gap in classroom practice. Lastly, I discuss the variety of forms taken by semantic waves and discuss how LCT concepts themselves enable the cumulative building of knowledge in research and practice.

2. Legitimation Code Theory: Semantics[3]

Legitimation Code Theory (LCT) is a sociological framework for researching and informing practice. LCT construes knowledge as both socially produced and real, in the sense of having effects (Maton & Moore 2010), and explores the effects of different forms taken by knowledge practices. Though LCT integrates insights from a range of approaches, its principal foundational framework was Bernstein's code theory (1971, 1977, 1990, 2000). LCT extends and integrates code theory to offer concepts that embrace more phenomena within a more systematic and integrated framework (Maton 2014b). This development is in close relation with empirical research. LCT is a 'practical theory' that is being used to explore a host of issues, practices and contexts in education and beyond (Maton 2016), both on its own and alongside complementary frameworks, especially SFL (Martin & Maton, Chapter 1, this volume; Maton & Doran 2016c; Maton *et al.* 2016c).[4]

LCT comprises a multi-dimensional toolkit, where each dimension offers concepts for analysing a set of organizing principles underlying practices as *legitimation codes* (Maton 2014b). There are five dimensions to LCT, each centred on conceptualizing a different form of legitimation code: Semantics, Specialization, Autonomy, Temporality and Density. In this chapter I focus on the dimension of Semantics which conceives social fields of practice as *semantic structures* whose organizing principles are conceptualized as *semantic codes* that comprise *semantic gravity* and *semantic density*. Put simply, semantic gravity conceptualizes context-dependence and semantic density conceptualizes complexity. I begin by defining these concepts.

Semantic gravity (SG) refers to the degree to which meaning relates to its context and may be stronger (+) or weaker (–) along a continuum of strengths. The stronger the semantic gravity (SG+), the more meaning is dependent on its context; the weaker the semantic gravity (SG–), the less dependent meaning is on its context. For example, the meaning of the name for a specific plant in Biology or a specific event in History embodies stronger semantic gravity than that for a species of plant or a kind of historical event, which in turn embodies stronger semantic gravity than processes such as photosynthesis or theories of historical causation. Semantic gravity thus traces a continuum of strengths with infinite capacity for gradation. One can also dynamize this continuum to analyse change over time in terms of: *weakening* semantic gravity (SG↓), such as moving from the local particulars of a specific case towards generalizations; and *strengthening* semantic gravity (SG↑), such as moving from generalized ideas towards concrete and delimited cases.

Semantic density (SD) refers to the degree of condensation of meaning within socio-cultural practices, whether these comprise symbols, terms, concepts, phrases, expressions, gestures, clothing, etc. Semantic density may be relatively stronger (+) or weaker (–) along a

[3] The framework was introduced in Chapter 1 of this volume; concepts are defined again here to enable this chapter to be read on its own.

[4] For LCT research, see: http://www.legitimationcodetheory.com

continuum of strengths. The stronger the semantic density (SD+), the more meanings are condensed within practices; the weaker the semantic density (SD–), the fewer meanings are condensed. Put another way, semantic density conceptualizes complexity: the stronger the semantic density, the more complex the practices. The strength of semantic density characterizing a practice is not intrinsic to that practice but rather relates to the *semantic structure* within which it is located. For example, the term 'gold' commonly denotes a bright yellow, shiny and malleable metal used in coinage, jewellery, dentistry, and electronics. However, within the discipline of Chemistry it is related to an atomic number, atomic weight, electron configuration, and much more. Many of these meanings involve relations to other meanings as part of compositional structures, taxonomies, and explanatory processes; for example, its atomic number represents the number of protons found in the nucleus of an atom, identifies it as a chemical element, and situates it within the periodic table. Thus, 'gold' in Chemistry is located within a complex semantic structure that imbues the term with a greater range of meanings.[5] Thus, another way of conceiving semantic density is in terms of 'relationality': the more relations with other meanings, the stronger the semantic density (Maton & Doran 2016a, 2016b). In other words, the more connections made with other meanings, the more complex the meanings become, so the stronger the semantic density.

Semantic density thereby traces a continuum of strengths, with infinite capacity for gradation. This continuum can be dynamized to describe *strengthening* semantic density (SD↑), such as moving from a term, symbol or practice condensing a small number of meanings towards one implicating a greater range of meanings. For example, bringing together places, periods, customs, beliefs, etc. as 'Mycenaean Greece' in History, or relating cell structures, proteins, pigments, etc. of a leaf to define 'photosynthesis' in Biology. Conversely, one can describe *weakening* semantic density (SD↓), such as moving from a highly condensed symbol to one involving fewer meanings. For example, unpacking technical concepts into simpler terms typically enacts a limited number of their meanings, weakening the semantic density of the knowledge being expressed.

As will become clear, the examples given above for relative strengths of semantic gravity and semantic density are neither definitional nor definitive. The forms taken empirically by different strengths of semantic gravity and semantic density are different in each object of study and for each form of data. No empirical example is the definition of any specific strength of semantic gravity of semantic density. Accordingly, much research in LCT is devoted to developing 'translation devices' or multi-level typologies that translate between concepts and different objects of study.[6] These translation devices involves types, but 'semantic gravity' and 'semantic density' are not themselves types. Put another way, 'semantic gravity' and 'semantic density' are not categories into which complex and changing empirical practices are placed. *All* practices are characterized by *both* semantic gravity *and* semantic density; what differs are their strengths, which may vary independently to generate *semantic codes* (SG+/–, SD+/–). As shown in Figure 1, these continua of strengths can be visualized as axes of the *semantic plane* with four principal modalities:

[5] There is more than one kind of semantic density. Here (and throughout this chapter) I illustrate *epistemic–semantic density* based on the *epistemological condensation* of formal definitions and empirical descriptions (Maton & Doran 2016a, 2016b). Commonsense understandings may exhibit stronger *axiological-semantic density* based on *axiological condensation* of affective, aesthetic, ethical, political or moral stances (Maton, 2014b: 153–170).

[6] See Maton & Chen (2016) on how they work, Maton & Chen (Chapter 2, this volume) and Chen *et al.* (2011) for an example with specialization codes, and Maton & Doran (2016a, 2016b) for examples with epistemic-semantic density.

- *rhizomatic codes* (SG–, SD+), where the basis of achievement comprises relatively context-independent and complex stances;
- *prosaic codes* (SG+, SD–), where legitimacy accrues to relatively context-dependent and simpler stances;
- *rarefied codes* (SG–, SD–), where legitimacy is based on relatively context-independent stances that condense fewer meanings; and
- *worldly codes* (SG+, SD+), where legitimacy is accorded to relatively context-dependent stances that are complex.

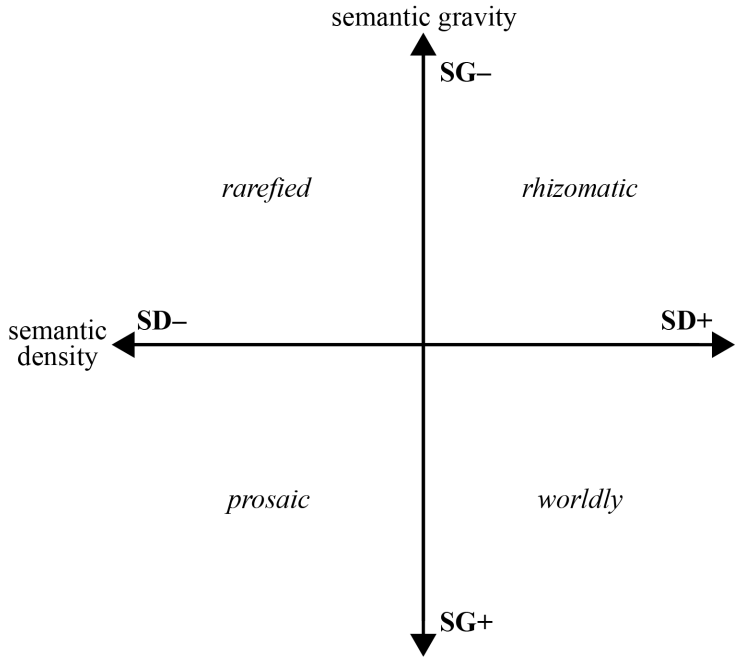

Figure 1: The semantic plane (Maton 2016: 16)

2.1. Extending code theory: Semantic codes

The LCT dimension of Semantics is not derived from or related to discourse semantics from SFL, though analyses using these two sets of concepts are complementary (see Martin & Maton, Chapter 1, this volume). The concepts of semantic gravity and semantic density are entirely sociological. 'Semantic gravity' was first introduced at a Bernstein conference in 2007 and published in a collection of papers from that conference (Maton 2008, 2009); similarly, 'semantic density' was first presented at a Bernstein conference in 2008 and published in its accompanying collection (Maton 2011a).

As discussed in Maton (2009, 2011b, 2013), 'semantic gravity' and 'semantic density' originate from conceptualizing ideas left untheorized by Bernstein's framework in order to meet the demands of empirical research. Studies using other dimensions of LCT were increasingly highlighting issues of context-dependence and complexity as significant for understanding their objects of study. Turning to Bernstein's theory for help showed the need for theoretical development to address these issues. Context-dependence is tacit in his early work that distinguishes 'elaborated codes', which 'orient their users towards universalistic meanings' and 'are less tied to a given or local structure', from 'restricted codes' that 'orientate, sensitize, their users to particularistic meanings' and 'are more tied to a local social structure' (1971: 176). Context-dependence also resurfaced, obliquely, in Bernstein's later distinction between segmented 'horizontal knowledge structures' and

integrating, generalizing and abstracting 'hierarchical knowledge structures' (2000). Both models also hint at the issue of condensation, albeit in different ways: the earlier distinction (1971) foregrounds 'condensed symbols' in terms of whether understandings are explicated or shared among actors and left unarticulated; and 'knowledge structures' (2000) raise questions of how ideas are interrelated in ways enabling more or less complexity of meaning.

Though touched upon by Bernstein's framework, the understanding of context-dependence and complexity remained at best tacit, entangled, and wholly descriptive. Theoretical development was thus needed. Moreover, the new concepts needed to be of a particular kind. Both Bernstein's early and later models offer dichotomous types (elaborated/restricted codes and hierarchical/horizontal knowledge structures). As Bernstein admitted, dichotomous types are 'limited' and 'very weak' in their 'generating power' (2000: 124). He offered greater power with the concepts of 'classification' and 'framing' that explore one set of organizing principles (strength of boundaries and control) underlying practices as 'pedagogic codes'. However, those concepts did not capture context-dependence or complexity. So, what was required was the development of similar concepts to 'pedagogic codes' but focused on context-dependence and complexity. This is what was achieved by 'semantic gravity' and 'semantic density' and their combination into 'semantic codes'.

One implication of the greater 'generating power' offered by semantic codes is to avoid a deep-seated dichotomy in educational thinking more generally. Education debates have been dominated by a recurring opposition between 'theoretical' and 'practical' knowledges. This takes many forms, including 'academic' / 'everyday', 'commonsense' / 'uncommonsense', and 'horizontal' / 'vertical'. These pairs are usually represented as exhaustive and mutually exclusive. However, semantic codes reveal this opposition as false. Using the new concepts, the oppositions offered in debates can be understood as representing *rhizomatic codes* (SG–, SD+) and *prosaic codes* (SG+, SD–), respectively. Put simply, each of the pairs contrast context-independent and complex knowledge with context-dependent and simpler knowledge. They thereby exclude the possibility of *rarefied codes* (SG–, SD–) of knowledge that is context-independent but condenses few meanings (such as empty jargon) and *worldly codes* (SG+, SD+) of knowledge that is context-dependent but complex (such as professional and vocational knowledge). Semantic codes thus allow us to see what has been previously hidden by debates and dominant thinking in education.

2.2. Dynamizing code theory: Semantic profiles

Semantic codes go further than revealing additional kinds of knowledge practices. While integrating a typology, they also offer a topology: the semantic plane (Figure 1) represents a potentially infinite number of relational positions. This is invaluable for research. Many models of knowledge are of limited practical use. As researchers soon experience, simple typologies often struggle to capture both empirical practices, which rarely fit neatly within their categories, and processes of change within and between types. As I argue elsewhere (Maton 2013, 2014a, 2014b), the answer is not to abandon typologies but rather to additionally capture the organizing principles that generate the knowledge practices they delineate. By avoiding homogenizing and strongly-bounded categories, the concepts comprising 'semantic codes' enable research to conceptualize differences and movements not only between but also within forms of knowledge practices. That is to say, one can analyse strengthening and weakening of semantic gravity or semantic density (SG↑↓, SD↑↓) both between semantic codes (between quadrants of Figure 1) and within semantic codes (across a quadrant of Figure 1).

The capacity of the concepts to explore processes of change is further enhanced by the analytic method of *semantic profiling* (Maton 2013). Dynamizing static accounts of structures is crucial for capturing knowledge-building, a practice enacted through time. Tracing the strengths of semantic gravity and semantic density of practices over time reveals a *semantic profile* and an associated *semantic range* between their highest and lowest strengths. Figure 2 offers a heuristic representation of three illustrative profiles. Portraying a simple scale of strengths on the y-axis, and time on the x-axis (such as the unfolding of classroom practice, curriculum or text), Figure 2 traces a high *semantic flatline* (A), a low *semantic flatline* (B), and a *semantic wave* (C), and shows their respective *semantic ranges,* where A and B have much lower semantic ranges than C.

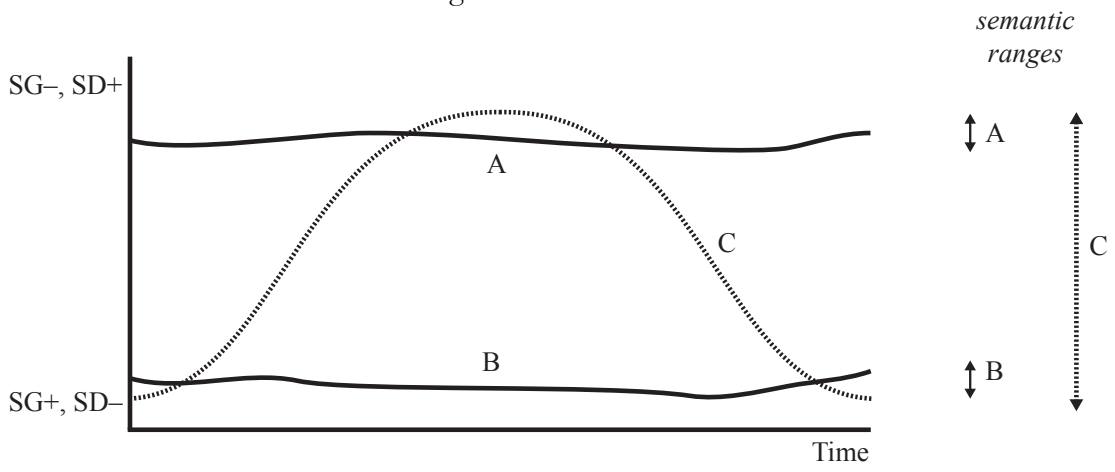

Figure 2: Three illustrative semantic profiles (Maton 2014b: 143)

I should emphasize: these and other profiles I discuss in this chapter are simplified for brevity. First, they combine semantic gravity and semantic density as a single line, with their strengths moving together inversely. As I have emphasized, the strengths of semantic gravity and semantic density may change independently. Tracing semantic gravity and semantic density separately (as studies often do) reveals where they are both relatively strong and both relatively weak, embracing all four semantic codes. Second, as I demonstrate below, semantic waves are not necessarily bell-shaped. Third, the featured profiles are heuristic. As mentioned above, research is currently developing sophisticated instruments for calibrating typological scales of strengths with precision (e.g. Maton & Doran 2016a, 2016b).

Nonetheless, these simplified examples provide a starting point for illustrating how semantic profiling reorients thinking about what kinds of knowledge are powerful and what enables knowledge-building. By dynamizing analysis, it shifts the focus from particular forms of knowledge to how knowledge changes over time. Crucially, it is also underpinning a growing body of studies into intellectual practices, curriculum, pedagogy, and assessment. This has been a constant thread of concept development in LCT: concepts emerge from and for empirical research, and continue to evolve in close engagement with real-world data. Accordingly, I now illustrate their value through summarizing several studies. For brevity, I confine my discussion to one conjecture emerging from research: the significance of semantic waves.

3. Semantic waves in educational achievement

A growing range of studies are exploring the bases of achievement in education by analysing the semantic profiles of student assessments. This research increasingly suggests

that knowledge practices expressing semantic waves – strengthening and weakening of context-dependence and complexity – is rewarded across subject areas and levels of education. For contrast, I shall briefly consider examples of the humanities in schooling and 'critical thinking' in higher education.

A compulsory unit of secondary school English for students taking the Higher School Certificate (in New South Wales, Australia) requires students to explore abstract notions such as 'the journey' and 'belonging' in relation to diverse texts (Maton 2014b). Between 2005 and 2008, students were asked to draw on three texts to answer the question: 'To what extent has studying the concept of imaginative journeys expanded your understanding of yourself, of individuals and of the world?'. Figure 3 represents the semantic profiles of two essays. The high-achieving essay (unbroken line in Figure 3) was included in official syllabus documents as an exemplary model. This essay begins and ends by drawing on complex literary meanings (stronger semantic density) to bring together its examples in relation to a generalizing and abstract idea (weaker semantic gravity); for example, the essay begins:

> The journey, especially in the imaginative sense, is a process by which the traveller encounters a series of challenges, tangents and serendipitous discoveries to arrive finally, at a destination and/or transformation.
> (quoted, Maton 2014b: 118)

From this relatively high start, the essay moves down the semantic scale to describe simply the concrete particularities of each example, such as its author and main focus. Then, the essay moves upwards from these simple descriptions towards more generalized and complex 'literary' ideas concerning that text, until reaching how the text relates to the notion of 'imaginative journeys'. This movement is repeated throughout the essay, tracing a series of semantic waves across its three texts (see Figure 3).

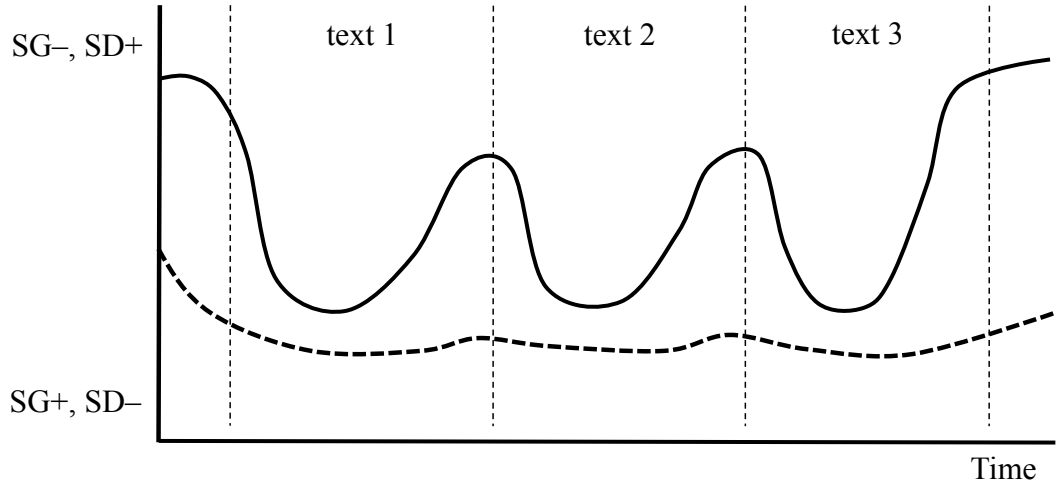

Figure 3: Semantic profiles of two student essays in school English

In contrast, the low-achieving essay (dashed line in Figure 3) traces a relatively low semantic flatline. Here knowledge is expressed through a non-technical, non-literary discourse (weaker semantic density) that is firmly grounded in the context of each specific text's relations to everyday life (stronger semantic gravity). For example, discussing the novel *Ender's Game*, the student writes:

> It wasn't hard at all to imagine battle school as a real place because I was familiar with several scientific objects which surrounded us. For example, the 'Desk' sounds very familiar to a lap top computer.

The essay never moves away from expressing very concrete and simple meanings: it remains firmly rooted near the bottom of the semantic scale (see Figure 3). So, the low-achieving essay remains entirely within a *prosaic code* (SG+, SD–). In contrast, the high-achieving essay includes both a *prosaic code* (SG+, SD–) and a *rhizomatic code* (SG–, SD+). More importantly, the essay also weaves those two codes together through its wave-like structure.

This brief summary highlights semantic profiles that resonate with studies into other disciplines and levels of education that are revealing both the ubiquity and diversity of semantic waves. Szenes *et al.* (2015), for example, analyse student assignments to show how the highly valued practice of 'critical thinking' is assessed within university degrees in Business and Social Work. Figure 4 portrays an example of a high-achieving 'reflective journal' from a unit in Business. The journal comprises three principal stages. The first stage, in which the student discusses their beliefs and values ('excavation' in Figure 4), is characterized by a rapid series of deep semantic waves as the journal shifts quickly between decontextualized, conceptual ideas of cultural values (such as notions of 'individualism') and straightforward, concrete examples from the student's cultural context that are said to embody those values (such as the Australian cricketer Sir Donald Bradman). In the second stage, the student relates his/her own behaviour during teamwork with other students to these values ('reflection' in Figure 4). Here semantic waves are milder: discussion of behaviour is generalized and conceptualized rather than simply recounted; and theoretical ideas are more context-dependent and simplified as their meanings are delimited to those concerning the behaviour. In the final stage ('transformation'), the journal not only brings these forms of knowledge into relation but transforms them further as the student provides a list of generalized skills for successful participation in future teamwork situations that are claimed to embody the concept of 'intercultural competence'. Semantic shifts now lessen to reach a midway point in the scale.

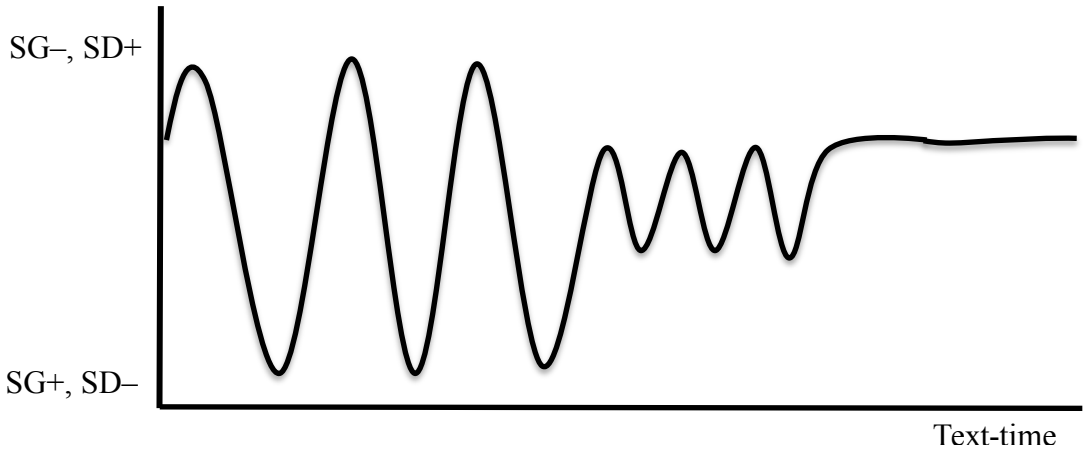

Figure 4: Semantic profile of a 'critical reflection' journal in undergraduate Business (adapted from Szenes *et al*, 2015)

Analysis of 'critical reflection' essays from Social Work highlight differences in their semantic profiles: the profile of Figure 4 is repeated but with an additional stage of low flatline at the start. This reflects differences in their subject matter: the Social Work

assignments require a 'critical incident' to be simply and concretely described at the outset as the basis for discussion in the rest of the assignment (Szenes *et al.* 2015). Indeed, comparing Figures 3 and 4 suggests that semantic waves can differ between subject areas (English/Business), kinds of assignment (essay/critical reflection journal) and level of education (school/university). I return to these differences in section 5, below. Here, I wish to highlight that what is shared by the examples thus far is an overall pattern of semantic waves that weave together different forms of knowledge. This general finding is echoed in studies of curriculum, textbooks and student assessment across the disciplinary map, including engineering (Wolff & Luckett 2013), English (Christie 2016), design (Shay & Steyn 2016), freemasonry (Poulet 2016), History (Martin *et al.* 2010, Matruglio *et al.* 2013), marketing (Arbee *et al.*, 2014), and physics (Georgiou et al., 2014; Georgiou 2016). Moreover, studies of intellectual practices are suggesting that mastery of semantic waves is also crucial to knowledge-building in research. Maton (2014b) analyses the sociological frameworks of Basil Bernstein and Pierre Bourdieu, showing how the former has a greater semantic range that enables cumulative development through semantic waves that weave the concrete particularities of empirical phenomena with abstract and highly condensed concepts. In contrast, Hood (2016) reveals the segmentation characterizing ethnographic writing in cultural studies, as research both fails to achieve semantic waves that reach beyond the specificities of each context and leaves theory and data disconnected and unchanged.

4. Semantic waves in classroom practice

Mastery of semantic waves may underlie achievement in education, but it is unevenly distributed across society. Students from different social backgrounds come to education with dispositions that encompass different semantic ranges. Maton (2014b: 204–5) re-analyses Holland's iconic study using Bernstein's concepts (1981) to show how students from social classes have different semantic coding orientations. Students differ in their capacity to successfully realize practices that embody different semantic codes. As this and other research (e.g. Hasan 2009) reveals, the ability to move between concrete, simpler meanings and abstract, generalized and complex meanings is associated more with socialization practices in cultural middle-class families than those of working-class families. Among the questions such 'semantic variation' raises for education are whether classroom practices help model semantic waving and weaving to all students and, if not, how they can do so.

These issues were broached by a major transdisciplinary study of knowledge-building in secondary schooling: the 'Disciplinarity, Knowledge and Schooling' or DISKS project that used LCT and SFL as complementary frameworks. The study was structured into three main stages. First, data collection principally comprised video-recordings of 100 lessons in Years 8 and 11 of both urban and rural secondary schools in New South Wales, Australia. To explore contrasting areas of the disciplinary map, the lessons were in Science (Year 8) or Biology (Year 11) and Ancient History or Modern History (depending on school). Second, LCT and SFL were drawn on to analyse teaching texts, student assessments and classroom practice, focusing on phases of classroom interaction in which knowledge was actively transformed in some way, such as unpacked, repacked, recalled from the past, built on, elaborated, reworked, projected into the future, etc. Third, these analyses formed the basis for a pedagogic intervention in which teachers were trained to engage in 'joint construction' with their students, in order to model semantic waves and teach the linguistic resources they involve. See Martin (2013) for discussion of the SFL analysis, Matruglio et al. (2013) for an illustrative analysis of History using LCT and SFL, and Macnaught *et al.* (2013) for discussion of the pedagogic intervention. Detailing the

LCT analyses is beyond the scope of this paper. Here I shall simply discuss two semantic profiles traced by knowledge expressed in classrooms that highlighted a key issue for knowledge-building.

4.1. High stakes and down escalators

The issue concerns what can be described as the 'high stakes' of teaching and learning. As portrayed in Figure 5, classroom practice must traverse a potential *semantic gap* between what are often called 'high-stakes reading' and 'high-stakes writing'. On one side is the academic discourse to be learned, typically embodied in written forms such as textbooks or source documents and accessed through reading. On the other side is the knowledge students must display in their assessments, mostly though not exclusively in writing tasks, to reveal successful mastery of the academic discourse. Though the position on the semantic scale of the latter relative to the former varies (typically lower but rising from earlier to later years of study), our analyses of teaching texts and students' assessments suggest both sides exhibit weaker semantic gravity and stronger semantic density than the knowledge expressed in classroom discourse. In short, they are higher up the semantic scale. One question this raises concerns how this potential gap is traversed: how can classroom activities reach between knowledges that are higher up the semantic scale?

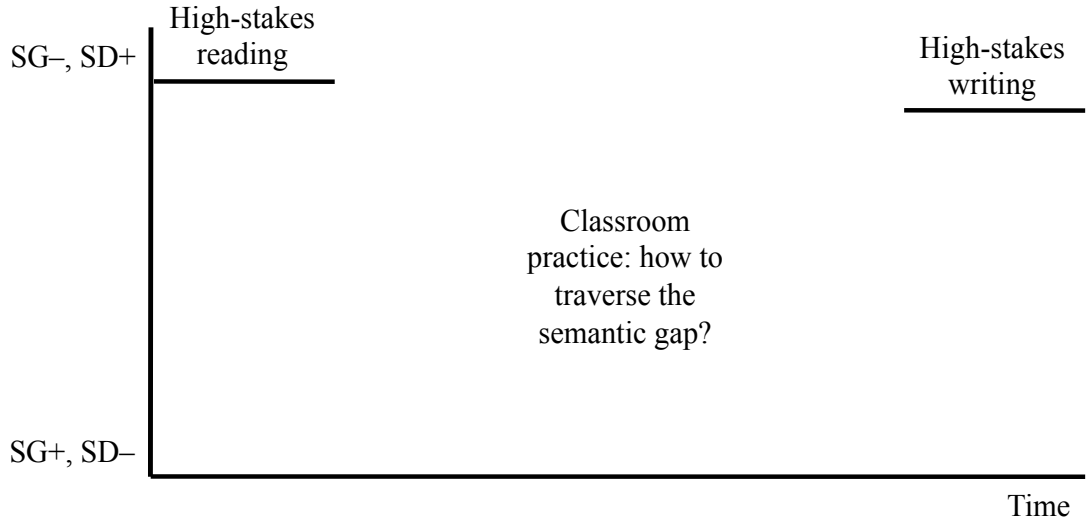

Figure 5: The high stakes of teaching and learning

One profile of classroom practice we frequently found in our study did not traverse the semantic gap. As depicted in Figure 6, this profile comprised a series of *downshifts*: from context-independent and complex ideas (SG–, SD+) towards simpler and more concrete understandings, often including examples from everyday life (SG+, SD–). The practices associated with this 'down escalator' profile typically involved teachers repeatedly unpacking and exemplifying meanings from written sources. As illustrated below in section 4.2, unpacking may form part of other profiles; however, the signature of the 'down escalator' profile is the exclusive focus on and repeated nature of this unpacking. For example, when reading together through a text or source, teachers often explained ideas and words to students using less technical, more everyday language and examples, and then returned to the text, finding more points to unpack and discuss. This traces a series of downshifts or 'down escalators'. However, rarely, if ever, did teachers move back up into academic discourse by repacking meanings and examples into more technical terms. Thus, this teaching practice models movements downwards but not back upwards from non-

technicalized, concrete and often segmented knowledge towards more complex, technicalized knowledge that is plugged into the constellations of meanings constituting academic discourse. This represents a problem for knowledge-building: knowledge characterized solely by stronger semantic gravity and weaker semantic density may be too tied to specific contexts and too disconnected from other meanings to either build upon previous knowledge or be built upon in the future.

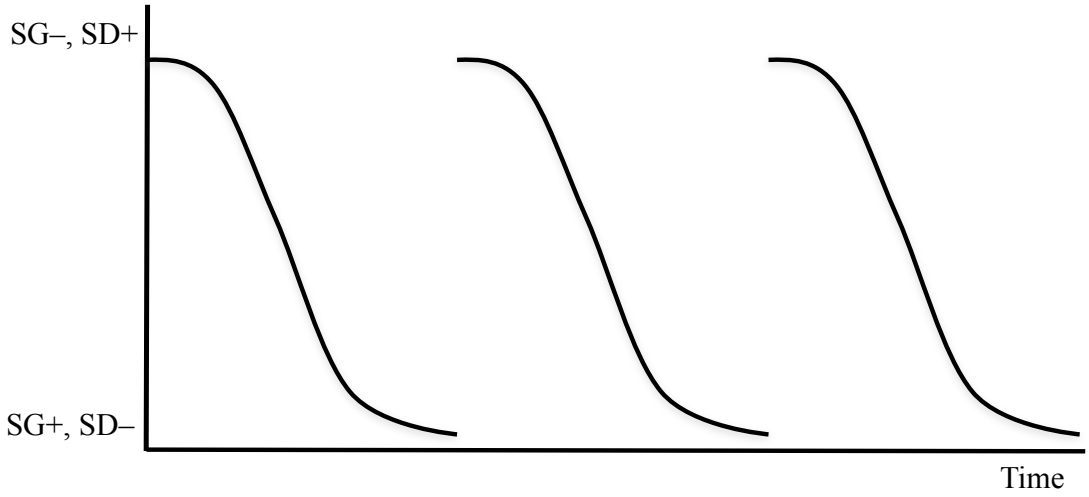

Figure 6: A 'down escalator' profile

This was not, however, the only semantic profile we discovered in classroom practice. Though not as widespread, the study found teaching that also modelled upshifts and so created semantic waves in the academic discourse being expressed. Moreover, these semantic waves also model how meanings may be transformed through semantically weaving together different forms of knowledge. To illustrate these shifts I shall explicate a single semantic wave in two brief examples from Biology and History.

4.2. Examples of semantic waves

My first example is from a Year 11 Biology classroom in which the topic of discussion is 'biological lines of defence', focusing on the 'cilia':

Teacher	Okay [student's name] what are the 'cilia'. What was it? No? [Student's name] do you know what cilia is? No? Someone must know what they are...
Student	Hairs
Student	The little hairs?
Teacher	The little hairs. And basically, they beat in an upward motion from inside your body out through to your nose. [Teacher is waving arms upwards]. So, they beat up and they take the pathogens away with them. And, guys, I don't know if I've ever told you this, but when you smoke cigarettes, the tar actually causes your cilia to, because it's so heavy, to drop, and so your cilia don't work properly after that because they're too heavy, they've dropped, so they can't beat the pathogens out of your body! So that's one reason that smoking's bad as well. Okay! Alright, write this down under description!

Figure 7 portrays the semantic profile of this classroom interaction. The excerpt begins with the teacher introducing 'cilia', an abstract scientific term that condenses a wide range

of meanings within Biology (see Martin 2013). The context of the science classroom, the teacher's request for a definition, and the unfamiliarity of the word announce its relatively high position on the semantic scale ('concept' in Figure 7). With contributions from students, the teacher then unpacks some meanings condensed within the term using both previously learned concepts, such as 'pathogens', and everyday language, such as 'the little hairs', as well as body language (waving her arms). She also provides a concrete example from everyday life: that smoking stops cilia from performing a function integral to their definition. Locating the 'cilia' in the body and setting limits to its functions strengthens semantic gravity; unpacking the term by outlining a small number of its meanings weakens semantic density. As shown by 'unpacking' in Figure 7, this moves the knowledge being expressed down the semantic scale towards more grounded and less complex meanings (SG+, SD–).

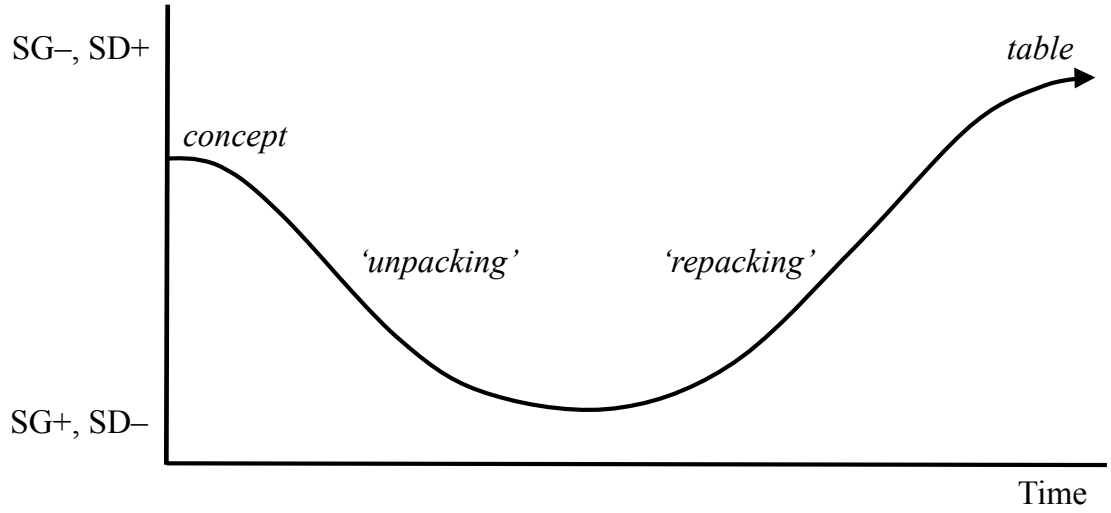

Figure 7: Example of a semantic wave in Biology teaching

I should emphasize that to view the unpacking of academic discourse as weakening its semantic density is *not* to negatively evaluate such activity. Translating a technical term into commonsense understandings reduces its range of meanings, but that is the purpose here: to provide a point of entry for newcomers into those complex meanings. This represents a potential starting point for the teacher and students to progressively strengthen its semantic density through elaborating, extending and refining additional meanings, such as by locating the term within systems of composition, taxonomies and processes. The 'down escalator' profile discussed earlier eschews this possibility by returning to the start of the sequence and commencing a new round of unpacking. However, in this example the teacher engages in repacking knowledge into the term.

cilia	Hair-like projections from cells lining the air passages	Move with a wavelike motion to move pathogens from the lungs until it can be swallowed into the acid of the stomach

Figure 8: Biology teacher's table entry for 'cilia'

The excerpt given ends with the teacher telling the students to 'write this down under description'. At this point the teacher writes on the board what is shown as Figure 8: 'cilia', a brief definition, and a description of a function they serve in the body. This is more than a summary of the unpacking; it begins to repack the term 'cilia' by bringing together meanings without specific contexts such as smoking. In other words, it begins moving the knowledge being expressed back up the semantic scale – 'repacking' in Figure 7. This achieves a semantic wave. Indeed, the upshift reaches beyond the level of the term 'cilia' because this definition forms part of a larger table (reproduced here as Figure 9) that the teacher and students are working through together to learn about biological lines of defence. The table reveals a greater range of relations within which the term 'cilia' is embedded, including biological processes and causal explanations (for example, 'cilia' form part of the workings of 'chemical barriers'). Thus, in Figure 7 'table' is shown higher than 'concept': it represents more generalized and complex knowledge. As the table shows, the semantic wave thus forms part of a longer sequence in which teaching and learning builds on previously discussed ideas that are then taken forward into future practice.

Line of defence	Description	What it does
skin	Skin continuously grows by new cells being produced from below. Cells fit tightly together to form a protective layer covered by dead cells.	When unbroken skin prevents the entry of pathogens. Pores in the skin secrete substances that kill microbes. Skin constantly flakes off carrying microbes away. It is a difficult environment for a pathogen to grow (no water).
mucous membrane	Cells lining the respiratory tract and openings of the urinary and reproductive systems that secrete a protective layer of mucous.	
cilia	Hair-like projections from cells lining the air passages	Move with a wavelike motion to move pathogens from the lungs until it can be swallowed into the acid of the stomach
chemical barriers	Acid in the stomach, alkali in the small intestine, the enzyme lysozyme in the tears.	Stomach acid destroys pathogens including those that are carried to the throat by cilia and then swallowed. Alkali destroys acid resistant pathogens. Lysozyme dissolves the cell membranes of bacteria.
other body secretions	Secretions from sweat glads and oily secretions from glands in hair follicles.	Contain chemicals that destroy bacteria and fungi.

Figure 9: Table used for teaching lines of defence in a Biology classroom

It should be emphasized that this example from Biology is only one form of semantic wave. To illustrate this, my second example is from a Year 11 History classroom in which a take-home assignment on 'the influence of Greek and Egyptian cultures in the Roman Empire' is being discussed. The question includes terms from the academic discourse of History characterized by weaker semantic gravity and stronger semantic density: 'Greek culture', 'Egyptian culture' and 'Roman Empire' embrace a range of meanings concerning time periods, locations, practices, beliefs, etc. Moreover, the question condenses more than the sum of its terms: explicating 'influence' requires understanding historical processes. The knowledge evoked by the question thereby sits relatively high up the semantic scale. The teacher then unpacks meanings from the question, repacks them into a concept, and then unpacks that concept.

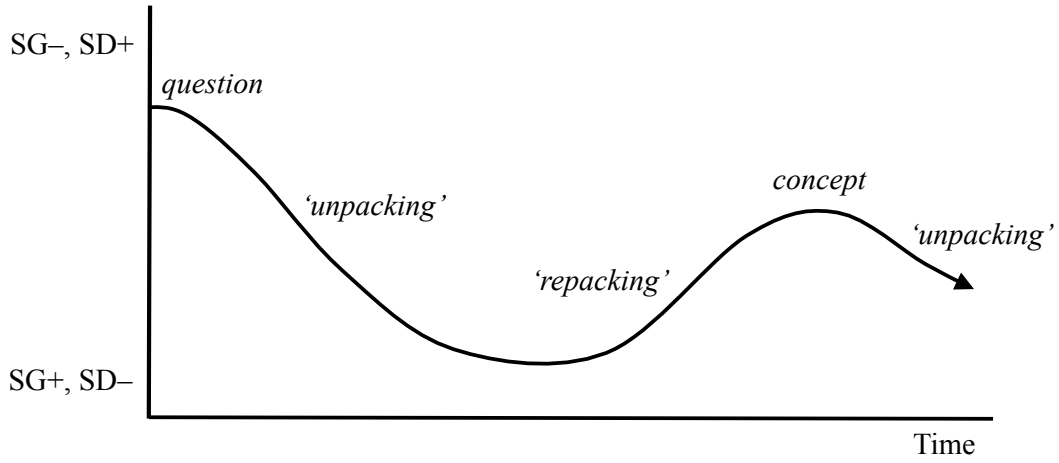

Figure 10: Example of a semantic wave in History teaching

The excerpt begins as follows:

> Teacher This is a little bit hard: "The influence of Greek and Egyptian cultures." What does that mean? What would the influence of Greek and Egyptian cultures mean, okay? No idea, right?

The teacher thus begins by indicating the knowledge being discussed is relatively high on the semantic scale by discussing its difficulty: 'This is a little bit hard … No idea, right?'. Figure 10 thus depicts the profile as beginning relatively high ('question'). The teacher then moves the knowledge being expressed down the semantic scale in stages ('unpacking' in Figure 10) by providing a series of examples of 'influence':

> Teacher What it means is, if we started to look at all the things in Pompeii and Herculaneum, what objects may be showing Greek design? Or Egyptian design? Or Greek mythology? Or Egyptian mythology? Or what building techniques like columns? Are there Greek columns? Do, you know, are the themes of their artwork reflecting it?

With the examples of 'objects' that 'may be showing Greek design', 'Egyptian design', 'Greek mythology' and 'Egyptian mythology', the knowledge expressed by the teacher begins to move down the semantic scale by specifying and unpacking meanings from the wide-ranging, abstract terms of the question, a move continued by the more specific and concrete example of 'building techniques' and 'columns', which is in turn exemplified by 'Greek columns'. The teacher also grounds the question in the historical period (through

examples of prior events in history) and the current discussion of the question in the context of previous lessons:

> Teacher So, it's saying …remember when we started, we said that Pompeii had originally been settled by Greeks? Okay? And if we look at where Italy is, it's not that far from Egypt at this time, umm, we've, we've had, umm … Cleopatra has been killed by the time the volcano erupts, she and Mark Antony are dead and Egypt is part of the Roman Empire.

Thus far, the teacher has downshifted the knowledge being expressed. However, rather than return to the question and repeating this procedure (like 'down escalators'), she moves knowledge back up the semantic scale:

> Teacher So there would be massive amounts of trade going on, and umm, you know people visiting their diplomats you know or their, their, ambass[adors]…like their envoys and things like that all going back and forth across the countries. So, ideas. When you get trade in ideas – you wouldn't have heard this word before – we call it 'aesthetic trade'. Have you heard of it? Yeah.
> Student You told us before.
> Teacher Ohh! Told you before great, *excellent*! You remember aesthetic trade! 'Trade in ideas'. So, of course, when you've got contact with the country you're gonna get the trade in ideas coming as well.

This discussion weakens semantic gravity by discussing recurrent events (trade and diplomatic visits) rather than specific events, and strengthens semantic density by 'packing up' various activities being conducted between countries into 'trade in ideas' and then into the technical term 'aesthetic trade' (see 'repacking' to 'concept' in Figure 10). Though this does not return to the heights embodied by the question, this upshift almost completes a semantic wave to explain one key aspect of 'influence'.

As with the Biology example, a semantic profile is typically part of a bigger picture, set within proceeding and subsequent practices. In this example, the knowledge being expressed descends the scale again: the teacher provides examples of the concept of 'aesthetic trade' and emphasizes how 'hard' questions can be 'unpacked' in this way:

> Teacher So that's what that one is. It looks hard, but all you've gotta do is have a look and think what things are there. Let me give you a big clue some of them are massive. [Teacher sings…] Laah-la-lah-la- la-la-la-la-lahh, la-lah
> Student Theatres
> Student La-lahh
> Teacher Theatres. Okay, theatres are a Greek design. The Greeks invented the theatre, and then the Romans take the idea because they like it too. So, some of them are very obvious.

The teacher thus transforms academic discourse into everyday discourse and then back again, weaving together different forms of knowledge to explain a key aspect of the knowledge students are being asked for by the question. In particular, the passage illustrates how the teacher modelled not only downshifting but also upshifting from simpler, contextualized meanings towards complex, decontextualized meanings.

4.3 Semantic waves and high stakes

Though specifying and 'unpacking', generalizing and 'repacking' may be valuable pedagogic strategies, the principal point of the examples discussed above is not to identify exemplary practices. There are many other ways to move up and down the semantic scale. Rather, the point is to illustrate semantic waves in the knowledge being expressed. One conjecture arising from the DISKS project is that semantic waves not only model the form required to succeed but also, unlike the 'down escalators' profile, help students access the complex semantic structures of academic discourse. In short, we suggest that one means for traversing the semantic gap between high-stakes reading and high-stakes writing may reside in a series of waves progressively reaching further up the semantic scale, as depicted by Figure 11. In other words, semantic waves may build on each other over times. Moreover, semantic profiles can be traced at any level – exchange, phase, lesson, unit, course, curriculum, educational career, etc. As one moves from micro through meso to macro levels, analysing profiles may fractally reveal waves within waves that aim to progressively move higher as they build upon previous waves of knowledge (see 'detail' in Figure 11).

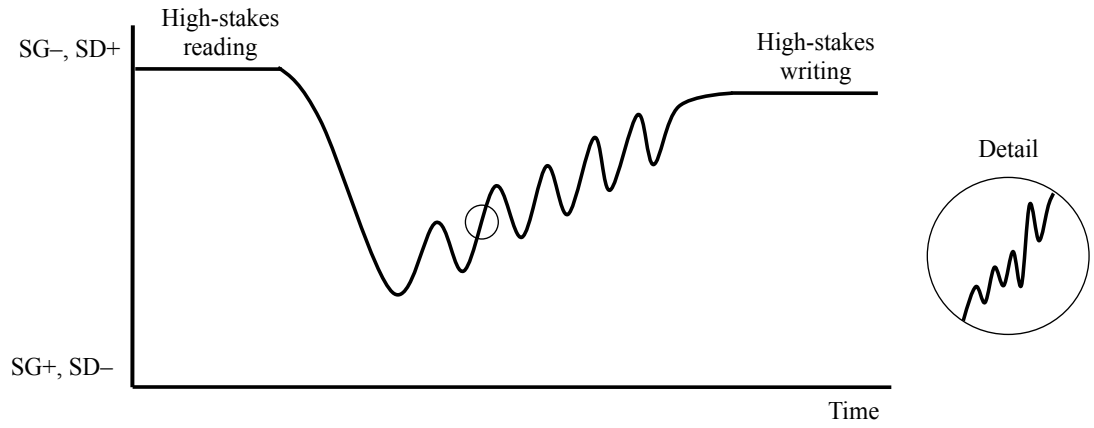

Figure 11: Semantic waves and the high stakes of teaching and learning

However, LCT concepts are not restricted to analysing data and generating conjectures. They can also form the basis for theoretically-informed practice (see Maton *et al.* 2016a). As part of the DISKS project a small-scale pedagogic intervention was undertaken. This involved training teachers to engage in 'joint construction' with students as a means of teaching them how to move up the semantic wave and master the linguistic resources required for high-stakes writing (Macnaught *et al.* 2013). Since that study other scholars have also enacted the notion of semantic waves to shape teaching practices in other contexts, including Chemistry (Blackie 2014) and Political Science (Clarence 2016) at university.

5. Different kinds of semantic waves

Throughout this chapter I have emphasized that semantic waves can take many forms. Studies are revealing the diverse nature of semantic waves generated by a series of features, including range, directional shifts, entry and exit points, flow, and threshold.

First, in terms of *semantic range*, though the limited nature of flatlines may be problematic, it is not a simple case of 'the higher the better'. For example, research into undergraduate physics (Georgiou *et al.* 2014) reveals that students may reach too high up the semantic scale in their assessed work, using concepts, principles, equations or laws that

are overly generalizing or which condense more meanings than appropriate to their assignment. This 'Icarus effect' suggests one facet of being inducted into a subject area is learning the semantic range appropriate to addressing different kinds of problem-situations.

Second, though both upward and downward shifts are required for cumulative knowledge-building, the directions of *semantic shifts* may play different roles across academic subjects. This chapter has emphasized the significance of upshifts for classroom practices because of their relative neglect by many teachers studied in the DISKS project. However, research into professional education (e.g. Shay & Steyn 2016) suggests that downshifts may be crucial in teaching and learning appropriate ways to select, recontextualize and enact abstract and complex knowledge within concrete and specific cases of professional practice. Where the key is application of knowledge in specific contexts, downshifting may be crucial.

Third, semantic waves do not always look like the examples discussed in this chapter (all of which started and ended high). They may begin and end at other points on the semantic scale. For example, starting from concrete and simpler meanings may offer students a more engaging way in and out of the central focus of an activity. Similarly, practically-oriented subjects, such as vocational education, often begin and end with concrete examples and simpler meanings, creating bell-shaped waves. Ongoing research is thus exploring the role of different *entry points* and *exit points* in research publications, lessons, student assignments, etc.

Fourth, while the classroom examples exhibited relatively strong *semantic flow* or connectedness between consecutive points, this is not always the case. Knowledge expressed in practices may involve disconnected shifts up and down, such as unexplained jumps between theories and data or concepts and examples, or minimally linked moves that create vertiginous shifts in the context-dependence and condensation of meanings. This can offer insights into, for example, problems experienced in successfully integrating theory and examples by students in assignments, by teachers in their teaching practice, and by research in relating concepts to data.

Last, the *semantic threshold,* or extent to which accuracy matters, may vary. Ongoing research suggests that the degree of this threshold differs across subject areas and through stages of education. For example, the definition of the function of 'cilia' offered by the teacher earlier in this chapter is not entirely correct: it too closely relates the respiratory system to the gastro-intestinal system. At this stage of the curriculum, however, it is within the bounds of semantic threshold: too much accuracy at this point may become confusing for students. Further research may show that such simplified definitions are later elaborated and clarified as students progress through the curriculum, raising the semantic threshold.

Moreover, the nature of this threshold may change. This chapter has discussed only epistemological forms of semantic gravity and semantic density, where the knowledge comprises formal definitions and empirical descriptions. Here, semantic threshold concerns epistemological accuracy. However, there are other forms, such as axiological-semantic gravity and axiological-semantic density based on affective, aesthetic, ethical, political or moral stances (Maton, 2014b: 153–170). In these cases, having the right political or moral attitude may be crucial. For example, in educational research the notion of 'student-centred learning' is condensed with political connotations (Maton 2014b) and analyses of History lessons reveal the moral meanings condensed within such terms as 'colonialism', 'nationalism' and 'imperialism' (Martin *et al.* 2010). In effect, this is to bring together Semantics with Specialization (see Maton & Chen, Chapter 2, this volume): epistemological forms concern epistemic relations and axiological forms concern social relations. Space precludes discussing this issue further here; the simple point is that there are more forms

that semantic profiles can take, not only in terms of their shape but also in terms of what kinds of knowledge are involved.

6. Conclusion

Almost everyone in education shares a desire for cumulative knowledge-building, but this requires tools that can explore the organizing principles of knowledge practices. This chapter has introduced and exemplified concepts from the LCT dimension of Semantics. It has only touched the surface of how Semantics can help explore academic discourse: the dimension includes more concepts and they can used in more ways than have been discussed here. However, it does illustrate how Semantics can shed light on cumulative knowledge-building. Specifically, the chapter focused on the conjecture that semantic waves represent a key to cumulative development by enabling the recontextualization of knowledge through time and space. This also highlights that what may be powerful is not one form of knowledge, such as theoretical or practical knowledge, but rather how different forms are related and changed. In short, power resides in *semantic waves* that *weave* together and transform knowledges.

I have, however, emphasized that there is much more to be discovered. As discussed in section 5, semantic waves may take many forms – more research is required into the specific semantic profiles of different subject areas and stages of curriculum. Moreover, the concept of semantic threshold offers the salutary lesson that semantic waves may be a necessary but not sufficient condition for success, that 'getting it right' (whether epistemologically or axiologically) may be crucial. This also highlights the significance of working with subject specialists, and that building knowledge requires mastering both its form and its content. It is why, for example, the pedagogic intervention of the DISKS project was conducted collaboratively with teachers of Biology and History (Macnaught *et al.* 2013). Other issues for research include exploring the semantic codes of actors. As shown by the essays discussed in section 3, not all students recognize that semantic waves are a crucial aspect of assignments and/or realize such a profile in their written assessments. More generally, not everyone is equally capable of enacting the semantic codes required for achievement. As illustrated in Maton & Chen (Chapter 2, this volume), practice is the meeting of two sets of codes: those defining the context and those characterizing actors' dispositions. More research is required into coding the dispositions that students bring to contexts by virtue of their past experiences, to reveal who is predisposed to succeed or fail and to suggest ways forward to achieve greater social justice in education. Different groups of knowers may require different ways of teaching them how to achieve the semantic profiles necessary for success.

Our understanding of semantic profiles, let alone cumulative knowledge-building, is thus at an early stage. However, this is not the final chapter: it develops ideas for further development; it contributes to a wider work-in-progress by a diverse range of scholars in LCT. Moreover, as this body of work is showing, the ideas outlined here provide a basis for exploring these issues further. Turning the tools of Semantics upon themselves helps explain this productivity: the concepts embrace an extensive semantic range, from abstract, generalizing, highly condensed and complex meanings as part of the wider sociological framework of LCT, to concrete, specific and simpler meanings in practical applications. As a growing number of studies illustrate, they can be enacted within research into an wide array of problem-situations. The concepts thereby enable analyses of an expanding range of apparently different phenomena to be brought together, highlighting their underlying uniformities and differences. As a whole, research practice in LCT thus itself embodies semantic waves to build knowledge about knowledge–building.

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