



Making semantic waves: A key to cumulative knowledge-building

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ABSTRACT

The paper begins by arguing that knowledge-blindness in educational research represents a serious obstacle to understanding knowledge-building. It then offers sociological concepts from Legitimation Code Theory – ‘semantic gravity’ and ‘semantic density’ – that systematically conceptualize one set of organizing principles underlying knowledge practices. Brought together as ‘semantic profiles’, these allow changes in the context-dependence and condensation of meaning of knowledge practices to be traced over time. These concepts are used to analyze passages of classroom practice from secondary school lessons in Biology and History. The analysis suggests that ‘semantic waves’, where knowledge is transformed between relatively decontextualized, condensed meanings and context-dependent, simplified meanings, offer a means of enabling cumulative classroom practice. How these concepts are being widely used to explore organizing principles of diverse practices in education and beyond is discussed, revealing the widespread, complex and suggestive nature of ‘semantic waves’ and their implications for cumulative knowledge-building.

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Semantic waves are the pulses of cumulative knowledge-building.

1. Introduction: the cumulative and the segmental

Almost everyone in education shares a desire for cumulative knowledge-building. Researchers typically aim to generate ideas that have utility or appeal beyond the specificities of their originating contexts. Educators urge the need for pedagogic practice to have, as Bransford & Schwartz (1999: 61) put it, ‘positive effects that extend beyond the exact conditions of initial learning’ by enabling 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 and skills that can build throughout ‘lifelong learning’ (Field, 2006). Thus, cumulative knowledge-building in research, teaching and learning are at the heart of education. Conversely, research and policy debates are replete with concern over segmentalism, when knowledge is so strongly tied to its context that it is only meaningful within that context. That this remains a serious problem is acknowledged across disciplinary and institutional maps, from arts to sciences, school to university, education to training (e.g. Christie & Macken-Horarik, 2007; Wheelahan, 2010). How the segmental may be overcome to enable the cumulative, however, is less clear.

This problem forms the starting point for the inter-disciplinary research discussed in the papers collected in this Special Issue. Freebody (2013) outlines some key issues serving as the background to this research, which focuses specifically on teaching in secondary schools. The current article offers a means of conceptualizing knowledge-building in terms of features of the knowledge itself. Specifically, I highlight the significance of ‘semantic waves’ for cumulative teaching. Martin (2013) explores the linguistic resources actors marshal to achieve semantic waves in teaching, identifying a trio of complexes he terms ‘power words’, ‘power grammar’ and ‘power composition’. Matruggio, Maton, and Martin (2013a) draws on both these

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papers to explore the temporal features of semantic waves in teaching, focusing specifically on History. Finally, Macnaught, Maton, Martin, and Matruglio (2013) discusses how ‘semantic waves’ and Martin’s ‘power trio’ were enacted in a pedagogic intervention involving teacher training. The current paper is thus primarily concerned with establishing and illustrating some of the key conceptual ideas that shaped and emerged during this research project and which, as I shall discuss, are being used in a growing number of studies into diverse practices.

The paper begins by exploring two obstacles to understanding and enabling knowledge-building: knowledge-blindness, whereby educational research overwhelmingly obscures knowledge as an object; and, among models that do see knowledge, segmental theorizing of its forms. Secondly, I introduce concepts from Legitimation Code Theory, a sociological framework that builds primarily on the approach of Basil Bernstein. These concepts of *semantic gravity* and *semantic density* offer insight into one set of organizing principles of knowledge practices, and enable the analysis of change over time in terms of *semantic profiles*. Thirdly, these concepts are employed to examine knowledge within classroom practice. Drawing on a major study of secondary school History and Biology, I highlight how teaching often involves (to put it simply) a repeated pattern of exemplifying and ‘unpacking’ educational knowledge into context-dependent and simplified meanings. This raises questions of how this knowledge may be transformed to become the relatively decontextualized and condensed knowledge students must demonstrate in educational assessments to show their mastery of pedagogic subjects. Using brief examples from History and Biology lessons I illustrate how *semantic waves*, involving shifts in meaning in both directions, offer a potential means of traversing this gap in classroom practice. Fourthly, I discuss how the concepts outlined here are being used to explore the organizing principles of diverse practices in education and beyond, and their relations with other concepts and frameworks. Lastly, I return to the issue of cumulative knowledge-building to consider what light these ideas might shed on this widely shared goal for education.

2. Knowledge-blindness and segmental theorizing

2.1. Knowledge-blindness in educational research

Much educational research is characterized by ‘knowledge-blindness’ (Maton, 2013): knowledge as an object is obscured. The forms taken by this condition result at least partly from how psychology and sociology have influenced educational research over recent decades (Freebody, Maton, & Martin, 2008). On the one hand, psychologically-informed approaches typically focus on generic processes of learning and sideline differences between the forms of knowledge being learned. Research on ‘transfer’, for example, explores forms of knowing (‘knowing with’, ‘knowing that’, ‘knowing how’, etc.) rather than knowledge (Bransford & Schwartz, 1999). This construction of the object for research has been bolstered by the dominance of constructivisms, which include a view of ‘knowledge’ as mental processes and states of consciousness that reside within the learner. The notion of knowledge as an object of study emergent from but irreducible to how individuals know is thus obscured. On the other hand, approaches informed by sociology and cultural studies have tended to focus on the effects of power relations for the experiences and beliefs of different social groups (Maton & Moore, 2010). Here the central aim is to unmask the social power underpinning knowledge, to reveal those whose interests it serves or diminishes, where the form taken by that knowledge is considered arbitrary. Here, knowledge is reduced to a reflection of social power.

Educational research has thus typically backgrounded knowledge as an object. Key issues for research are exploring processes of learning and revealing whose knowledge is being learned. What is being learned and how it shapes these processes of learning and power relations among knowers have been largely obscured. Such knowledge-blindness thus proceeds as if the nature of what is taught and learned has little relevance. Accordingly, debates over teaching have oscillated between ‘traditional’ and ‘constructivist’ pedagogies that are generalized across the curriculum, and knowledge-building has been typically understood generically, as accumulation of content or ill-defined skills such as ‘critical thinking’. How the forms taken by educational knowledge may enable or constrain cumulative teaching and learning remains relatively under-researched.

2.2. Segmental theorizing of knowledge

Highlighting the prevalence of knowledge-blindness is not to say there exist no models of knowledge. A host of thinkers, including Bourdieu, Foucault, Habermas, and Piaget, have distinguished everyday or commonsense knowledge from educational or uncommonsense knowledge (Bernstein, 2000). Similarly, there exist numerous attempts to characterize forms of academic knowledge. For example, Biglan (1973a, 1973b) typologized disciplines into hard/soft, pure/applied, and life/non-life; Kolb (1981) offered categories of abstract/concrete and active/reflective; and Becher (1994; Becher & Trowler, 2001) combined these typologies to describe the cultural and cognitive styles of academics as disciplinary ‘tribes’. Such distinctions are legion: effective/ineffective; context-independent/context-dependent; conceptual/contextual; and many more, including the well-known taxonomies of Bloom (1976) and Shulman (1986). The creation of knowledge typologies is a thriving cottage industry.

These models are to be welcomed: they bring knowledge into view as an object of study. Categories such as abstract/concrete or context-dependent/context-independent offer a useful starting point for highlighting knowledge – I drew on such terms in the Introduction to this paper as a simple way into the issues. However, overcoming knowledge-blindness is but a first step. It is not enough to see knowledge, one also needs to theorize knowledge in ways that

enable knowledge-building to be explored in empirical research. This highlights a second obstacle: most models embody a segmental form of theorizing. They may expand or contract, overlap or integrate the types of knowledge they delineate, but they nonetheless offer a series of types into which relatively few empirical practices neatly fit and which struggle to accommodate change within or between them.

This issue is often mentioned when such models are proposed and debated. Proponents temper their advocacy by admitting they cannot do justice to the empirical complexity and variation of all kinds of knowledges. Similarly, critics focus on difficulties placing empirical practices into types, identify missing kinds of knowledge, and argue for further categories or sub-types. Such caveats and criticisms highlight the problem, but where they view the solution as delineating more categories they misunderstand its nature. The principal limit to such models is not simply whether they offer sufficient categories to embrace the variegated and changing nature of knowledge practices but rather that such theorizing cannot *by itself* fully embrace such diversity. It is *not* that typologies are a misstep; rather, it is that they are a valuable *first* step. The *next* step is to conceptualize the organizing principles that generate these diverse kinds of knowledge practices (and others yet to be delineated in these models).

Bernstein's model of 'discourses' and 'knowledge structures' (2000) offers a particularly pertinent example. By foregrounding forms of development, it is the most relevant model; as one of the most suggestive typologies, it also reveals their limits. Bernstein distinguished, first, between 'horizontal discourse' or everyday knowledge and 'vertical discourse' or educational knowledge. Horizontal discourse 'entails a set of strategies which are local, segmentally organized, context specific and dependent, for maximizing encounters with persons and habitats' (2000: 157). Vertical discourse comprises 'specialized symbolic structures of explicit knowledge' (2000: 160) where meaning is related to other meanings. Bernstein further distinguished within vertical discourse between knowledge structures. 'Hierarchical knowledge structures', exemplified by the sciences, are explicit, coherent, systematically principled and hierarchical organizations of knowledge that attempt to create generalizing theories that integrate knowledge across an expanding range of apparently different phenomena. 'Horizontal knowledge structures', exemplified by the humanities, comprise a series of segmented approaches, each with its own distinctive criteria. One issue these types highlight is knowledge-building: hierarchical knowledge structures develop by new theories integrating and subsuming previous ideas; horizontal knowledge structures develop through adding another segmented approach. Bernstein was describing the production of knowledge in intellectual fields, but these types can be homologously extended to distinguish: hierarchical and horizontal *curriculum structures*, where new units either extend and integrate or remain strongly bounded from knowledge articulated in preceding units; and *cumulative* and *segmental learning*, depending on whether students' understandings transfer across contexts and over time or remain locked into their pedagogic contexts (Maton, 2009).

Bernstein's model is insightful and suggestive. It has inspired a renewed focus in sociology and linguistics on knowledge practices (Christie & Martin, 2007; Christie & Maton, 2011; Maton & Moore, 2010). It has also brought knowledge-building into the foreground. Nonetheless, Bernstein's model represents a valuable *first* step on which to build by conceptualizing the principles underlying discourses and knowledge structures. This is to ask: what makes something horizontal or vertical, hierarchical or horizontal? Muller (2006) suggests 'verticality' and 'grammaticality' as key characteristics, usefully highlighting internal and external relations, but the question remains: what underlies these characteristics? It is unclear what they refer to or how they can be enacted in substantive research. Problems arise as soon as one attempts to operationalize the model to analyze empirical data. Few practices fit into the dichotomies, many combine characteristics of knowledge structures, and processes over time, such as research or classroom practice, elude the conceptualization.

Bernstein himself highlighted these kinds of limitations, noting that, at this stage of conceptual development, understanding of the organizing principles underlying such dichotomous forms is 'very weak' in its generative power (2000: 124). Nonetheless, as Bernstein wrote of other ideas, this 'does not mean that we abandon such a conceptual syntax but should recognize it for what it is, something good to think with, or about' (2000: 133). Against the tendency to regard each paper as the final word, he also emphasized that 'a paper is part of a development leading to a new development' (2000: 125). The model was made to be developed further. It is thus a valuable *first* step; as Muller (2006: 14) states, 'for all its richness, this analysis merely starts the ball rolling'. Usefully, Bernstein's framework also offers blueprints for how to keep it rolling. Code theory emphasizes the analysis of organizing principles underlying practices to enable research to determine difference, variation and similarity, and to explore change over time. Bernstein's model of change in knowledge structures also foregrounds the necessity for such concepts to be capable of enactment in research into all kinds of practices, to embrace the greatest range of phenomena within the most economical conceptual framework. Using Bernstein's blueprints for cumulative knowledge-building to cumulatively build on Bernstein's knowledge is an ongoing concern of Legitimation Code Theory, to which I now turn.

3. Legitimation Code Theory: Semantics

Legitimation Code Theory (LCT) is a sociological toolkit for the study of practice. It forms a core part of social realism, a broad 'coalition' of approaches (Maton & Moore, 2010) which axiomatically reveal knowledge as both socially produced and real, in the sense of having effects, and which explore those effects (Maton, 2013; Moore, 2009; Muller, 2000; Wheelahan, 2010; Young, 2008). Though LCT integrates insights from a range of approaches, its principal foundational framework is Bernstein's code theory (1971, 1975, 1990, 2000; see Moore, 2013). LCT cumulatively works within the problematic and

approach of code theory to offer concepts that extend existing conceptual tools (Maton, 2013). This development is in close relation with research. LCT is a practical framework that is being used to explore a host of issues, practices and contexts in education and beyond (e.g. Maton, Hood, & Shay, 2013), both on its own and alongside complementary frameworks, especially systemic functional linguistics (e.g. Hood, 2010, 2013; Matruglio, Maton, & Martin, 2013b).¹ As Maton (2013) emphasizes, LCT is a work-in-progress, an ongoing and open-ended endeavour that foresees its own repeated refinement, deepening and extension through dialectical relations with empirical studies, foundational frameworks, and complementary approaches. LCT is also a multi-dimensional conceptual toolkit; each dimension offers concepts for analysing a particular set of organizing principles (or *legitimation codes*) underlying practices. Here I focus on the most recently developed dimension of Semantics.

3.1. Semantics

The LCT dimension of Semantics constructs social fields of practice as *semantic structures* whose organizing principles are conceptualized as *semantic codes*, comprising strengths of *semantic gravity* and *semantic density*. These concepts have their genesis in all three dialectical relations mentioned above (Maton, 2009, 2011, 2013). First, substantive studies using concepts from the longer-established LCT dimension of Specialization, including the project discussed in this paper, ‘spoke back’ to the theory, highlighting issues of context-dependence and condensation of meaning that this dimension was not fully grasping – the framework needed extending. Secondly, these two issues are also highlighted by Bernstein’s code theory, principally in his models of elaborated and restricted codes (1971) and discourses and knowledge structures (2000). However, they remained conflated within dichotomous types and their organizing principles had yet to be conceptualized – this foundational framework needed development. Thirdly, a series of collaborative studies with systemic functional linguists raised questions of how linguistic features such as ‘grammatical metaphor’ were expressed in knowledge practices – a complementary framework highlighted new facets of phenomena.²

Semantic gravity (SG) refers to the degree to which meaning relates to its context. Semantic gravity may be relatively 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. All meanings relate to a context of some kind; semantic gravity conceptualizes how much they depend on that context to make sense. (The nature of the context is analyzed using other concepts; see Section 5.3). How strengths of semantic gravity are realized empirically depends on the specific object of study (Maton, 2013). Nonetheless, to give a simple 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. Moreover, by dynamizing this continuum to analyze change over time, one can also describe processes of: *weakening* semantic gravity (SG↓), such as moving from the concrete particulars of a specific case towards generalizations and abstractions whose meanings are less dependent on that context; and *strengthening* semantic gravity (SG↑), such as moving from abstract or generalized ideas towards concrete and delimited cases.³

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 continuum of strengths. The stronger the semantic density (SD+), the more meanings are condensed within practices; the weaker the semantic density (SD–), the less meanings are condensed. (The nature of these meanings, which may comprise formal definitions, empirical descriptions, feelings, political sensibilities, taste, values, morals, affiliations, etc., is analyzed using other concepts; see Section 5.3).

The degree of condensation within a symbol or practice relates to the *semantic structure* in which it is located. For example, Martin (2013) shows how the term ‘cilia’ is situated by the academic discourse of Biology within: compositional structures that describe the physical constituents of cilia and what cilia are constituents of; taxonomic structures that involve different ways of classifying parts of the body; and a range of biological processes and causal explanations in which cilia play a role. In short, by virtue of its positions within the constellations (relational systems of meanings) comprising the semantic structure of the intellectual field of Biology, ‘cilia’ possesses a semantic density of considerable strength. This strength is, though, not essential or intrinsic to the term itself. Within Biology, the semantic density characterizing ‘cilia’ in research publications is likely to be stronger than that characterizing the term’s use within school textbooks, which in turn may be stronger than its use in classroom discourse or student work products. Furthermore, for terms that are also in everyday use

¹ To keep abreast with LCT research, publications, and events, see: <http://www.legitimationcodetheory.com>.

² Discomfort with inter-disciplinary dialogue, conceptual development, the term ‘semantics’, and close analyses of textual data could lead some sociologists to profanize this dimension as overly inspired by or resembling linguistics. This would ignore relations to substantive studies in code theory and to Bernstein’s framework (which was itself influenced throughout by SFL), and decontextualize the concepts from their wider sociological framework (weakening their semantic density).

³ In LCT, the meanings of ‘↑’ (strengthening) and ‘↓’ (weakening) remain the same across all code concepts. Thus, ‘weakening semantic gravity’ is denoted by ‘SG↓’, though weaker semantic gravity (SG–) is typically placed at the top of semantic scales.

(unlike 'cilia'), these pedagogic realizations are, in turn, likely to exhibit stronger semantic density than uses in horizontal discourse.⁴ For example, 'gold' may be commonly understood as, for example, a bright yellow, shiny and malleable metal that has been used in coinage, jewellery, dentistry and electronics, whereas within the discipline of Chemistry the term may additionally signify such meanings as an atomic number, atomic weight, electron configuration, lattice structure, a capacity for reflecting infrared radiation and for conducting electricity and heat, and much more. Many of these meanings involve compositional structures, taxonomic structures or 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 is situated, *inter alia*, within the periodic table, among many other relations. Thus, in Chemistry 'gold' is relationally situated within structured, complex, and evolving webs of meanings – the 'constellations' comprising its academic discourse (Maton, 2013) – imbuing the term with a far greater range of meanings. Semantic density thereby traces a continuum of strengths, with infinite capacity for gradation.

This continuum can also be dynamized to describe *strengthening* semantic density (SD \uparrow), such as moving from a symbol or term that denotes a small number of meanings towards one that implicates a greater range of meanings. For example, bringing together a series of places, time periods, customs, ideas, beliefs, etc. within the term 'Mycenaean Greece' in History; or relating the structures of cells, proteins, pigments, etc. within a leaf to describe the process of 'photosynthesis' in Biology. Strengthening semantic density is thus creating (or revealing) constellations of meanings. Conversely, one can describe *weakening* semantic density (SD \downarrow), such as moving from a highly condensed symbol to one that involves fewer meanings. For example, explaining a technical term from a written academic source in simpler terms typically enacts only a limited number of the meanings it possesses within that source: it reduces its range of meanings to those given in that explanation, weakening semantic density by delocating the term from its constellational relations with other terms in its semantic structure. (Thus, though commonly called 'unpacking', this practice might be more accurately described as 'partial unpacking').

3.2. *Semantic profiles*

Revisiting obstacles to exploring knowledge-building, the concepts of semantic gravity and semantic density overcome knowledge-blindness and segmental theorizing. Rather than gathering empirical characteristics, they bring the principles underlying those characteristics into the light. The relative strengths of semantic gravity and semantic density may be varied independently to generate *semantic codes* (SG+/-, SD+/-) that conceptualize one set of organizing principles of practices. Put another way, 'semantic gravity' and 'semantic density' are not categories into which complex and changing empirical practices are to be placed. All practices are characterized by both semantic gravity and semantic density; the question for empirical research concerns their strengths. However, they do not dispense with notions of boundaries, such as between types. Semantic codes combine typology and topology, notions of boundaries between categories and continua of difference: they offer a 'both/and' rather than an 'either/or'. Semantic codes embrace *both* four principal modalities (given by varying '+/-' within SG+/-, SD+/-), which provide a basis for typologizing practices (e.g. Shay, *in press*, on curriculum in professional education), *and* continua of strengths along which practices can be situated to generate their positions within a relational topology (see Maton, 2011: 66). The concepts thereby move beyond segmented and homogenizing categories such as abstract/concrete, to additionally embrace differences between and within different forms, as well as change over time.⁵

Dynamizing static accounts of structures is crucial for capturing knowledge-building, a practice enacted through time. Conceptualizing processes of strengthening and weakening semantic gravity and semantic density (SG $\uparrow\downarrow$, SD $\uparrow\downarrow$) enables research to trace the *semantic profile* of practices over time, and the associated *semantic range* between their highest and lowest strengths. For example, Fig. 1 describes a *semantic scale* of strengths of semantic gravity and semantic density on its y-axis, and time on its x-axis (such as the unfolding of classroom practice, curriculum or text). Fig. 1 traces several illustrative profiles and their respective *semantic ranges*: a high *semantic flatline* (A1), a low *semantic flatline* (A2) and a *semantic wave* (B). Semantic profiles take the pulse of knowledge-building; semantic ranges reveal, for example, how faint the pulses of flatlines are compared to those of waves. Again, this conceptualization combines categories with continua; as illustrated by the dotted line in Fig. 1, typologies of knowledge, such as horizontal discourse/vertical discourse, may also be distinguished. Semantic waves may thus involve the *semantic weaving* together within practices of different types of knowledge or semantic codes.

⁴ I am here describing *epistemic semantic density* based on *epistemological condensation*; commonsense understandings may exhibit far stronger *social semantic density* based on *axiological condensation* (see Section 5.3, below; Maton, 2013). The point here is that 'semantic density' does not project a deficit model of horizontal discourse: it may exhibit relatively strong semantic density of a different kind.

⁵ It is possible to redescribe categories such as abstract / concrete as the end-points of a continuum. However, their definitions are vague, hotly-contested, embedded in dichotomizing discourses, elide instances with principles, and possess considerable axiological loading within debates. They also often conflate *semantic gravity* and *semantic density*. In short, they are characterized by weaker epistemological condensation, stronger axiological condensation (see Section 5.3), and a limited range of semantic gravity. Notably, using existing categories such as abstract/concrete to analyze categories such as abstract/concrete would offer less insight into their value and limits.

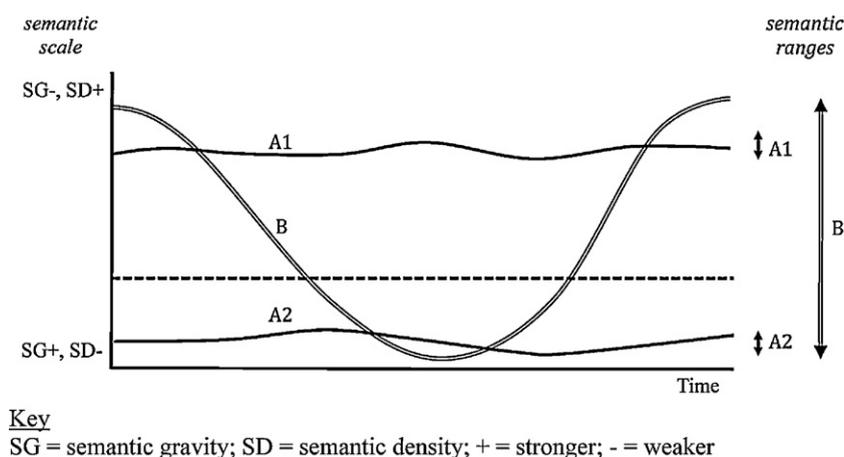


Fig. 1. Illustrative semantic profiles and semantic ranges.

3.3. Simplicity

I should emphasize that the discussion of concepts thus far is but a basic introduction – the definitions are anything but definitive. As discussed in Section 5 (below), studies using these concepts are rapidly revealing both their fecundity and complexity. There is, for instance, more than the one form of semantic density I shall explore in this paper. Similarly, semantic profiles are more complex than presented here. Those I depict as figures trace together the strengths of semantic gravity and semantic density as a single line, with the two strengths moving together inversely. However, the two strengths may change independently and not always in this manner. Thus, different profiles could be drawn for SG and SD, there is more than one possible ‘semantic scale’, and the one used in this paper does not embrace two semantic codes (SG+, SD+ and SG–, SD–). Moreover, these figures are heuristic; other studies are developing means for calibrating semantic scales and plotting profiles with greater precision. Research is also revealing semantic waves of different amplitudes, frequencies, lengths and shapes – they are not homogeneous. Nonetheless, as I discuss below, ‘unpacking’ must begin somewhere, and the simple semantic profiles above were central to the collaborative research into cumulative teaching in secondary schooling discussed in the papers comprising this special issue.

4. Modelling semantic waves in teaching

The ‘Disciplinary, Knowledge and Schooling’ project (DISKS) utilized LCT and systemic functional linguistics (SFL) as complementary frameworks for exploring cumulative teaching in secondary schooling. 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). Secondly, LCT and SFL were drawn on to analyze 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. Thirdly, 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 (Macnaught et al., 2013). Three dimensions from LCT were drawn on in the project: Specialization, Semantics and Temporality. It is beyond the limits of this paper to explicate the substantive and theoretical outcomes of this research. Here I shall focus on Semantics and specifically on one issue for cumulative knowledge-building that became central to the project’s pedagogic intervention.

4.1. High stakes and down escalators

The issue I focus on concerns what can be described as the ‘high stakes’ of teaching and learning. As heuristically portrayed in Fig. 2, 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 educational knowledge 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 pedagogic subject. Though the position on the semantic scale of the latter relative to the former varies (such as being 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. One

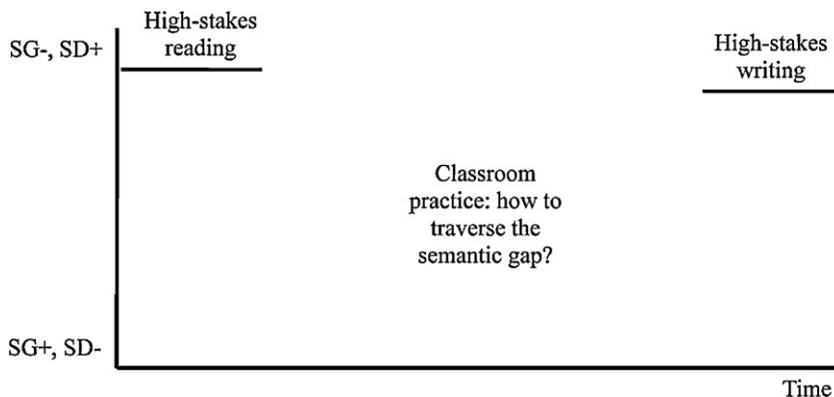


Fig. 2. The high stakes of teaching and learning.

question this raises concerns how this potential gap is traversed; how do classroom activities mediate between knowledges that are higher up a semantic scale?

Analyses of phases of interaction highlighted several semantic profiles of classroom practice. As depicted in Fig. 3, one that featured frequently comprises a series of *downward semantic shifts*: from highly condensed and decontextualized ideas (SG–, SD+) towards simpler, more concrete understandings, often including examples from everyday life (SG+, SD–). The pedagogic practices associated with this ‘down escalator’ profile typically involved teachers repeatedly ‘unpacking’ and exemplifying meanings from written sources. As I illustrate below, such ‘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 particular ideas and words to students using less technical, more ‘everyday’ language and examples, and then returned to the text, repeatedly finding points to ‘unpack’ and discuss, but rarely if ever moving back into the pedagogic discourse of the subject through ‘repacking’ explicated meanings and examples into terms or ideas. Thus, the profile models movements downwards but not back upwards from knowledge that is non-technicalized, concretized and often segmented (such as into disparate examples) towards more condensed, technicalized knowledge that is ‘plugged into’ the constellations of meanings constituting academic subjects. This represents a potential problem for cumulative knowledge-building: knowledge characterized solely by relatively strong semantic gravity and relatively weak semantic density may be too related to specific contexts and too disconnected to either build upon previous knowledge or be built upon in the future.

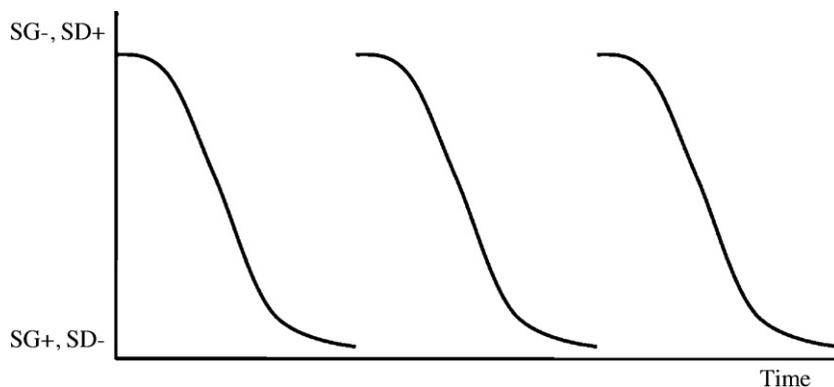


Fig. 3. A ‘down escalator’ profile.

4.2. Semantic waves

A contrasting semantic profile characterizing classroom practice in the study involved not only *downward semantic shifts* but also *upward semantic shifts*. These *semantic waves* thereby offer the possibility of additionally modelling transitions of knowledge from contextualized and simpler understandings towards more integrated, manifold and deeper meanings. Moreover, they model how meanings may be transformed through semantically weaving together different forms of knowledge within practice. To illustrate these shifts I shall explicate a single wave in two brief examples from Biology and History.

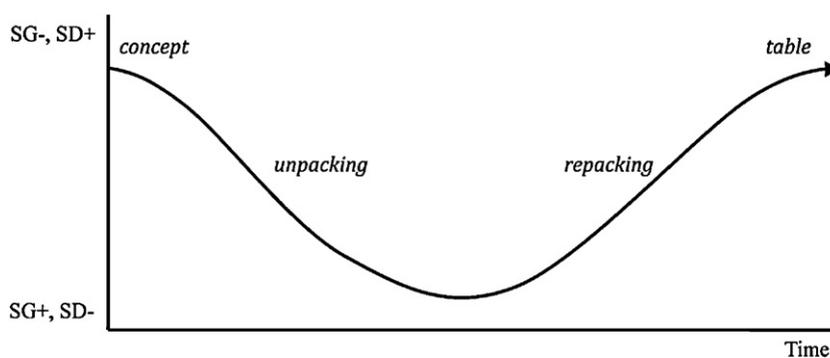


Fig. 4. Example of a semantic wave in Biology teaching.

4.2.1. A semantic wave in a Biology classroom

In this example from a Year 11 Biology classroom, the topic of discussion is biological lines of defence, focusing here 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!

Fig. 4 portrays the semantic profile of this classroom interaction. The example begins with the teacher introducing 'cilia', an abstract scientific term that condenses a wide range of meanings within Biology (Martin, 2013). The context of the science classroom, the explicitly stated focus of this particular lesson, the teacher's solicitation of a definition, and the unfamiliarity of the word, together announce its high position on a semantic scale ('concept' in Fig. 4). With contributions from students, the teacher then explicates some meanings of the term using a combination of 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 the 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 delineating a limited number of its meanings weakens semantic density. This moves down the semantic scale towards more grounded and less condensed meanings.

I should emphasize that to conceptualize the partial 'unpacking' of educational knowledge 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: to provide a point of entry for noviciates into those meanings. This also represents a potential starting point for progressively strengthening 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 eschews this possibility by returning to the start of the sequence to commence a new 'unpacking'. However, in the current 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
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Fig. 5. Biology teacher's table entry for 'cilia'.

After telling the students, as quoted above, to 'write this down under description', the teacher writes on the board: 'cilia', a brief definition, and a description of a function they serve in the body (see Fig. 5). This is more than a summary of the preceding passage of 'unpacking'; it begins to 'repack' the term 'cilia' by bringing together elaborated meanings without specific contexts such as smoking. In other words, it begins moving expressed knowledge up the semantic scale ('repacking' in Fig. 5). This upward semantic shift is then continued further: the definition forms part of a table (reproduced as Fig. 6) that the class works through together in learning about biological lines of defence. This 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'), tracing a semantic wave. As the table highlights, this wave forms part of a longer sequence in which the current teaching and learning builds on previously discussed ideas and is 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 glands and oily secretions from glands in hair follicles.	Contain chemicals that destroy bacteria and fungi.

Fig. 6. Table used for teaching lines of defence in a Biology classroom.

4.2.2. A semantic wave in a History classroom

My second example is from a Year 11 History classroom discussion of a take-home assignment on ‘the influence of Greek and Egyptian cultures in the Roman Empire’. The question includes terms from the pedagogic discourse of History with relatively weak semantic gravity and relatively strong semantic density: ‘Greek culture’, ‘Egyptian culture’ and ‘Roman Empire’ embrace a range of meanings concerning time periods, geographical locations, practices, beliefs, etc. Moreover, the question condenses more than the sum of its terms: ‘influence’ elicits understanding of historical processes. Though here interleaved with analysis, the following quotes represent continuous interaction, which begins:

Teacher This is a little bit hard, “H. 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 begins by indicating the knowledge being discussed is relatively high on the semantic scale (‘a little bit hard ... No idea, right’). Notably, an indicator was unnecessary in the Biology example: the term’s technical nature announces itself, as it were, while terms in History may be less self-evidently specialized (cf. [Martin, 2013](#) on ‘flexi-tech’). [Fig. 7](#) thus depicts the semantic profile as beginning relatively high. The teacher then moves the knowledge down the semantic scale in stages (‘unpacking’ in [Fig. 7](#)) 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?

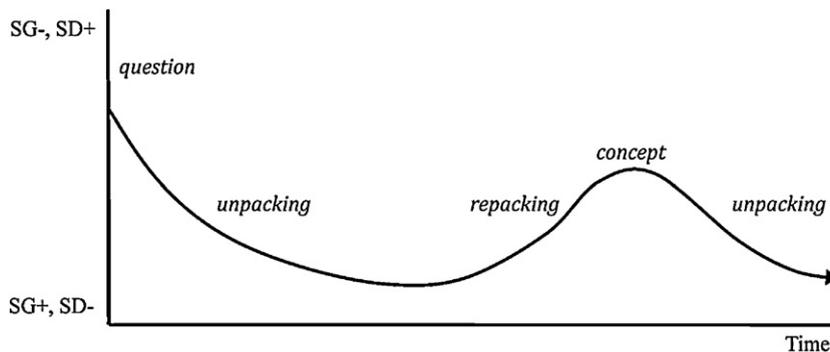


Fig. 7. Example of a semantic wave in History teaching.

With the examples of ‘objects’ that ‘may be showing Greek design’, ‘Egyptian design’, ‘Greek mythology’ or ‘Egyptian mythology’, the knowledge expressed by the teacher begins to descend the semantic scale by specifying and unpacking meanings from the wide-ranging, abstract terms, a move continued by the more specific and concrete examples of ‘building techniques’, which is in turn exemplified by ‘columns’. Moreover, the teacher provides a second avenue of descent by grounding the question in the historical period through examples of prior events in history (see [Matruglio et al., 2013a](#)) and the current discussion of the question in the context of what has been learned in 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.

As discussed above, our research often encountered such downward semantic shifts in secondary classrooms. However, in this case, the teacher begins to move knowledge in the opposite direction:

Teacher So, there would be massive amounts of trade going on, and umm, you know people visiting their diplomats you know or their, their, ambassadors. ... 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 addressing recurrent events (trade and diplomatic visits) rather than specific events, and progressively strengthens semantic density by ‘packing up’ the various activities being recurrently conducted between countries as ‘trade in ideas’, and thence into the technical term, ‘aesthetic trade’, which also exhibits weaker semantic gravity (see ‘repacking’ to ‘concept’ in [Fig. 7](#)). Though this does not return to the heights embodied by the question, this upwards shift almost completes a semantic wave in explaining 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 practice. In this example, the knowledge discussed descends the scale again through the teacher providing examples of the concept ‘aesthetic trade’ and emphasizing how seemingly ‘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. 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.

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 is less to identify exemplary practices than to illustrate semantic waves in the knowledge being discussed. The DISKS project also explored other dimensions of knowledge (Section 5, below), as well as the complex linguistic resources they enact ([Martin, 2013](#)) and the role of time in their creation ([Matruglio et al., 2013a](#)). From this research, we tentatively conjecture, *inter alia*, that one means for traversing the potential 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 [Fig. 8](#). This tentative conjecture underpinned a small-scale pedagogic intervention that comprised the third stage of the research. As [Macnaught et al. \(2013\)](#) discusses, in the light of the pervasive nature of the ‘down escalator’ profile, we focused on training teachers to engage in ‘joint construction’ with students as a means of moving up the semantic wave and master the linguistic resources required for high-stakes writing.

Our research project focused on one specific issue, but the notion of semantic waves may ripple out further. The examples given here each trace a single semantic wave through a brief passage of classroom practice, in order to demonstrate that this phenomenon need not be lengthy. However, the endpoints – a table of ‘biological lines of defence’ and further historical examples of ‘aesthetic trade’ – highlight their location within more extended sequences of activity. 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 previously waved knowledge (see ‘detail’ in [Fig. 8](#)). This may also involve, as in a ‘spiral curriculum’, revisiting knowledge to heighten or deepen past waves. Although, for example, [Liu \(2012\)](#) details how successful pedagogies such as the Reading to Learn programme ([Rose & Martin, 2012](#)) trace semantic waves, further studies are required to explore the veracity of these tentative conjectures. On these issues the DISKS project suggests more than it can show. Nonetheless, as I now discuss, other studies are revealing the widespread and manifold nature of semantic waves and the fertility of semantic profile analysis.

5. The depth of semantic waves

Having introduced somewhat abstract and condensed concepts from LCT in Section 3, the examples of semantic waves in classroom discourse in Section 4 were relatively simple, concrete, and drawn from the specific focus of one research project. I concluded by suggesting semantic profiles may be analyzed for contexts and practices beyond single passages of classroom discourse. Here I continue this last direction by discussing how studies are showing semantic waves to be more pervasive and complex, and the concepts for analysing them more fecund, than hitherto suggested. Substantively, studies are revealing that semantic waves: appear far beyond classrooms; take many forms; interact with other principles underlying practices; and relate to the dispositions of actors. Theoretically, they are showing that semantic profile analysis can: explore a wide range of practices; embrace manifold diversity; form part of multi-dimensional analyses of practices; and embody a social justice agenda. I address each of these four couplets in turn.

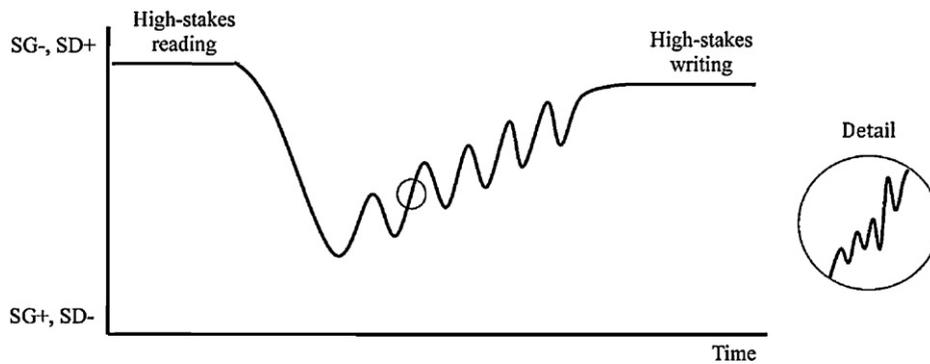


Fig. 8. Semantic waves and the high stakes of teaching and learning.

5.1. Reaching beyond classrooms: pervasive profiles

Substantive studies are revealing the forms, attributes and roles of semantic codes and profiles across a growing range of practices and contexts. Research is exploring research, curriculum, pedagogy and assessment in, for example, subjects from across the disciplinary map, including cultural studies (Hood, 2013), design studies (Shay & Steyn, 2013), English (Christie, 2013), engineering (Wolff & Luckett, in press), environmental education (Tan, 2013), jazz education (Martin, 2012), journalism (Kilpert & Shay, 2012), marketing (Arbee, 2012), nursing (O'Connor, McNamara, Ahern, MacRuairc, & O'Donnell, 2011), physics (Lindström, 2010; Zhao, 2012), sociology (Stavrou, 2012), and teacher education (Shalem & Slonimsky, 2010). Other studies are also exploring practices beyond education, such as parliamentary procedures (Siebörger & Adendorff, 2011) and freemasonry apprenticeship (Poulet, 2011).

These studies are showing that, while its use in the DISKS project gave rise to some tentative conjectures regarding the nature of cumulative pedagogic practice in secondary school classrooms, the value of the approach does not rest upon the fertility or otherwise of those specific and localized suggestions. Published and ongoing studies are showing the wider applicability of semantic profile analysis and the significance of those profiles for understanding powerful and cumulative knowledge practices within otherwise disparate terrains. They are suggesting that, whatever the field, the recontextualization of knowledge – an essential attribute of building knowledge over time – requires *both* upwards shifts from specific contexts and meanings, *and* downward shifts from generalized and highly condensed meanings. Simply put, semantic waves represent the pulses of knowledge-building. In educational research, for example, approaches often trace either high flatlines reflecting abstract discussion of condensed concepts that engage little with empirical data or low flatlines comprising empirical descriptions that remain bounded from studies of other contexts. In contrast, cumulative theories with explanatory power can be enacted within specific contexts in substantive studies (concretizing and engaging only some of their meanings), and enable empirical descriptions to be translated back into and transform the constellations of the theory – i.e., they trace semantic waves (Maton, 2011, 2013). Similarly, studies of student work products are suggesting semantic waves play a role in achievement. Fig. 9 draws upon Maton (2009, 2013) to portray the semantic profiles of high- and low-achieving student essays from secondary school English that discuss three texts in relation to the abstract idea of 'the journey'. The high-achieving essay traces a series of semantic waves between wide-ranging and literary ideas and the concrete particularities of each text; the low-achieving essay traces a semantic flatline with strongly bounded discussion of highly contextualized and simple meanings from each text.

5.2. Embracing complexity: diverse profiles

Profiles involving both upward and downward semantic shifts may be pervasive but they are not uniform; the examples analyzed in this paper are not the only form semantic waves take. The aforementioned studies are demonstrating the

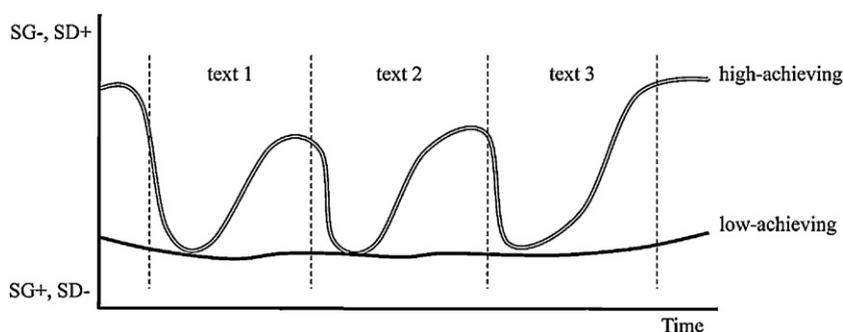


Fig. 9. Semantic profiles of two student essays in school English.

diversity of profiles and the ability of Semantics concepts to embrace that complexity by exploring an expanding range of characteristics, 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, as the low-achieving essay of Fig. 9 highlights, it is not a simple case of “the higher the better”. Research into undergraduate physics education, for example, reveals that students may reach too high up the semantic scale in their assessed work, to grasp for concepts, principles, equations or laws that are overly abstract and generalizing or which condense more meanings than appropriate to their assignment (Georgiou, 2012). 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.

Secondly, though both upward and downward shifts are required for cumulative knowledge-building, the directions of *semantic shifts* may play different roles across fields. In discussing classroom examples (Section 4) the importance of ascending a semantic scale was emphasized in response to the frequency of ‘down escalators’ in lessons analyzed for the DISKS project. In contrast, studies of professional education (e.g. Kilpert & Shay, 2012) are highlighting that *downward* semantic shifts are not confined to ‘unpacking’ and are crucial in teaching and learning appropriate ways to select, recontextualize and enact abstract and condensed principles of knowledge within concrete and specific cases of professional practice.

Thirdly, semantic waves do not necessarily begin and end on relative highs in the manner of the examples. Beginning from concrete, simpler meanings may offer a more engaging way into and out of the central focus of an activity or topic. Ongoing research is thus exploring the role of different *entry* and *exit points* on semantic scales in research publications, lessons, student assignments, etc. Fourthly, while the classroom examples exhibited relatively strong *semantic flow* or degree of connectedness between consecutive points, this cannot be assumed. Knowledge expressed in practices may realize 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. Lastly, the *semantic threshold*, or extent to which accuracy matters, may vary among practices and contexts. Ongoing research is suggesting that the degree of this threshold as well as its nature, such as relative emphases on epistemological and axiological issues, differs across subject areas and through stages of education. For example, the definition of the function of ‘cilia’ offered by the teacher in Section 4.2 is not entirely correct biologically in too closely relating the respiratory system to the gastrointestinal system.⁶ Further research may show, however, that such simplified definitions go on to be elaborated and clarified as students progress through the curriculum, raising the semantic threshold. The concepts for semantic analysis thereby embrace prolific diversity, of not only practices but also profiles.⁷ This diversity highlights that semantic waves are not homogeneous and no one kind is a universal panacea. It suggests a key question for research is: what profiles serves what purposes, for whom, and in which contexts?

5.3. Plugging into multi-dimensionality: Semantics and other principles

That studies suggest semantic waves appear in a range of institutional and disciplinary contexts does not negate differences between practices. For example, as Bernstein (1990) highlights, practices within fields of production, recontextualization, and reproduction cannot be reduced to each other – they have different logics. Thus, homologous semantic profiles across the research, curriculum, and pedagogy of a subject area would not suggest these practices are unproblematically the same. One would also need to explore the organizing principles whereby knowledge is recontextualized between these fields and their effects on that knowledge. Moreover, strengths of semantic gravity and semantic density are likely to differ for the same sets of ideas across these three fields. For example, as noted in Section 3.1, recontextualizations of ideas

⁶ I am grateful to Gabi De Bie for bringing this to my attention.

⁷ These attributes offer a simple list for profile analysis of exploring 7-Gs: going in (semantic entry), going up and going down (semantic shifts), gamut (semantic range), going along (semantic flow), going out (semantic exit), and getting it right (semantic threshold)

from research to curriculum to pedagogy are likely to involve, *inter alia*, weakening semantic density. So, though profiles may be similar, their location on a semantic scale may differ.

In addition, semantic codes are not the only principles underlying practices. For example, similar semantic profiles may recur across subject areas that differ along other dimensions. In the DISKS project the knowledge expressed in lessons in both Biology and History offered similar semantic profiles but fundamentally differed in other ways. Drawing upon concepts from Specialization, a second dimension of LCT (Maton, 2013), revealed that Biology lessons embodied a *knowledge code* (where legitimacy emphasizes epistemic relations to objects of study) and History lessons embodied a *knower code* (where legitimacy emphasizes social relations to actors). As a wide array of research is showing, these specialization codes have different effects for educational practice (Maton et al., 2013).

The concepts of Semantics thus form part of a multi-dimensional toolkit for exploring complexity. Moreover, these dimensions can be integrated. In Section 3 I highlighted that the nature of the context (for semantic gravity) and the meanings being condensed (for semantic density) may take a range of forms that can be analyzed using other concepts. For example, using Specialization reveals different forms of semantic density (Maton, 2013). A technical term may involve the *epistemological condensation* of meanings of other concepts or empirical referents, as illustrated in the classroom examples of 'cilia' and 'aesthetic trade'. This is the form I have focused on throughout this paper. However, studies also highlight semantic density involving *axiological condensation* of emotional, ethical, political and moral stances. For example, in educational research stances associated with 'student-centred learning' are typically condensed with political connotations (Maton, 2013); and analyses of History lessons reveal the moral stances condensed within such '-isms' as colonialism, nationalism and imperialism (Martin, Maton, & Matruglio, 2010).

5.4. Integrating with knowers: Semantics and social justice

While semantic profiles offer insight into the organizing principles of knowledge, not everyone is equally capable of enacting the semantic shifts required for achievement. As the essays depicted in Fig. 9 highlight, not all students recognize that semantic waves are a crucial aspect of this assignment and/or realize such a profile in their written assessment. Moreover, as actors are apprenticed into the semantic structures of specialized discourses such as academic subjects, one would expect their appreciation of the diverse applicability and manifold meanings condensed within ideas to deepen. This highlights a key issue for further research: the diverse and potentially evolving semantic ranges of actors.

Practice, as Bourdieu (1993) emphasized, is the meeting of two evolving histories, embodied in the logics of the context and of actors' dispositions, or (in Bernstein's terms) codes and coding orientations. Social realist calls to recover knowledge for educational research emphasize, and studies using the multidimensional toolkit of LCT typically explore, the attributes of knowledge expressed in practices. Codes have been the primary focus. However, overcoming knowledge-blindness does not require succumbing to knower-blindness. Accordingly, LCT can also be used to analyze the dispositions actors bring to educational contexts by virtue of their previous experience. There is a pre-existing tradition of research drawing on code sociology (e.g. Holland, 1981) and systemic functional linguistics (Hasan, 2009) that explores the coding orientations of actors and their social distribution. In LCT terms these highlight that a greater semantic range, the capacity to reach higher up the semantic scale, from concrete, simple meanings to highly abstract, condensed meanings, is not equally distributed across actors from different social backgrounds. More detailed attention to this existing work and further research are required to explore both the coding orientations of different knowers and their relations to the codes dominating educational contexts. For example, while the DISKS project tentatively conjectures that cumulative teaching involves semantic waves, modelling such waves in pedagogic practice does not guarantee enabling all students to experience cumulative learning. Nonetheless, the concepts provide the means for bringing analyses of knowledge and knowers together to reveal ways in which more learners can acquire the keys to the legitimate codes.

6. Conclusion

Almost everyone in education shares a desire for cumulative knowledge-building, but commitment is not consequence. Knowledge-blindness and segmental theorizing represent two obstacles to grasping the complex nature of knowledge-building, revealing its organizing principles, and enabling greater social equality of access to those principles across diverse institutional and disciplinary fields. This paper has offered concepts to further these aims: semantic gravity, semantic density, and their arrangements within semantic codes and profiles. Building on issues highlighted by Bernstein's framework and in substantive studies, these concepts bring one dimension of knowledge practices into view. They also represent a step forward by supplementing typologies with a means for exploring the organizing principles of knowledge practices and change over time.

One tentative conjecture proposed in this paper has been that semantic waves represent a key to cumulative development by enabling the recontextualization of knowledge through time and space. I emphasized, though, that semantic waves may take many forms and are not, by themselves, the answer to everything. Moreover, the concept of *semantic threshold* offers the salutary lesson that semantic waves may be necessary but not sufficient, that 'getting it right' may remain 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 concluding the DISKS project was a collaborative engagement with teachers of Biology and History (Macnaught et al., 2013). Our understanding of semantic profiles, let alone

cumulative knowledge-building, is thus at an early stage. However, to reiterate Bernstein, this is not the only or terminating paper: it develops ideas for further development; as I discussed, it contributes to a wider work-in-progress by a diverse range of scholars. Moreover, as this growing 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 and code theory, to concrete, specific and simpler meanings in practical application. As a growing number of studies illustrate, they can be enacted within research into a 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. To traverse the semantic gap between the concepts and such diverse data and practice, many studies are developing 'external languages of description' (Bernstein, 2000) for translating between the concepts and their differing realizations within specific objects of study. In doing so, studies often incorporate existing typologies, enabling their findings to build on and extend past work, and thereby revealing how waves may also weave by bringing together knowledges of different types. As a whole, this research practice is thus embodying what it studies – semantic waves as the pulses of building knowledge about knowledge-building.

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